AIR FORCE

PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBIR programs is with the Air Force Systems Command Deputy Chief of Staff for Technology and Requirements Planning. The Air Force SBIR program manager is Mr. James R. Meeker. Inquiries of general nature or where a problem exist requiring attention of the Air Force SBIR Program Manager should be addressed to:

Department of the Air Force
HQ AFSC/XTXC (SBIR Program Manager)
Andrews AFB DC 20334-5000

Under NO circumstances shall an SBIR proposal be submitted to the AF SBIR Program Manager. The potential offerors are reminded that NO additional technical information can or will be made available by the Air Force during the solicitation period. The only source for technical information is the Defense Technical Information Center (DTIC). Please refer to the section contained within this solicitation on the procedures for obtaining DTIC data.

Five (5) copies of each Phase I proposal shall be addressed to the office designated below. Any question regarding the preparation and processing of a proposal should be initially referred to the Air Force Small and Disadvantaged Business Utilization (SADBU) specialist identified in the following.

Topic No.	Address for Proposals	AF SADBU Specialists
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AF89-120 Thru AF89-138	AFWAL/MLK SBIR Program Manager Area B, Bldg 406, Rm 149 Wright-Patterson AFB OH 45433-6553	Mr. George Laudenslayer ASD/BC Wright-Patterson AFB OH 45433 (513) 255-5422
AF89-139 Thru AF89-157	AFWAL/POMP SBIR Program Manager Area B, Bldg 18A, Rm A103 Wright-Patterson AFB OH 45433-6563	Mr. George Laudenslayer ASD/BC Wright-Patterson AFB OH 45433 (513) 255-5422
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AF89-162 Thru AF89-168	AFWAL/POMP SBIR Program Manager Area B, Bldg 11A, Rm 201 Wright-Patterson AFB OH 45433-6503	Mr. George Laudenslayer ASD/BC Wright-Patterson AFB OH 45433 (513) 255-5422
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AF89-001 TITLE: Armament Research

OBJECTIVE: To develop innovative ideas/concepts and analysis methodologies associated with air deliverable conventional munitions/armaments.

DESCRIPTION: New and innovative ideas/concepts and analysis methodologies are desired in the area of air delivered non-nuclear munitions and armaments. These include energy sources and conversions, bombs, submunitions, warheads, fuzes including safe and arm devices for air-to-air missiles, dispensers, rockets, sensors and seekers, explosives, carriage and release equipment, aerodynamic and structural technologies, fiber optics, solid-state inertial components, exterior ballistics, analysis, and lethality and vulnerability assessment techniques. Some examples of desired research are low drag/observable weapon airframes, conformal and terminal guidance, heavy metal self-forging fragment warheads, heavy metal shaped charges, long rod penetrators, reactive fragment warheads, and computational fluid dynamics including interactive grid generation techniques.

AF89-002 TITLE: High-Speed High-Density Video Data Memory System

OBJECTIVE: To develop a fast acquisition video data memory system for airborne environment applications.

DESCRIPTION: The Air Force is interested in developing a video data memory system capable of acquiring and storing video data from new solid state imagers with output of up to 500 frames per second, 1024 x 1024 pixel resolution, and 8 bits per pixel. In order to provide flexibility, the frame resolution should be programmable up to 1024 x 1024 pixels. The system must store 30 seconds of data with a trigger input for storage of either the last 30 seconds or the next 30 seconds of data. In addition, the system must be capable of operation in extremely severe airborne and test range environments. It is desired that the system have a volume of less than 200 cubic inches (e.g., 3 inches x 6 inches x 10 inches). Parallel input architectures may be considered; however, the memory device must allow many rewrites. Architectures proposing parallel inputs should allow flexibility in the number of inputs per frame. The system should provide single frame digital and standard NTSC analog output.

The Phase I task is to provide a detailed study of a new, high density memory technology. Emphasis should be on the summary fabrication, manufacturing processes, and packaging of the high-density memory device. The Phase II task will conduct hardware demonstrations and fabricate a prototype unit to provide feasibility.

AF89-003 TITLE: High Temperature Composite Weapons

OBJECTIVE: To explore developments in low cost, high temperature composite material for advanced air-to-air missile airframes.

DESCRIPTION: Considerable work has been accomplished in high temperature composite materials for air-to-air missile application. Unfortunately, composite material technology for these demanding flight profiles results in the use of high cost materials and manufacturing techniques. There is a need for special emphasis on the use of high technology/low cost composite materials, manufacturing processes, and assembly techniques that will result in light weight, high strength, and low cost/high production rate characteristics which can be applied to asymmetric, complex shaped air-to-air missile airframes.

The fundamental goal of this program is to develop a technology base in low cost composite weapon airframe manufacturing processes for air-to-air missile applications. Specific objectives include identification and evaluation of potential low cost composite materials, manufacturing processes, and assembly techniques for an advanced air-to-air weapon.

The technical challenge is to survey the technology base in composite materials, manufacturing processes, and assembly techniques as applied to an advanced shaped air-to-air weapon airframe for the purpose of minimizing he cost of its construction.

Phase I of this SBIR task will conduct a survey of potential low cost combinations of materials and manufacturing techniques for a variety of flight envelopes and temperature profiles. The advantages and disadvantages of each combination will be reported on according to the cost effectiveness, weight, producibility, quality assurance, strength, and temperature capability. An advanced conformally carried air-to-air missile airframe will then be designed from the selected composite materials. The vehicle design must react, without degradation of performance, to the worst case free flight, ejection, and captive carriage load conditions. Finally, the Phase I task will recommend fabrication approaches to be demonstrated in Phase II.

PhaseII of this SBIR task is expected to demonstrate the Phase I recommendations by the manufacture and assembly of several components of an advanced airframe. Static loads testing will be conducted to verify structural integrity of the airframe.

AF89-004 TITLE: Stored Munitions Vulnerability

OBJECTIVE: To develop munitions insensitive to detonation while in storage but function normally when fuzed.

DESCRIPTION: The Air Force maintains a variety of munitions in relatively vulnerable locations. These storage locations are prime targets because an impact (detonation) in the storage area could cause one weapon to detonate, and could potentially detonate the remainder of the weapons in the storage area. The storage areas are high-value targets due to the relatively low cost (one weapon) and high yield of a successful mission. The Air Force is developing a blast mitigation system to reduce the probability of large-scale fratricide in storage areas. The mitigation system consists of physical barriers in contact along the length of, and in contact with adjacent bombs along with a rectangular block mounted at the center of the rectangular array formed by four bombs. The purpose of these mitigators is to deflect fragments from a detonating unit away from the adjacent and diagonal bombs, thus reducing or eliminating sympathetic detonation.

The program will concentrate on alternative methods for reducing large-scale fratricide in bomb storage areas.

AF89-005 TITLE: Extended Shelf-Life Weapon System

OBJECTIVE: To investigate methods of ensuring weapons systems can withstand a ten-year storage period.

DESCRIPTION: The Air Force Sensor Fuzed Weapon is being designed as a no-maintenance munition capable of withstanding a storage period of ten years with no degradation in reliability. Accelerated aging tests will be conducted on the system to determine its ability to endure this period. But serious risk is involved in achieving this requirement as it is totally unproven in any other system. Legislation has recently come into affect attesting to this risk by requiring that all extended shelf-life requirements be handled on a “cost-plus” basis only. Research of methods for ensuring the shelf-life durability of complex weapons systems is a must if “no maintenance” requirements continue to be imposed on contractors. Sealed dispensers, improved storage containers, sealed components, and the use of desiccants are all areas of innovative research.

AF89-006 TITLE: Impact of Extended Storage Periods on Various Advanced Composite Materials

OBJECTIVE: To determine deterioration levels of advanced composite materials under various storage conditions.

DESCRIPTION: The use of composite materials for weapons and weapons systems within the Department of Defense (DOD) is increasing every year. Until recently, the primary usage had been with aircraft for which there already existed a database which DoD could compare. The use of composite materials for air-to-air and air-to-surface weapons is now being seriously studied. The fundamental goal of this task is to develop a plan for testing the impact of long term dormant storage on various composite materials.

Phase I of this SBIR task is to identify composite materials in use today and recommend a plan for identifying their deterioration levels during extended storage.

Phase II of this SBIR task will be laboratory demonstration of the reaction of composite materials to simulated USAF munition storage conditions.

AF89-007 TITLE: Analysis of Ballistic Range Data Using Artificial Intelligence

OBJECTIVE: To employ artificial intelligence to expedite the reduction of aeroballistic range data.

DESCRIPTION: The development of a "User Friendly Expert System" employing the emerging field of Artificial Intelligence is required to reduce the 3-5 year on-the-job experience required to become an expert in data analysis. The technology being sough will merge the current analysis techniques with an artificial intelligence system such that the time of the learning process is substantially reduced and the quality of the technical analysis is improved.

Phase I of this SBIR task is to employ artificial intelligence in conjunction with the current "Linear Theory" analysis of experimentally measuring trajectories. Presently a knowledgeable engineer is required to examine the data in order to make reasonable "initial guesses" for the linear theory routines. The accuracy of these guesses greatly affects the ability of the routines to successfully fit the equations of motion to the experimental trajectory. Artificial intelligence could be used to reduce the experience needed, time and effort in this process.

Phase II of the SBIR task is to use the same type of artificial intelligence scheme for use with the six-degree-of-freedom (6-DOF) nonlinear routine. Similar initial guesses are required for the 6-DOF input in order for these routines to converge to the correct solution.

AF89-008 TITLE: Composition Control of Bulk High Temperature Superconductors for Infrared (IR) Sensors

OBJECTIVE: To demonstrate improved IR sensors using high temperature superconductors of precisely controlled composition.

DESCRIPTION: Recent rapid developments in high temperature superconductors have shown that a basic understanding of superconductivity is lacking. Very little is known about the exact mechanism of high temperature superconductivity. Any useful developments in IR sensors using high temperature superconductors will depend on a more thorough understanding of superconducting mechanism as they relate to the microstructural aspects of the material. It has been hypothesized that present materials only exhibit superconductivity along distinct paths within the bulk of the material instead of throughout the material because of the lack of composition control of the mixture during fabrication. Making practical long-wavelength IR sensors requires superconductivity to be achieved throughout the entire cross-section of the material rather than just along these distinct paths. Methods must be established for precise composition control, characterization, and standardization of bulk ceramic superconductors.

Phase I should investigate methods of fabricating superconductor sensor elements that have precisely controlled composition and microstructure. The sensor elements fabricated using these techniques will be tested to determine what effect composition control has on the relative amount of superconductivity and on measurement of critical current density versus temperature needed for practical IR sensors. Phase II will exploit favorable composition control methods for characterization and standardization of superconductor compounds for IR sensors. These methods shall be used in the fabrication of prototype IR sensors for testing to determine spectral response and operating temperature range.

AF89-009 TITLE: Computational Continuum Mechanics for Conventional Warhead Design and Analysis

OBJECTIVE: To develop improved computational methods and physical models for hydrocode applications to conventional weapon design.

DESCRIPTION: New methods are sought to extend current capabilities of hydrocodes using either finite difference or finite element methods to solve impact problems or problems involving the explosive acceleration of metals.

Innovative developments in constitutive modeling and fracture modeling are desired to more realistically treat weapon-target interaction processes. More efficient computational algorithms are required for treatment of three-dimensional warhead concepts under consideration. Phase I efforts should be limited to the evaluation of a single area of research related to either computational techniques or material modeling. Phase II efforts should demonstrate the capabilities in the framework of a research code or a temporarily modified hydrocode such as HULL, EPIC, DYNA, or any other code generally available to the research community. Follow-on efforts should address formal implementation in specific hydrocodes.

AF89-010 TITLE: Multi-stage/Multi-Mode Air-to-Surface Warhead Technology

OBJECTIVE: Develop technology for next generation of air-to-surface missiles for mobile ground target defeat.

DESCRIPTION: Improvements in modern armor technology have presented a special challenge for anti-armor missile warhead designers. This, combined with the range of vehicle types incorporated in mobile ground targets such as a motorized rifle battalion, make it desirable for the warhead to change its functional characteristics as a result of input data from either smart fuzing and/or advanced sensors. Multi-dimensional warhead design approaches are needed to increase warhead effectiveness as a result of this information flow. Some examples of required research in warhead design includes materials selection, dual/tandem warheads, fuzing/initiation requirements, and sensor submunitions is also needed. All work should be responsive to the developing sensor/fuzing technologies. Phase I work should focus on developing a fundamental understanding through basic research of some unique idea in the areas previously mentioned (materials selection, dual/tandem warheads, etc.)

Phase II work should exploit the understanding developed in Phase I to mature the concept and show/demonstrate potential warhead applications.

AF89-011 TITLE: Precision High Speed Test Track Position Time Data System

OBJECTIVE: To develop a system that will time sled position data to within one microsecond.

DESCRIPTION: The United States Air Force High Speed Test Track at Holloman Air Force Base, New Mexico has a requirement to obtain precision position time data on rocket propelled sleds. The sled velocities where the precise data are required range from 2000 feet long and the 1000 foot area may be selected at any interval along the 50,000 foot long Test Track; therefore, the system must be portable. A minimum of 25 data points are required; there will be 25 time measurements to correspond with 25 positions in the 1000 foot interval. The requirement for the time accuracy is one microsecond and the implications of this are substantial. The time delays associated with an ideal telemetry system range from 2 to 33 microseconds along the 50,000 foot Test Track and there additional delays inherent in the telemetry hardware. These delays can be calculated and measured, but they cannot be eliminated. A telemetry system will be used to transmit the time data to minimize delay times. The trackside data system will be surveyed in place and rigidly mounted to prevent any change in position from sled shock-waves and overpressures. The trackside data system will also have to be rugged to withstand the aerodynamic pressures and the effects of rocket motor blasts. The environmental conditions are also severe. The summer temperatures reach 120 degrees or more on the Test Track and a shimmering effect is seen in the air waves near the ground under these conditions. Early morning temperature inversions near ground level are also a common occurrence near the Test Track.

The program will develop the hardware to obtain time data on high velocity sleds and the mounting hardware to install the trackside data system at various locations along the Test Track.

AF89-012 TITLE: Hypervelocity Launcher Research

OBJECTIVE: Advanced hypervelocity launcher technology through advancements in related subsystem and diagnostic technology development.

DESCRIPTION: New and innovative ideas and concepts are desired in the area of hypervelocity launcher technology. Programs addressing either experimental research or theoretical analysis are acceptable. Proof-of-principle experiments at the system level as well as the subsystem technologic research addressing critical issues for electrothermal, electro-magnetic, and advanced gas gun concepts are of interest. Desired research areas include but are not limited to hypervelocity launcher diagnostic and instrumentation techniques emphasizing data integrity in launcher hosted environments, launcher power conditioning, distribution and feed emphasizing high efficiency. The following specific examples are typical.

Velocity Measurement Diagnostics. Innovative methods for measurements of projectile velocity both in-bore and down range are sought. Desirable features include high immunity to plasma and EMP, high accuracy (.1%), high sampling rate (>MHz), broad range (0.1-20 km/sec), rapid-fire/multishot applicability (5-10 shot bursts at 1-20 shots/sec).

Ultrasound Diagnostics for Hypervelocity Launchers. Innovative applications of highly time and/or spatially resolved ultrasound diagnostic methods to the areas of: Plasma armature structural phenomenology, projectilebore interface, plasma density and boundary layer, dynamic measurements of barrel structural integrity, bore erosion and real time telemetry.

High Temperature Superconductor Opening Switch. Innovative methods for a solid state high current opening switch employing high temperature superconducting material are sought. With rapid fire electromagnetic launcher application as the goal the required technologies include; high cooling rate, high temperature structures, fabrication techniques, rapid-uniform quenching methods, and high current normal conductor interfaces.

AF89-013 TITLE: Computational Fluid Dynamic Model of Projectile Impacts Into Fuel Tanks

OBJECTIVE: Use computational fluid dynamic (CFD) models to simulate the reactions within fluid-filled tanks.

DESCRIPTION: Air-to-Air missile warhead fragments that impact onto aircraft targets can produce damage from a number of causes. One such cause is rupture of fuel-filled fuel tanks positioned around the air inlet to the aircraft engine. Another cause is complete penetration through the fuel-filled tank, exiting the tank and damaging components buried deep inside the aircraft, such as the engine. CFD methods may be helpful in determining the reactions to impacting warhead fragments caused by the fuel in the aircraft fuel tanks. These reactions will dictate whether or not the fuel tanks rupture, or whether or not the fragments pass completely through the tanks before they lose their total velocity and are entrapped within the tank.

The fundamental goal of this SBIR task is to model the impact of a warhead fragment of given size, weight, and striking velocity into a fuel-filled tank. Then, the reactions of the fragment, the fuel and the tank will be described in theoretical terms.

The technical challenge is to develop the CFD techniques that apply to this highly transient event, over the critically short time periods wherein the fragment's momentum/energy is transferred to the fluid, and ultimately the tank and tank supports.

Phase I of this task is to identify available data on impacts of warhead fragments on fuel tanks, and to review literature in the technical area of hydrodynamic ram. Preliminary studies will be made of the controlling parameters describing the phenomena of fragment penetration info fluids. The purpose of this initial task is to identify the feasibility of using CFD to predict effects on warhead fragments from fuel-filled tanks. The feasibility germination shall be demonstrated by sample CFD computations illustrating some facets of the total problem.

Phase II of this SBIR task will be directed towards a full demonstration of CFD analysis of a fuel-filled tank impacted by warhead fragments. The Phase II effort will include tank rupture from fragment impact, complete perforation of the tank where the fragment enters one side and exits the other, and the case where the fragment merely loses it's total impact velocity and is captured within the fluid.

AF89-014 TITLE: Innovative Methods for Target Detection in Aerosols

OBJECTIVE: To demonstrate improved target detection devices that can discriminate a target in an aerosol.

DESCRIPTION: The Air Force Armament Laboratory is interested in innovative optical techniques for target detection through aerosols. Although all-weather optical fuzes would be ideal, current optical fuzes are limited by the inability to operate reliably in or through aerosols.

Phase I is a feasibility study to evaluate unique passive and/or active optical fuzing techniques. The techniques considered should be evaluated on the basis of performance (especially in aerosols), complexity, cost and reliability.

Phase II should use the information gained in Phase I to construct breadboard optical fuze sensors for testing. The most promising concept (s) shall be constructed and tested for ability to discriminate a target in an aerosol environment.

AF89-015 TITLE: Innovative Methods for Fabrication and Polishing Conical Fiber Optic Arrays

OBJECTIVE: To demonstrate polishing techniques that maximize optical throughput while minimizing internal reflections.

DESCRIPTION: The Air Force Armament Laboratory is interested in innovative techniques for fabricating optical target detection devices. Current array fabrication and polishing methods are inadequate to reach desired performance levels. Making practical fiber optic arrays for sensors requires control of the fiber-to-holder bonding to reduce damage to the fibers during polishing as well as improved methods of coupling between fibers, laser diodes and photodetectors. Also improved performance and uniformity of optical splitters (star couplers) is desired.

Phase I of this task should investigate methods of conical array fabrication and polishing. The arrays fabricated using these techniques shall be tested to determine throughput and losses due to internal reflection.

Phase II of this task shall use the information gained in Phase I to fabricate a breadboard optical target detection device and to characterize its performance.

AF89-016 TITLE: Application-Specific Integrated Circuits for Weapons Effects Assessment

OBJECTIVE: Evaluate the use of application-specific integrated circuits (ASICs) in conventional weapon technology assessments.

DESCRIPTION: The DoD services have developed a mature technological foundation for the evaluation of conventional weapons effects against all types of material targets. The fundamental objective of this task is to evaluate the potential cost savings, if any, that may be realized in computer resources expended (computer time costs, mini-computer purchases, code architecture studies, etc.) in running computer codes standard within the DoD using ASICs. Trade-offs need to be evaluated in costs of ASICs that are dedicated to certain repetitive computations against the ordinary costs of running FORTRAN computer programs on mainframe or mini-computers.

Phase I of this SBIR task will analyze existing weapons effects computer programs, identify areas that may be appropriate to ASIC applications and access the projected cost effectiveness of using ASICs in place of computer code computations on a variety of computer hardware.

Phase II of this task is expected to be the application of a specific ASIC prototype to a specified portion of a weapon effects program, so that the results of the methods that use ASIC technology can be compared to those using simple computer codes.

AF89-017 TITLE: Innovative Technology for Rapid Area Clearance of Unexploded Ordnance

OBJECTIVE: Investigate innovative technologies for rapid area clearance of unexploded ordnance from critical areas.

DESCRIPTION: Enhanced Base Recovery After Attack (BRAAT) operations are needed to restore sortie generation capability as soon as possible. The Air Force is looking to advanced technology to provide BRAAT operations. The first step in the BRAAT process is to remove, destroy or neutralized unexploded ordnance, including large numbers of anti-personnel and anti-material submunitions dropped on the air base to impede BRAAT operations. Current explosive ordnance disposal (ECD) operations are conducted very slowly and deliberately on a one person/one munition basis. One improvement currently being pursued by the Air Force involves the development of an armored bulldozer equipped with a clearance blade to push submunitions from critical hard surfaces. This approach has some limitations and more importantly does not solve the complete, overall rapid areas clearance problem. Most current R&D efforts are oriented toward the range clearing problem (priority on safety, but slow) or the minefield breaching situation (rapid, but clears only a narrow strip). The air base rapid area clearance situation is not being addressed. In addition, with the expected development of increasingly sophisticated munitions, submunitions and mines the rapid area clearance problem will become even more difficult in the future.

Phase I will investigate advanced and innovative technologies to determine those applicable to rapid area clearance of unexploded ordnance from critical air base sortie generation facilities.

Phase II will develop a feasibility demonstration of the most promising approaches.

AF89-018 TITLE: Miniaturization of Signal Processing Components for Guided Interceptors

OBJECTIVE: Identify methods of minimizing the mass and volume of on-board processing electronics for guided weapons.

DESCRIPTION: The Air Force is currently investigating technology that involves design of guided interceptors where mass and volume are severely restricted and processing of images at a very high rate is required. The processors must be able to handle data from over 16,000 pixels at a 100Hz rate, and must perform a series of operations on each pixel for each frame. The processor must be able to withstand harsh space and launch environments. The Air Force is interested in innovative approaches to reducing the processor volume, mass and power requirements while minimizing the capabilities of the unit. New technologies such as very high speed integrated circuits (VHSIC) and gallium arsenide seem to have shortfalls in meeting the needs for the processor. An innovative technique is required to meet the far-term interceptor weight goal, and must minimize the use of available space and weight for processing. Techniques such as combination of functions between the sensor signal processor and structural support of the unit are of particular interest.

The primary goal of this effort is to develop and test an approach for meeting the processor requirements in the allowable volume and mass.

The technical challenge is to perform standard image processing operations such as gain and offset, thresholding, centroiding, track and aim-point determination within the limited volume and mass at a very high frame rate.

Phase I of this SBIR task is to investigate different schemes for performing the functions and to develop comparisons of the capability of each to reduce the processor weight and volume and the processing power of each scheme. The investigation will produce a report which illustrates the comparison, the maturity of the technologies and the advantages and disadvantages of each. Phase I will also result in the design of a processor using the best candidate technology.

Phase II will consist of a design and fabrication of a breadboard unit using the design developed in Phase I.

AF89-019 TITLE: Fault Tolerant Processors for Guided Interceptors

OBJECTIVE: To identify fault tolerant methods of signal and data processing for guided interceptors.

DESCRIPTION: The Air Force is currently investigating the use of signal and data processing for interceptor applications requiring long life-times, high reliability and low maintenance. Processors are required for this application which have extended operating capabilities and which include features such as redundancy and error checking. The processor to be developed from this interceptor must be able to withstand a harsh storage and launch environment and must have a shelf life of up to ten years in orbit. The ability to perform prelaunch checkout of the processor is limited due to the extremely short engagement times for the interceptor. Also, the endgame processing rate requires that the processor be functional throughout this critical time. The volume and mass available onboard the interceptor are extremely limited and therefore minimize the amount or redundancy which can be employed.

The primary goal of this effort is to develop fault tolerant techniques which will allow the interceptor to perform its mission. The developed techniques should allow for error checking of functions during flight of the interceptor and should provide for alternate and graceful degradation in the event of component failure.

Phase I of this effort will be a study of the requirements for fault tolerance onboard the interceptor including a list of critical functions and timing required for those functions. The study will also identify available techniques for implementing fault tolerant schemes to insure that the functions are performed. The study should include an assessment of the impact of each technique on processing speed, and on interceptor mass and volume.

Phase II of this effort will be the design and development of bread-board processor employing the technique from Phase I which appears most capable of meeting the interceptor goals.

AF89-020 TITLE: Plastic Extrusions for Military Container Design

OBJECTIVE: Develop plastic extrusions for use in place of aluminum extrusions for military containers.

DESCRIPTION: Aluminum extrusions have proven more cost effective than steel fabrications for medium to large munitions and military equipment containers developed during the past ten years. Increasing aluminum prices and recent advancements in plastics technology may make plastic extrusions the next development breakthrough. Plastic extrusions may offer lower tooling and fabrication costs, lower maintenance, lower weight than aluminum and “weatherable” plastics which may be able to meet a 20-year life requirement.

The Phase I effort should investigate the adaptability of existing aluminum extrusion profiles to plastic extrusions, and determine or develop suitable plastic formulations for this application. Phase I should result in candidate profiles and formulations for Phase II work.

Phase II should consist of development of prototype containers using Phase I candidates selected for further development, and should address major producibility concerns, such as tooling, joining and manufacturing methods.

AF89-021 TITLE: Aerospace Ground Environmental Simulation Testing

OBJECTIVE: Develop advanced test and evaluation techniques, instrumentation and facilities.

DESCRIPTION: New and innovative ideas and concepts are needed to develop facilities, methods and techniques to accomplish the testing needed to meet requirements for aerodynamic, propulsion, space, and reentry testing. Simulation of aerodynamic flight conditions in large test facilities is a very expensive and technically challenging endeavor. Means of generating the flow conditions, the test technique and the measurement of performance and flow parameters is of interest. One specific example of a technical need is a method to heat and contain air on a large scale for true examples of needs are aircraft/store separation, transonic wall interference, viscous simulation, turbulence measurement, boundary layer diagnostics, diagnostics of high enthalpy flows, hypersonic nozzle design

and throat heat transfer, and real gas computational analysis. Other examples of areas of desired research are generation of hypersonic flow conditions for large scale aerodynamic, aerostructural, aerothermal, and propulsion testing of the test conditions, analysis and interpretation of the test results are also within the scope of interest. Space propulsion testing, contamination effects and scene sources are of interest. Hypervelocity launchers for reentry and impact testing, along with associated operational and measurement problems are of interest. Many of the methods of simulation now used for these technical areas either involve compromise of test conditions, high cost, poor productivity, or other major problems where innovative approaches might provide much needed benefits.

AF89-022 TITLE: High Surface Temperature Measurement Techniques

OBJECTIVE: Develop instrumentation and measurement techniques to measure test article wall temperatures from 3000-4500'F.

DESCRIPTION: High-enthalpy ground test facilities are currently under development at AEDC to support the development of future aerospace systems. To complement these new test facilities, significant advancement must be made in the test instrumentation to measure temperatures in the 3000-4500'F range. Such intrusive techniques as thermocouples and calorimeters are limited by material survivability and application techniques. Non-intrusive techniques often rely on an accurate knowledge of temperature-dependent material properties, such as emissivity and transmissivity, which are difficult to measure even at lower temperatures. Also, current non-intrusive techniques have limited spatial resolution and are directionally sensitive which complicates the interpretation of measurements. Emphasis for the development and validation of elevated wall temperature measurement techniques should be placed on measurement accuracy, instrument survivability for repeated use, and measurement compatibility with high temperature materials, such as those envisioned for use in future flight systems.

AF89-023 TITLE: Plasma Density Measurement System

OBJECTIVE: Develop a measurement system capable of determining free electron concentration values near models in arc heated flow fields and near the surface of hypervelocity projectiles.

DESCRIPTION: A key parameter in radar Bore Site Error (BSE) related testing is the free electron density (or plasma density) near the surface of the radar window. Radar BSE related testing is now being conducted at AEDC in the hypervelocity range/track G and the HEAT-HI arc facility. Presently the plasma density is determined indirectly by fitting a microwave transmission model to available data. A more direct, spatially resolved technique is required in order to improve data analysis. The plasma measurement system should be capable of determining free electron concentrations at distances from 0.1mm to 25mm from moving surfaces with a spatial resolution of 0.1mm. For the range/track application available measurement time is very short (on he order of 0.5 microsecond). Provisions for shot-to-shot model location variations should also be incorporated in the system design. For the arc heater application, measurements must be taken through a pulsating, turbulent, high temperature flow field. The electron concentration range from 10 to the eleventh power (10 exp 11) to 10 to the seventeenth power (10 exp 17) electrons per cubic centimeter is of interest. A laser Thompson scattering approach is of special interest.

AF89-024 TITLE: High Temperature Strain Measurement System

OBJECTIVE: Develop the technology necessary to make reliable strain measurements in the temperature range of 2000F to 4000F for wind tunnel test applications.

DESCRIPTION: Current state-of-the-art in strain measurement is limited to approximately 1800F and is highly unreliable at the high temperatures. A new strain measurement technique or principle may very well be required in this endeavor. The technique must be compatible with metallic, graphite, graphite composite, and possibly other advanced structural materials. This technology is needed for advanced materials testing as well as confirmation of flight vehicles to be tested in advanced test facilities (HYFAC) at the AEDC.

AF89-025 TITLE: High Temperature Flow Turbulence Measurement System

OBJECTIVE: Develop a measurement system capable of determining turbulent intensity in high temperature, high velocity flow fields generated in arc heated facilities.

DESCRIPTION: The heat-transfer rate to models in high temperature, high velocity arc heated flow fields is a key simulation parameter in reentry systems testing. The calculated heat-transfer rates to probe in AEDC arc facilities can be significantly less than measured values if a laminar heat-transfer math model is used. One possible reason for this discrepancy is turbulence enhanced heat transfer. A measurement system for determining high temperature (up to 10,000R total temperature) flow is required to characterize the flow fields and help identify the heat-transfer discrepancy. The system should be capable of sweeping a 24-inch diam flow field in three seconds or less with a spatial resolution of 2mm. Turbulent intensity values from 0.005 to 0.3 should be measurable to a resolution of plus or minus 0.002. A noninterference laser fluorescence technique is of special interest.

AF89-026 TITLE: In-situ Optical Property Measurement System

OBJECTIVE: Develop an in-situ optical property measurement system.

DESCRIPTION: The system must be capable of measuring the IR optical properties without the need for a sample of the surface to be removed and provide bidirectional reflectivity distribution function (BRDF) and hemispherical emissivity over the range of 2-9 micrometers. The solid surfaces may be either metallic or dielectric and may be considered to be smooth but not necessarily highly polished. IR surface properties are required on a wide variety of military hardware. The primary requirement is for aircraft engine exhaust system components. The system should be portable enough to allow optical properties to be assessed on both flat and curved surfaces (radii on the order of 30cm). Spectral resolution of 0.1 microns and angular resolution of the BRDF of 10 degrees is desired. Compromises between cost, resolution, accuracy and measurement should be considered.

AF89-027 TITLE: Corrosion Resistant Pressure Transducer

OBJECTIVE: Develop a precision, corrosion-resistant pressure transducer suitable for rocket motor chamber pressure measurements during propulsion testing.

DESCRIPTION: Presently, most precision pressure transducers used to make pressure measurements during rocket propulsion testing are constructed of 304 stainless steel and similar metals. The transducer diaphragms are often damaged by corrosion after being used for these measurements. Gases present during these measurements include HC1 and H2So4. Typically, these pressure transducers cannot be removed from the rocket motors for cleaning for at least 24 hours after the test. During this period, acid residues continue to interact with the diaphragm and other parts of the transducer, gradually rendering the transducer inoperative. A pressure transducer is needed which can be used to measure pressures, without damage, in such corrosive environments. Full scale ranges from 5 to 2000 psia are needed with measurement uncertainties less than 0.5 per cent of reading from 10 to 100 per cent of full scale.

AF89-028 TITLE: Digital Video Data Storage System

OBJECTIVE: Develop a low cost data acquisition and display system which can digitize and store video data at standard framing rates and play it back for processing an off-line storage.

DESCRIPTION: The system must be capable of digitizing video images on-line at standard video framing rates of 30 frames per second with an 8 bit pixel resolution of 512 by 512. A memory capacity of 2 minutes of data is required. The hardware should interface with RS-170 video signals for both input and output.

AF89-029 TITLE: CAD/CFD Grid Generation Interface

OBJECTIVE: Develop a software package that will accept as input surface coordinate information generated by Computer Aided Design (CAD) software and transform that input into a form which is compatible with grid generation software used in the application of Computational Fluid Dynamics (CFD).

DESCRIPTION: The software package must be capable of accepting surface coordinate information as generated by existing AEDC CALMA software. Output generated by the solicited program must be in the format which existing AEDC grid generation programs (SVTGD2D/3D) will readily accept. The proposed software package must be user-friendly (menu driven) and must execute on AEDC hardware, which includes both Apollo (DN580 series and above) and Silicon Graphics IRIS (1000 and/or 2000 series and above) workstations. Because of the increasing demand for flow field analysis requiring CFD, and because there are many CAD packages available on the market today, development of a program which could bridge the gap between these widely used technologies should provide a much needed addition to the users of this application software.

AF89-030 TITLE: Continuous Water Monitoring System

OBJECTIVE: Develop a system to monitor return cooling water flow from AEDC to the lake and provide an alarm for predetermined levels of selected impurities such as ethylene glycol.

DESCRIPTION: Process cooling water at AEDC is returned to Woods Reservoir and must comply with federal regulatory guidelines for concentration of impurities. A continuous monitor and alarm system is required to detect environmentally controlled compounds, i.e., oils, ethylene glycol, methyl chloride, in the cooling water return. The instrument should be accurate to a few parts per million and provide a 15 minute analysis response time to permit diversion of contaminated cooling water to a retention pond.

AF89-031 TITLE: Command, Control, and Communications Systems/Subsystems

OBJECTIVE: Develop innovative concepts for Air Force Command, Control, and Communications (c3) Systems and Subsystems.

DESCRIPTION: This covers all aspects of AF C3 systems and subsystems. Proposals may address subjects not specifically given in other SBIR topics. Proposals may be for any aspect of AF C3 missions including: Strategic C3; General Purpose Forces C3; Ballistic Missile Tactical Warning/Attack Assessment C3. Atmospheric Surveillance and Warning; World Wide C2; Air Traffic Control; all AF ground based and airborne early warning systems; all communications systems; and C3 Countermeasures and Electronic Warfare. This topic offers great flexibility to both proposers and Air Force managers. Past submissions included: advanced communications systems concepts, database management systems, novel information processing systems, multilevel communications security concepts, artificial intelligence applications to AF systems, air surveillance systems and target detection systems. AF managers evaluate proposals on their merits and applicability to ESD programs.

AF89-032 TITLE: Tactical Command, Control, and Communications And Intelligence (C3I) Systems/Subsystems

OBJECTIVE: Develop innovative concepts and initiatives for Air Force tactical C3I systems and subsystems.

DESCRIPTION: Topics centers on increasing the warfighting capabilities of the Tactical Air Force's (TAF'S) in the areas of command, control, communications, and intelligence. The systems covered in this topic include, but are not limited to, the Airborne and Ground Tactical Air Control System (TACS), NATO Air Command and Control Systems (ACCS), and the Korean TACS (KTACS), and improvements to these systems. Specific areas of interest are interoperability in joint and combined operations, upgrades and improvements through technology and application of existing and planned systems into architectures for the future. Proposals may address specific element, such as the Tactical Air Control Center (TACC) of Air Support Operations Center (ASOC). New concepts can also

be explored addressing technology's impact on future systems in terms of operational capability, logistics, mobility, etc. AF managers evaluate proposals on their merits and applicability to ESD programs.

AF89-033 TITLE: Assessment of Electronic Systems Production Designs In Meeting Functional and Physical Requirements

OBJECTIVE: Develop methodology to determine whether production designs can meet functional and physical requirements of electronic systems under development.

DESCRIPTION: When applying the available technology to produce an electronic system, during transition from engineering design to production design, undesired characteristics may enter the production design. These characteristics can result in the production design not meeting systems physical or functional requirements. The DoD acquisition activities cannot afford to uncover such occurrences late in the development cycle, or worse, during production. Examples of these characteristics are: crosstalk and reflections on electrical conductors; line delays and impedance changes; hardware factors such as package lead pitch, printed wiring board line widths and spacing dielectric thickness, buried vias; and other such physical or electrical hardware characteristics may cause these. The goal of this effort is to develop a tool using latest state-of-the-art techniques or tools such as pattern recognition and classifier theory, artificial, intelligence, or expert systems to enable contractor and government engineers to identify these undesired effects in candidate production designs and correct them.

AF89-034 TITLE: E-3 Sensor Data Fusion Algorithms

OBJECTIVE: Develop algorithms for air surveillance data/sensor fusing (merging) to eliminate multiple tracks from a single target/track.

DESCRIPTION: The E-3 AWACS currently has several on-board surveillance sensors, e.g. radar and IFF, and several more under development. As the number of sensors increases, the air surveillance picture displayed at the operator's console becomes more cluttering and confusing when a single target appears as multiple sensor outputs on the display. Fusing (merging) of several tracks for the same target into a single track is highly desirable to simplify the surveillance picture for the operator and to increase target track and identification accuracy. Innovative algorithms which can fuse data for up to 4000 simultaneous targets from each of up to 10 different sensors need to be developed. The development of such algorithms may include demonstrations and evaluations under different wartime scenarios using computer simulations.

AF89-035 TITLE: Hardening Electronic Devices Susceptible to High Power Microwave (HPM) Radiation

OBJECTIVE: Develop High Power Microwave (HPM) hardening techniques for incorporation into existing C3I systems.

DESCRIPTION: At microwave and millimeter wave frequencies the signal power burnout thresholds determined for Electromagnetic Pulse (EMP) excitation are no longer valid. There is considerable concern over the susceptibility of electronic components to High Power Microwave (HPM) signal injection. Lead inductances, stray frequencies significantly alter the equivalent circuit and component response at HPM frequencies. Many ground-based and airborne electronic systems not originally threatened by HPM radiation, were developed with commercial advanced state-of-the-art components that are highly susceptible to HPM effects.

The purpose is to develop HPM hardening techniques which can be incorporated into existing microwave/millimeterwave equipment, sensors and other C3 subsystems without significant systems modification. A few of the typical systems of concern are Tactical Air Control Center (TACC), E-3 AWACS, JTIDS, HAVE QUICK, SINGARS, and TRACALS. These systems are composed of many subcomponents (Radars, Radios, Microwave, Troposcatter, computers Power Systems, etc). The effort should concentrate on one or two subsystems with a rationale for their selection. The product will be a description of potential hardening devices/techniques, effectiveness of each technique or combinations of techniques and complexity (cost, etc) of specific subsystem

installation and support/maintenance requirements. Phase II would complete above efforts and develop product specification for selected techniques and produce an initial proof-of-concept hardware demonstration package.

AF89-036 TITLE: Neural Computing Architectures for Natural Language and/or Vision

OBJECTIVE: Develop and demonstrate a methodology for interfacing fine-grained

DESCRIPTION: One of the most important problems confronting machine designers has been that of directly interfacing computer technology with human elements. Recent advances in neural computing, parallel and optic computing, an linguistics render feasible the goal of natural language and vision interfaces for computer systems. Neural computing permits the implementation of learning through rules, while new architectures can provide the performance needed by highly concurrent execution. In order to verify these concepts, different approaches should be experimented with for knowledge representation and retrieval using neural computing techniques. These should include associative retrieval, layered representation, and interaction among different knowledge sources (such as a blackboard system). Parallel architectures as well as optical computing techniques should be investigated. Phase I would investigate these alternatives and Phase II would develop a simulation environment as a testbed of simple applications.

AF89-037 TITLE: Automated Acquisition and Dissemination of Distributed System Software Design Knowledge

OBJECTIVE: Develop a software tool capable of acquiring and disseminating the knowledge required to design time-critical applications for distributed computing systems.

DESCRIPTION: High performance distributed computing systems promise a revolution in computing power and reliability. These new architectures make it possible to design systems which can meet demanding response time, throughput, and availability goals. However, revolutionary advances in software design practice will be required before the potential of distributed architectures can be realized. To accomplish this, system designers must be provided with appropriate design knowledge for exploiting the parallelism in their applications. To accomplish this, system designers must be provided with appropriate design knowledge for exploiting the parallelism in their applications. Issues such as task communication and synchronization, shared memory management, software to hardware mapping, and operation during failure modes must be addressed. Managing the complexity and quantity of the software design information for effective use of distributed computing systems requires an automated software tool to assist in its distribution. In addition, design rules are highly specific to the architecture and the application, an automated tool for distributed system software design knowledge is also needed. The knowledge acquisition tool must be able to transform general software design guidance into architecture and application specific design rules. Phase I will find measures of performance and means of control for time-critical distributed system software design, design a software tool for dissemination of distributed system software design knowledge, and propose and evaluate a method for acquiring application and architecture specific software design knowledge. Phase II will demonstrate the feasibility of the proposed design through prototype construction and evaluation. This prototype will be used to develop specific software design rules for a selected distributed system application.

AF89-038 TITLE: Command, Control, Communications, and Intelligence System Engineering Life Cycle Data Model

OBJECTIVE: To specify a data model of the Command, Control, Communications, and Intelligence (c3I) system engineering and development life cycle, and describe an associated system life cycle toolset.

DESCRIPTION: The modern C3I systems are ever increasing in sophistication. Because of their heavy reliance on computer systems, they are placing an increasing burden on system/software engineering and development technology. As a result, there is a critical need for an integrated environment of advanced and sophisticated system/software engineering and development tools to support both the technical and management aspects of the system development process. Of major importance is an environment’s life cycle database as the integrating

mechanism which facilitates 1) the transition of data across life cycle phases, 2) the sharing of data by tools, and 3) the automated production of formal life cycle products.

The technical challenge for Phase I of this effort is to specify a data model, or schema, that identifies and defines all technically oriented data created and manipulated during the Air Force C3I system development life cycle. Identification of data shall driven by pertinent Air Force and DoD system/software development regulations and standards (i.e. data explicitly identified or implied by the regulations and standards that is ultimately used in the preparation or fabrication of formal deliverables or products). The data model shall be specified using Entity-Relationship (ER) modeling techniques and shall be documented, both textually and graphically, in a technical report.

Based on the Phase I data model, Phase II shall investigate state-of-the-art computer aided software engineering (CASE) and computer aided design/computer aided manufacturing (CAD/CAM) tools which are capable of supporting the creation and manipulation of life cycle data identified in the data model. The Phase II technical report shall describe these tools, as well as requirements for new, non-existant tools, and their association with the data model. In addition, because data requirements have evolved from the need for relatively straightforward, conventional information to sophisticated knowledge about a particular application domain, Phase II shall also investigate and identify data model design alternatives for an intelligent database manager. The database manager would provide highly efficient storage and management of large, shared stores of both knowledge-based conventional data, allowing the data to be collectively used by both knowledge-directed and conventional tools.

AF89-039 TITLE: Strategies for Testing Parallel Software

OBJECTIVE: To identify and develop innovative approaches to testing software developed for high performance computer architectures.

DESCRIPTION: Rapid advances have been made along several lines of high performance computer architectures, ranging from fine-grained parallel systems to course-grained systems to neural-network machines. Producing high quality software to match the high performance potential of these machines promises to be very difficult, with testing of parallel software being an immediate problem. Testing parallel software for reliability rather than just functional acceptance is also desirable for these machines. This effort seeks to develop improved software test techniques for parallel software by assessing the current status of testing capabilities for high performance architectures and identify and develop those techniques with the greatest potential for producing reliable software systems. New solutions are needed to deal with the testing problems of massively parallel architectures and new tools should be explored for dealing with this problem (such as program visualization to make sense of voluminous data generated in high performance architectures or animation for showing the structure of an algorithm and its execution path as it is processed). Phase I should result in a technical report that identifies and assesses the potential of several approaches to testing parallel software. Proof-of-concept demonstrations against sample testing problems should be furnished for the techniques with the highest potential. The report should recommend the techniques with the greatest potential for producing high quality software and outline a research plan to develop the chosen technique. For Phase II, the development plan should be refined and implemented. The end product should be a prototype software package which assists in automating the software testing technique for parallel software.

AF89-040 TITLE: High Modulation Rate Optical Transmitter

OBJECTIVE: To develop innovative concepts/designs for high rate optical modulation of analog RF signals.

DESCRIPTION: Photonic technology at semiconductor laser wavelengths has demonstrated high payoff as an RF waveguide alternative either for remoting of antenna systems at the radio frequency or in implementation of phased array antennas. Such systems are EMI/RFI/EMP tolerant and provide significant advantages over conventional RF waveguide implementation. Requirements exist to implement such systems at center frequencies up to 60 GHz. Typical bandwidths are 10-20% carrier. Novel designs/applications of materials are necessary to implement modulators capable of functioning at radio frequencies up to 60GHz by modulating the RF signal onto a

semiconductor laser. Phase I will investigate approaches and candidate designs. Phase II will fabricate and demonstrate a high modulation rate optical transmitter.

AF89-041 TITLE: Conformal Optical Focusing Elements for Laser Communication

OBJECTIVE: Develop innovative concepts for conformal optical focusing elements in laser communication detection.

DESCRIPTION: Current laser communication systems utilize telescopes and electro-mechanical control for signal detection. This approach is bulky and inflexible and makes application aboard moving platforms, e.g., aircraft, difficult. Optical detectors are small size, thus they need focusing elements to gather the light energy. Use of telescopes requires expensive mechanical control. This project seeks to develop innovative methods to result in conformal focusing elements, which could be controlled electro-optically; this would allow for greater field-of-view, more compact designs and higher signal availability, thus resulting in greater system utility. Use of holographic elements as focusing devices is a possible approach. Phase I will provide proof of concept feasibility and Phase II will provide design, fabrication, and demonstration of a conformal focusing element.

AF89-042 TITLE: Low Noise Gigahertz Electro-optic Components

OBJECTIVE: Develop electro-optic components that improve microwave performance of fiber optic phased array beam-forming networks.

DESCRIPTION: Fiber optic beam-formers for microwave array antennas presently suffer from poor impedance match of electro-optic components, mediocre SNR and dynamic range, and slow switching times between beam positions. The lack of impedance matching circuitry in today's laser diodes and photodiodes results in poor electro-optic conversion efficiencies. Noise sources include link reflections, phase noise and up-converted dc noise in the laser, and shot noise in the photodiode. This effort seeks to develop components at the 0.85 micron wavelength which reduce noise and/or improve impedance matching and switching speed. Possible considerations include laser diodes, photodiodes and intensity modulators impedance-matched to 50 ohms, thin-film optical isolators, intensity modulator arrays, and novel electro-optic switches with equal numbers of input and output ports in powers of two. Phase I will provide proof-of-concept feasibility and Phase II will provide design, fabrication, and testing of the components.

AF89-043 TITLE: Integrated Design of "SMART" Phased Array Systems

OBJECTIVE: Define design principles for a smart phased array system which integrates digital beam-forming with self-monitoring of array performance with limited automatic failure compensation, and with rapid (microsecond) nulling.

DESCRIPTION: In surveillance applications, highly integrated digitally beam-forming phased arrays will be needed that combine array failure detection and compensation with protection against blinking jammers. Integration will be achieved with multi-processor interconnection network, the bulk of the processing taking place at the antenna elements in order to minimize high data-rate, wide bandwidth communications with a central computer. The design is to be economical as possible, and should allow for the possibility of adding, in a follow-up project, a further stage of smartness in which the integrated (neural-like) network becomes capable of discriminating among a limited set of targets.

In Phase I, the black box design of a digital network should define the functional and algorithmic requirements. Pick only a few but typical types of error for correction or functional compensation, specify the adaptive algorithm best suited for near real-time nulling, and demonstrate the functional compatibility of integrated operations. In Phase II, a specific design is to be proposed and tested, with maximum use of simulators.

AF89-044 TITLE: Antenna Pulse Pattern Synthesis in a Complex Medium

OBJECTIVE: Synthesize aperture distributions that compensate for focusing/defocusing of pulsed beams in the ionsphere.

DESCRIPTION: Pulsed electromagnetic beams launched in the ionosphere are subject to two kinds of deformation that tend in opposite directions without, however, canceling each other: a) self-focusing due to the removal of electrons from the pulse trajectory (lens effect), and b) defocusing due to fluctuations in the electron density. Effect a) has been studied in the past, and L. Felsen, URSI June 87 Symposium). Two types of pulses are to be considered: a) pulses for which a carrier frequency is defined (e.g., normal radar pulses), and b) the novel "focus-wave" pulses, i.e., the non-carrier-based localized energy packets recently introduced by J. Brittingham, R. Ziolkowski, A. Sezginer, and T. Wu.

Phase I:

Prepare curves for the self-focusing of type a and b pulses in the ionosphere under conditions producing maximum deformation of the beam, for frequencies from UHF into the infrared. Use the known deterministic ray paths and initial conditions of the geometric theory of diffraction to construct initial conditions for ray-centered transport equations governing the statistical moments of high frequency fields in weak large-scale random fluctuations. Apply this technique to calculate the maximum defocusing effects to be expected in the ionosphere, for frequencies from UHF into the infrared.

Phase II:

On the basis of results obtained in Phase I, compute and discuss numerical values for the combined self-focusing and defocusing of pulsed beams (types a and b) under typical conditions in the ionosphere, for frequencies between UHF and the infrared. Propose phase corrections in large aperture phased arrays that will at least partially compensate for self-focusing and defocusing effects in both type a and b pulsed beams.

AF89-045 TITLE: Self-Survey of Distributed Thinned Phased Arrays

OBJECTIVE: To compare experimentally the performance of self-survey techniques with adaptive beam-forming in distributed arrays.

DESCRIPTION: Very large, distributed, thinned phased arrays are a candidate for space-based sensors. They will suffer significant mechanical distortion due to their large size and lightweight. Such arrays will require self-calibration or self-cohering procedures in order to correct for this distortion. Two basic approaches to self-cohering have been suggested, self-survey and adaptive beamforming. Self-survey, using multiple laser ranging devices, calculates the position of all elements in an array, one to another. With accurate knowledge of element or subarray positions, phase correction can be made in order to focus and steer the array over wide angular sectors both on transmit and receive.

Adaptive beamforming ignores the relative position of the elements and uses the phase measurement from a beamforming source to focus the array over a localized region around the source. Refocusing is necessary to cover extended angular regions. Both approaches have merit and drawbacks, suggesting that a combination of these techniques should also be considered. Phase I of this effort should contain a comparison of the two approaches, an assessment of equipment requirements, and expected performance. A study of errors and the impact of errors on total system performance should be made, followed by the design of an experiment to demonstrate the two techniques for comparison. The Phase II of this effort should contain the experimental demonstration of self-survey and adaptive beamforming for comparison. A second objective of Phase II should be a demonstration of a combination of the two techniques.

AF89-046 TITLE: Airborne Testing of Active Aperture Arrays

OBJECTIVE: Develop a means of testing active aperture phased arrays by utilizing the doorway or other openings in the aircraft outer skin to mount an antenna system.

DESCRIPTION: Exhaustive testing of active aperture phased arrays will be required before the concept of "smart skins" becomes a reality. Ground testing of these new antenna systems is one step to flight test. Economical means of flight testing is sought. One answer would be to utilize the openings afforded by personnel, doorways, and freight doors. These breaks in the aircraft skin are already designed into the superstructure. A means is sought to "palletize" an antenna system demonstration to fit into the opening of the doorway. These structures will be conformal to the wide-body and support the aerodynamic loads. Normal doorways should hold a sensible-sized array for testing and by mounting the entire system to an easily removed "pallet", the antenna may be designed, built, and tested on the ground.

Phase I should provide an assessment of the efficiency of this concept along with a study of what size doors and hatchways are available on typical wide-bodied aircraft.

Phase II should include the complete design to the component level of a typical conformal antenna system. Solution to the problems of a) integration with the host aircraft power system, b) cooling the array, c) the mechanical integration to the door frame and d) removal of the test fixture for ground test.

AF89-047 TITLE: Compact Ultrafast Microwave Switching

OBJECTIVE: Develop photonic technology for switching microwave transmission lines at speeds of a few picoseconds at high R.F. voltage.

DESCRIPTION: Ultrafast switching of segmented charged microwave transmission lines has recently been used to generate short pulsed microwave signals at kilowatt power levels. Present technology uses large solid state lasers as drivers producing microjoule pulses of picosecond duration, to activate photoconductive microwave switches. For most Air Force Applications, significant reduction of both system size and weight is necessary. A direct approach is development of more compact efficient ultrafast semiconductor or solid state laser drivers and/or more efficient semiconductor switches. However, other generically different approaches may also be possible. An important feature of this requirement is the precise timing of the switching event to provide synchronization to within a picosecond and allow time delay among multiple switches with low jitter. Both closing and opening microwave switching techniques are of interest. Phase I should result in a technical report supporting the design of a compact, lightweight microwave switching technique of the required picosecond timing precision and power handling capability with hardware demonstration of at least one switch. For Phase II, switching of multiple segments of transmission line with multiple switches shall be demonstrated. Switching precision and synchronization will be measured along with demonstration of controlled delay and low jitter among switches.

AF89-048 TITLE: Ion Beam Modification of Ultrastructure Properties

OBJECTIVE: The objective of the proposed effort is to investigate ion beam modification of ultrastructure layers during growth.

DESCRIPTION: Low energy particle bombardment of the deposition layer during thin film deposition has been shown to significantly effect the physical properties of the resulting film. Ion beams have been used to densify films, improve the wear and oxidation resistance, lower deposition temperatures and amorphize crystalline layers. This effort seeks to study the effects of ion beams during deposition on the properties of thin multilayered ultra-structures. Of particular interest are the little studied effects of film densification and the amphorphous/crystalline aspects. Phase I will involve a simple proof-of-concept by demonstrating ion beam assisted growth and testing of a multilayered structure. Phase II will be a much more thorough study of the properties of various ion beam modified ultrastructures.

AF89-049 TITLE: Ternary Spatial Light Modulator

OBJECTIVE: Develop a light valve for optical computing capable of modulating light with three different and distinct states.

DESCRIPTION: Optical computing and signal processing holds the promise of extremely high data throughput rates due to its innate parallelism. The recent introduction of the binary phase-only filter has made real-time optical pattern recognition possible, as several breadboard systems have demonstrated. Recent computer simulations have shown that if a third state (a null of zero state) could be incorporated into the spatial light modulator (SLM) containing the correction filter, system performance would be considerably improved. It might be possible to modify existing binary SLM's to include this third state. Phase I should result in a technical report demonstrating feasibility of the concept and preliminary design, and Phase II will be fabrication and testing of the ternary state SLM.

AF89-050 TITLE: Amplifying Optical Switches

OBJECTIVE: Develop lossless 2 x 2 and N x N guided-wave electro-optical switches by using optical amplification in laser-like III-V quantum-well waveguides.

DESCRIPTION: Waveguided optical amplifiers can, in principle, overcome all losses inherent in an N x N integrated-optical switching network, but his concept has not been put into practice. This effort seeks to develop new lossless electro-optic III-V semiconductor switches comprised of reflectorless channel waveguides with forward-biased gain segments, and reverse-biased loss segments. The ridged or buried index-guides would have cross-sections that resemble a bulk-heterostructure or multiple-quantum-well laser diode. A possible approach to switching is to change the bias polarity on certain segments of a branched waveguide. On desired transmission paths, electroabsorption would attenuate the light by 30 dB. Wavelengths on the long-wave side of the gain spectrum appear optimum. Spontaneous emission noise, both dc and rms, is an issue. Phase I will provide an experimental proof-of-feasibility in a 1 x 2 or 2 x 2 switch. Phase II will provide sophisticated working models of quantum-well 2 x 2 amplifying optical switches that have been optimized for high performance.

AF89-051 TITLE: Avionics Applications of Ambient Temperature Superconductivity (ATSC)

DESCRIPTION: Confirmation of room temperature operation for superconducting materials (ASC) systems is imminent. This opens the door to entirely new technologies that are not merely extrapolations of helium temperature devices. Applications are sought for early incorporation of these technologies into avionic systems. The applications must include a realistic description of materials processing and manufacturing techniques. The following are specific examples of potential uses of ATSC materials:

a. Thermoelectricity: Ultrastructures of ASCs with thermoelectric materials show broad potential for electronic spot cooling.

b. Solid State Synchron sources for X-ray lithography.

c. Extra Low Frequency (ELF) Magnetometry. ATSCs will permit extreme sensitivity and dynamic range for devices employed by Earth and Planetry Sciences, Medicine, Biology and the Physical Sciences. Phase I efforts will be directed at establishing proof of concept within a given ATSC system. Phase II efforts must include operation of a prototype system of the new application. The Phase II proposal should detail the materials processing techniques and potential failure mechanisms and limitations of the approach.

AF89-052 TITLE: Avionics Applications of Ambient Temperature Superconductivity (ATSC)

OBJECTIVE: Develop innovative concepts/architectures for three dimensional optical random access memories.

DESCRIPTION: Progress and the development of technologies supporting command, control, communications and counter measures (C3CM) wideband communications and information handling are leading to requirements for small, non-mechanical, high capacity, extremely high access memories for supercomputers. The potential for using photonic concepts on crystalline or photo chemical materials offers solutions to the input/output (I/O) limitations of today's memories. During Phase I, this project seeks to define component technologies, explore architectures, etc., to accommodate orders of magnitude increases in throughput rate and access time. Phase II of this effort will refine the concepts exploited and demonstrate via breadboard model appropriate configurations.

AF89-053 TITLE: Natural Language Understanding for Message Dissemination

OBJECTIVE: Determine the feasibility of using natural language processing techniques in the area of disseminating intelligence message traffic.

DESCRIPTION: Contemporary message handling systems route and retrieve free-text messages by keyword search, in some guise. Formatted fields in the header are sometimes used in conjunction with keywords. Although the keyword approach is efficient and simple, it is also imprecise. Keyword approach lacks the inherent capability for high precision and the relationships between words. Phase I will determine if natural language understanding techniques can improve message selection for dissemination. Phase I will evaluate existing natural language techniques, while Phase II will implement the selected technique and demonstrate dissemination improvements based on natural language processing.

AF89-054 TITLE: Applications for Multi-Spectral/Multi-Source Imagery

OBJECTIVE: Analysis of the applicability of Photonics to the processing exploitation and display of multi-spectral/multi-source imagery.

DESCRIPTION: Historically, the volume of data and the complexity of computations associated with high resolution image processing has rendered the concept of near real time imagery exploitation as unachievable. With the growing need of the intelligence community for multi-spectral/multi-source exploitation, the magnitude of data volumes and processing complexities have grown significantly. Practical implementation of the required intel exploitation capabilities. Using conventional technologies will lengthen the time between collection and production of useful intelligence. The application of Photonics technology to this offers the potential of significantly reducing processing times. The new phenomenology and computational methods may offer the potential of significant advances in; image transfer rate, image transformation, dissimilar image correlation, automatic feature/target detection, image compression, image model (3-D) interaction and image product transmission. Phase I will address a high level assessment of Photonics application to the functions associated with high resolution multi-spectral/multi-source imagery exploitation. It will result in a report on the results of the analysis, identification, or critical technical issues, and if warranted, recommendations for a comprehensive program to apply Photonic technology in this area. Phase II will consist of a limited set of experiments which will demonstrate potential applications and the scope of technical challenges to be encountered.

AF89-055 TITLE: Massive Optical Fan-in/Fan-out

OBJECTIVE: Develop technological approaches for achieving massive optical fan-out and fan-in for Digital Optical Computing applications.

DESCRIPTION: One theoretical approach for an optical central processing unit involves free space or guided fan-out of a dual rail vector of optical control and data lines to a rectangular mask, followed by fan-in in the orthogonal direction. Optical OR logic is performed at light-transit speeds. The fundamental problem here is that there is no clear way to practically provide the massive fan-in, fan-out and masking needed to provide computing performance competitive with electronic technology. An initial concept development phase (Phase I) will be followed by proof-of-concept demonstrations (Phase II).

AF89-056 TITLE: Civil and Environmental Engineering Research

OBJECTIVE: To develop new and innovative ideas/concepts in the areas of civil and environmental engineering.

DESCRIPTION: Civil Engineering research includes postattack damage assessment and repair of facilities and utilities; firefighting chemicals and training; postattack assessment of damaged runways and taxiways; advanced construction materials for facilities and airfield pavements; noise and sonic boom effects on structures; small-scale modeling techniques for structural testing; hardened air-base facilities for protection against non-nuclear attacks; rapid runway repair; contingency launch and recovery surfaces; roughness of aircraft operational surfaces; aircraft shelters; tactical shelters; passive defense techniques; airfield pavements; geotechnical engineering; foundation engineering; site selection; structural analysis of air base facilities; advanced power systems; alternate energy sources; and aircraft fire/crash/rescue equipment. Environmental Engineering research includes environmental behavior and fate of Air Force fuels and chemicals; hazardous waste minimization; treatment and pollution control; environmental chemistry; advanced pollutant monitoring technology; pollutant transport; biodegradation of pollutants; and new concepts to eliminate, substantially reduce, or mitigate environmental consequences of future Air Force Weapons Systems.

AF89-057 TITLE: Regeneration of Vapor-Phase Activated Carbon

OBJECTIVE: To investigate, develop, and compare innovative and novel in-place, non-destructive techniques for regenerating vapor-phase activated carbon used for air-stripping tower emissions control.

DESCRIPTION: Vapor-Phase Activated Carbon systems are being considered for removal of the halogenated and aromatic hydrocarbons from the emissions control system. Spent activated carbon is generally reactivated using a high-temperature thermal process where the activated carbon is heated to about 1000 degrees centigrade. Many of the halogenated and aromatic hydrocarbons found in contaminated groundwater boil near 100 degrees centigrade. In-phase, nondestructive methods of regenerating activated carbon could reduce the operating cost of emissions control. Steam regeneration, chemical regeneration, bioregeneration, innovative heating techniques, and other novel methods should be investigated and compared for reducing the costs of regenerating vapor-phase activated carbon.

AF89-058 TITLE: Catalytic-Additive Combustor Lining

OBJECTIVE: Develop a catalytic lining for a turbine engine combustor to decrease hydrocarbon emissions.

DESCRIPTION: Hydrocarbon emissions from jet aircraft engines are prevalent at power settings of idle and 30 percent. The concentration of hydrocarbon emissions in the exhaust decreases as the power setting is increased. At 100 percent power, the concentration of hydrocarbon is negligible. However, during ground operations, lower power settings are predominantly used and the hydrocarbons are produced in significant amounts so that ground crews and flightline support personnel are affected. Depending on local meteorological conditions, emissions from ground operations can be transported into the air-handling units of nearby buildings in noticeable quantities. The design of a catalytic combustor that enhances free-radical-propogated combustion could reduce these emissions. Ceramic lined combustors are currently under development and are being tested by engine manufacturers. While many companies are pursuing this research, the main interest lies in the application of ceramic linings for increased performance and not for the reduction of emissions. The desired product is a combustor liner that minimizes the hydrocarbon emissions from a jet engine while maintaining combustor performance.

AF89-059 TITLE: Device for Characterizing Chemical Source Strength

OBJECTIVE: Develop an instrument that can be used to measure source strengths from chemical releases.

DESCRIPTION: Modeling accidental releases of hazardous materials requires accurate information on the volume of the material released to determine downwind concentrations. At present, the amount released can only be roughly estimated. Inaccuracies in the source emissions estimates will lead to uncertainties in the calculation of downwind

concentrations. Accurate knowledge of the source strength or emission rates will greatly enhance the accuracy and reliability of dispersion models. One recent example: the reduction in permissible exposure limits for hydrazine and hypergolic rocket propellants is driving a need for further improvements of source estimates thus ensuring the safety of people downwind from launch sites. Other hazardous chemical concerns to the Air Force are: ammonia, chlorine, hydrogen fluoride, and hydrogen sulfide. Equipment is needed that can provide real-time measurement of chemical emission rates to improve the reliability of downwind concentration calculations for as many chemicals as possible. The required technology will have the capability to accurately measure emission rates in real-time. The technology should be intrinsically safe and provide ease of operation for field use.

AF89-060 TITLE: Passive Hydrogen Chloride (HC1) Monitors

OBJECTIVE: Develop small, inexpensive, accurate, passive sensors to quantify HC1 emissions from space vehicle launches.

DESCRIPTION: Space launch vehicles generate large quantities of HC1, which is emitted into the environment. Sensors are needed that will measure HC1 concentration in a range of parts-per-billion volume (ppbv) to part-per-million (ppmv) and for times of 0.02—50 ppm-hr. Sensors should be low-cost (less than $100), should not require an external source of power, and should be free from interference from water and ammonia. These sensors will be deployed up to 5 miles from the launch site. They will remain unattended for up to 24 hours in the field before they are collected and analyzed.

AF89-061 TITLE: Disposal of Solid-Rocket Motors and Propellant

OBJECTIVE: Develop environmentally safe methods to dispose of solid-rocket propellants.

DESCRIPTION: Solid rocket propellants consist of a metal fuel, an oxidizer, and organic binder. Aluminum is usually used of as the fuel and a polymer is used as the binder. Ammonium perchlorate is almost always used as the oxidizer and when burned, it releases hydrogen chloride gas. Currently, the only method available for propellant disposal is open pit burning or detonation. In addition, the propellant can deflagrate and throw pieces of unburned fuel over a large area. Because of the release of hydrogen chloride and the dispersion of unburned propellant, open pit burning is becoming an environmentally unacceptable method of disposal. Alternatives to open burning of propellants is important for fielding new Air Force space launch vehicles which utilize solid-rocket motors. Technology is required that will dispose of all of the ingredients from the matrix of solid rocket propellants and minimize waste from the manufacturing process.

AF89-062 TITLE: Real-Time Particle Measurement in Exhausts

OBJECTIVE: Develop real-time instrumentation to measure jet engine and rocket motor exhausts particle mass and sizes.

DESCRIPTION: Current particle sizing/mass measurements require 20 minutes to an hour of sampling time for a suitably large sample to be collected. Real-time measurement would reduce the sampling times. Aircraft and rocket particulate emissions measurement is, at this time, inadequate. No acceptable way of collecting, sizing, and analyzing particulate emissions from these courses exists. A diffusion classifier has been developed for similar sampling, but has proven to be incompatible with chain-agglomerate particulate material such as jet smoke. An electrical aerosol analyzer has been tested/adapted to extract and measure jet engine test cell exhaust, but does not directly measure boot mass. A low pressure impactor to sample jet engine exhaust has been built, but it is not a real-time monitor. Data acquisition for this instrument is very time-consuming and collection substrates (greases and filter papers) are not optimum for the temperatures expected with engine and rocket exhausts. The technology that needs to be developed will transition a prototype sampling device that will allow real-time measurement of the various size classifications of particles in jet engine and rocket motor exhaust flow streams. The prototype must be able to withstand conditions of high temperature and turbulence. In addition, a computer driven data acquisition system will be integrated into the prototype design so that a turn-key system is developed.

AF89-063 TITLE: Characterization of Optical Fire Detector Stimuli

OBJECTIVE: Identify and characterize potential false alarm radiation sources at Air Force aircraft hangers to provide data for laboratory discrimination test methods.

DESCRIPTION: Many optical fire detectors in aircraft hangars are plagued with false alarms and many existing detection systems have been disabled in the field. Multiple wavelength, microprocessor-base flame radiation detectors offer better discrimination because more flame signature data is analyzed. These smart detectors cannot be accurately applied in the field because technology application information must be developed. The Phase I effort would review state-of-the-art fire detectors to determine their technological basis for fire sensing, analysis, and alarming. This information would then be used to define broad-band instrumentation that would be best for performing rapid scanning of Air Force aircraft hangars to determine the active false alarm stimuli. Phase II would involve using broad-band instrumentation to survey Air Force aircraft hangars/associated operations and equipment to acquire data describing active false alarm stimuli. Threat evaluations would be performed for various hangars and these data would be analyzed to formulate mission success criteria for accurate fire detection. Laboratory methods would be identified to test the sensitivity of flame radiation detectors toward fire detection and false alarm rejection.

AF89-064 TITLE: Thermodynamics of Advanced Refrigerants

OBJECTIVE: Investigate thermodynamic characteristics of refrigerant mixtures and effects mixed refrigerants have on standard refrigeration components.

DESCRIPTION: Refrigeration equipment is designed around a specific refrigerant to be used within that equipment. Materials used for the equipment elements, as well as capacity of the equipment, are selected on the basis of achieving the best efficiency of the equipment using the selected refrigerant. During critical situations, the ideal refrigerant may not be available to recharge a repaired air conditioning system to allow operations to resume within the affected facility. However, other non-ideal refrigerants may be available. The Phase I effort would review and analyze the impact of secondary and tertiary mixing of refrigerants on the capacity of refrigeration equipment and on the effect the mixture may have on equipment components such as seals, pumps, heat exchanger elements, etc. Mixtures to be analyzed should reflect those refrigerants, to include hydrocarbon based, that should be readily available at most Air Force bases. The Phase II effort would involve design and construction of it and experimentally verifying the thermodynamics of the mixtures as suggested in the Phase I effort. Verification must also be made on the expected effects of the mixture of specific components of the refrigeration equipment such as seals, lubricants, valves, pumps, heat exchangers, etc.

AF89-065 TITLE: Fiber-Reinforced Spall Protection

OBJECTIVE: Develop a fiber-reinforced spall protection system for new and existing concrete structures.

DESCRIPTION: The Air Force has a need for an economical spall protection system that can be easily installed on the inside walls of existing and new concrete structures. Spall fragments of concrete flying off the inside of a wall occurs when a wall is subjected to high impulse blast loadings as produced by conventional weapons. The blast loading applied to the front surface of the wall travels through the concrete as a compressive wave and reflects off the back wall as a tensile wave. This produces tensil stresses which exceed the low tensil strength of the concrete traveling at velocities in the range of 100ft/sec. The localized spalling of concrete must be contained to prevent injury and damage to personnel and equipment occupying the structure. Phase I will determine the feasibility of a fiber-reinforced spall protection system for flatwall concrete structures. Phase II should identify and evaluate loading functions and geometric responses of a protective system, identifying potential system concepts and materials, and address the feasibility in a report. Phase II, if approved, should evaluate the concepts and materials identified in Phase I and develop a complete fiber-reinforced spall protection system for installation in flatwall concrete structures.

AF89-066 TITLE: Energy Fields for Fire Extinguishment

OBJECTIVE: Identify the adjustment of flames by energy fields to cause or to increase the potential for fire extinguishment.

DESCRIPTION: Burning involves changes such as the relationship of atoms, arrangements of electrons and electron clouds, states for the various energy modes, temporary formation of intermediate transition state complexes, chemical ionization reactions, and quantity of magnetic moment, to name some of the fundamental characteristics. Some of these known changes have been quantified for use in flame diagnostics. For example, the chemical ionization process which produces ions in a flame is the basis of Flame Ionization Detection for gas chromatography and radiation (laser) absorption is used to change the state of reactants during saturated fluorescence diagnostics. The Phase I effort would review, analyze, and evaluate the application of electric, magnetic, microwave, and electromagnetic energy fields for causing or enhancing fire extinguishment. Existing applications and research of the various energy fields towards flames would be reviewed and interpreted, in relation to new efficient energy technologies (e.g., superconductivity), to identify the optimal techniques for potential applications to fire extinguishment. The Phase II effort would involve the design and construction of laboratory burner apparatus to study the identified optimal energy field methods and the conduct of experiments to quantify the efficiencies of energy fields for fire extinguishment with, and without, the addition of fire extinguishment agents.

AF89-067 TITLE: System for Macro and Micro Airfield Pavement Damage

OBJECTIVE: Provide a capability for expedient and accurate contour measurement (+- 0.25 inch elevation and +- 1 inch range accuracy over a 100 ft x 100 ft surface) and 3 dimensional mapping of bomb damaged pavement.

DESCRIPTION: This method is needed for precise damage assessment in the immediate vicinity of an explosively formed crater and to permit intermittent reassessment as upheaval reduction techniques are used. For initial damage assessment on a large scale, develop a neural network that will be able to identify the damage caused to airfield pavements in the event of attacks.

a. Time is a critical resource during rapid runway repair (RRR) minimum operating strip (MOS) selection and crater repair. Pavement upheaval is often difficult to recognize during visual inspection and current expedient measurement techniques take several minutes and are not as accurate as desired. A method/device is needed. This speed would be very helpful during MOS selection and final inspection of a finished repair, but it is critical during upheaval reduction efforts when the profile may be constantly changing. Too much upheaval reduction could result in an unacceptable sag which defeats the effort to salvage good pavement. The Phase I effort shall address system design and proposed prototype development and test plans.

b. The determination of runway damage due to an attack on an airfield presents many problems. One problem is identifying the extent of the damage. Since damage assessment may well be required at night and the environment after the attack may be highly dangerous to personnel due to the presence of biological and chemical agents, area denial mines and unexploded ordnance, it is desirable to develop an unmanned system to initially survey the airfield system for damage. One essential part of this system is the ability to quickly make an accurate assessment of the damage without endangering personnel. This can be accomplished by a system that operates autonomously with the ability to identify damage. This project would use neural network technology to develop a system using infrared imaging to identify damage to the airfield. The airfield damage includes bomb craters, spalls, unexploded ordnance, and debris. The viewing angle should be at a height of 6 feet with the option of using aerial photography.

AF89-068 TITLE: Human Systems/Subsystems Research

OBJECTIVE: To develop innovative human-related systems or subsystems for aerospace applications.

DESCRIPTION: This topic is intended to provide an opportunity for the proposer to submit ideas directed toward enhancing man's capability to function effectively and safely as an integral part of Air Force systems and military operations with the overall objective of increasing mission success. This general area includes: human factors engineering, such as methods improving man/machine interfaces or enhancing human physical or cognitive performance; personnel protection/life support, such as life support and crew escape from a transatmospheric vehicle, chemical warfare defense, such as mental hazards, such as identification of and protection of toxic materials and electromagnetic or ionizing radiations; and personnel training and simulation, such as new technologies that improve the effectiveness or efficiency of training programs and methods. Ideas are solicited that affect any or all of the operations, maintenance, and support roles of Air Force personnel. Areas of special interest include: (1) simple methods to estimate the operational manpower, personnel, and training and safety requirements of weapons systems during development; (2) the operational use/utility of robotic telepresence (sensory feedback to a human operator; particularly, flexible tactile sensing arrays for robotic hands and force reflection to the human operator of forces experienced by the robot's dexterous manipulators); and (3) equipment, systems, and procedures to be used for the treatment, stabilization, and transfer of casualties during war and times of natural disaster.

AF89-069 TITLE: Real-Time Environmental Monitoring Capability

OBJECTIVE: Develop air transportable instrumentation for on-site detection, identification, and quantification of chemical contaminants.

DESCRIPTION: The Air Force needs an instrument which can rapidly detect, identify, and quantify trace levels (5 to 10 parts per billion) of chemical contaminants on personnel, and surfaces, and in soil, air, and water. The instrument must be rugged, air transportable, and capable of rapidly analyzing soil, air, and water samples. Also, it should be capable of quickly tracking (in time and space) and monitoring unknown/known chemical contaminants and should require minimum training for qualified Air Force personnel. This equipment will be used to detect environmental pollutants and chemical warfare agents. Similarly, rugged field transportable equipment capable of nonintrusively determining droplet size is also required.

a. New Environmental Protection Agency and state environmental laws have increased monitoring requirements and lowered detection limits for organic chemical contaminants, making existing real-time detection equipment obsolete. Additionally, spills/leaks of hazardous chemicals require rapid field response and evaluation to protect life and property. Rapid, innovative survey techniques and on-site chemical analysis are necessary to keep up with this growing demand. The research scheme should be: (1) evaluate emergency response capabilities of current commercially available instruments; (2) compare field analytical results with previously approved methods; and (3) develop valid on-site analytical protocols for routine Air Force chemicals.

b. In order to sustain operations in a chemical warfare environment, the Air Force needs instrumentation which can detect surface chemical agent contamination on air base personnel and equipment. The instrumentation must quickly and accurately indicate the chemical agent type, amount, and location in order to determine the need for decontamination based on the potential for injury to personnel or damage to equipment. The equipment would be used to screen personnel in order to hasten entry into a contamination control area or toxic free area; its use must pose no hazards to personnel, including casualties with open wounds. The instrumentation will also be used to check equipment prior to loading onto a aircraft or to check interiors of aircraft or buildings; it must be capable of detecting agents in cracks and crevices. In both cases, the instrumentation must be capable of detecting low levels of all threat liquid agents without responding positively to decontaminants or any chemicals normally present on air bases.

c. In order to determine age and persistence of chemical warfare agents, it is necessary to nonintrusively determine droplet size. It is not imperative that this information be real time, as accuracy is more important than response time. Droplet size measurement must be tied to at least gross analytical discrimination. Innovative concepts using hardware or software methods are sought.

d. For all three subtopics, Phase I will consist of determining specific instrumentation requirements, validation testing, and selection. Phase II will include a one-year field test and final development of routine sampling methods and validation.

AF89-070 TITLE: Innovative Analysis Procedures and Equipment for Environmental Health and Drugs of Abuse

OBJECTIVE: Develop analytical procedures for environmental/occupational health pertinent materials and chemicals and drugs of abuse.

DESCRIPTION: Both the Air Force Drug Testing Laboratory (AFDTL), a high volume urinalysis drug testing facility, and the USAF Occupational and Environmental Health Laboratory's (USAFOEHL) environmental sample analysis division are interested in innovative analytical procedures. The AFDTL has a general interest in innovative analytical procedures for analyzing for the normal drugs of abuse and a specific interest in designer drug analysis. The USAFOEHL has a general interest in innovative analytical procedures for environmental chemicals and a specific interest in procedures for asbestos (i.e., fluorescent dye binding identification), hydrazine fuel in water and soil, work area solvents and airborne disocyanates. Innovative biological monitoring procedures may be applicable to some analytical needs. In all cases, the analytical procedures will have to be proven to the regulating agency such as the Environmental Protection Agency or Occupational Safety and Health Administration.
Both the AFDTL and the USAFOEHL are interested in robotic technology for all aspects of their laboratory procedures, from sample receipt through results reporting. As above, the robotic procedures would have to be acceptable to the regulating agencies where applicable and forensically defendable in case of litigation.

AF89-071 TITLE: Identification and Management of Hazardous Materials in Large-Scale Systems Acquisition

OBJECTIVE: Develop innovative concepts and mechanism for achieving effective hazardous materials management in large-scale systems acquisition.

DESCRIPTION: The proper management of hazardous materials through the life cycle of large-scale system is a problem that needs attention in the Air Force as well as industry. There are decisions made throughout the life cycle that impact health, safety, and environmental quality. Decisions made early in the design process may well drive subsequent system design, supportability, and operability. The Air Force needs a hazardous material identification database providing information on known hazardous materials in the Air Force inventory or in development. One possibility would be to use Quantitative Structure Activity Relationships (QSAR) to predict the likelihood of hazard for chemicals not in the database. Fundamental to such a database would be the development of a systematic approach for determining the extent and kind of toxicity information which should be available on a chemical as a function of its position in the development/cycle and its potential uses, including prediction of possible toxic actions from QSAR considerations. A multiple volume hazardous material management guide could be developed. This guide would serve as an important reference for defense contractors, Air Force development and acquisition personnel, and occupational health personnel. An example of a successful reference work for a different application is the Air Force Installation Restoration Program Toxicology Guide. Phase I would involve definition of the concept for use, assessment of the availability of the data required for such as database, and demonstration of QSAR approaches which could be used. Phase II would involve development of an initial database and demonstration of its ability to identify known hazards and suggest potential data gaps on uncharacterized chemicals.

The Air Force needs an aid to system designers, manufacturers, and maintainers that will greatly enhance decision-making capability. Such an aid would allow better up-front exploration of system design concepts and help ensure appropriate consideration of the effect of those decisions on downstream activities such as maintenance, logistics, operation, and disposal. As an example, a material (i.e., hydraulic fluid) selected strictly on performance characteristics might produce a prohibitively large environmental impact. The decision to incorporate hazardous materials/devices considerations into the acquisition process in an integrated fashion, such that overall life cycle costs can be managed to acceptable criteria. Phase I research will conclude with a report that clearly defines a

recommended approach and specifically addresses the merit and feasibility of that selected approach. Phase II will conclude with a working laboratory prototype and a demonstration of the developed technology.

AF89-072 TITLE: Dynamic Bleaching of Protective Materials by Ultra-Short Laser Pulses

OBJECTIVE: Produce methods of accurately capturing dynamic bleaching effects of single picosecond pulses on protective materials.

DESCRIPTION: Laser protective materials are designed to protect the wearer against the hazards associated with laser use. One major concern is the dynamic effects of ultra-short laser pulses on the protective material, the protective properties of the material may decrease, making the material less effective. In other words, the laser pulse may bleach the material, thus lowering its optical density. A need exists for a programmable device which captures the dynamic bleaching effect, in terms of the shape of the laser pulse that caused it, and digitally stores the pulse shape for later analysis. The device should have at least a 5 picosecond risetime and a vertical sensitivity ranging from 50 microvolts to 5 volts. It must have a delay line option to facilitate triggering. The device must have a dynamic range covering the most critical laser wavelengths and must have multi-channel capability. In addition to the device mentioned above, an innovative approach to capturing the bleaching effects is needed. The goal of Phase I is twofold: (a) Determine the feasibility of a device meeting the above standards and (b) Develop a programmable device which can capture, store, and process a single picosecond laser pulse and the effects of that pulse as it passes through laser protective materials.

The Phase II goal is to produce a functional, tested device meeting the above required specifications, including complete training and documentation on the proper use, configuration, and maintenance of the device.

AF89-073 TITLE: Computer Based Testing and Training in Intelligent Systems

OBJECTIVE: Develop prototype testing systems for Intelligent Tutoring System (ITS) and tools for developing of ITS by non-programmers.

DESCRIPTION: In order for ITSs to adapt to the instructional needs of individual students, ITSs must be able to diagnose skills and knowledge a student possesses at various stages of the training. Also, the successful application of artificial intelligence in training requires reductions in the time and programming expertise required to move from system concept to system prototype. This research will investigate and demonstrate enabling technologies to support rapid development on intelligent computerized applications by non-programmers. The following research areas are of interest:

a. Design Specifications for Student Model. This research would investigate the types of knowledge and skills explicated in Cognitive Psychology and Artificial Intelligence literature that are requisite for accurate assessment of an individual's capability to solve problems in a particular domain. The selection and presentation of test items would be based on the student's acquired knowledge and skills and those that have not yet been acquired.

b. Identify Psychometric Issues and Solutions in Computer Based Testing (CBT). The research would explicated the issues and implement solutions discussed in CBT literature. The issues and solutions include exposure control (selecting items from a pool of similar items so that a specific item is not presented too often), algorithms for selecting items for presentation, individual and group reports, partial scoring, multiple path solutions, techniques for presenting items (e.g., graphics, text, scrolling), and test termination criterion.

c. Design, develop, and document a prototype CBT software shell. The system should be hosted on a Zenith 248 or (80386 based) desktop computer and able to assess declaration and procedural knowledge, and problem solving skills.

d. This research would investigate approaches to providing non-programmers with these powerful capabilities by providing simple command languages, visually oriented programming systems, menu driven programming systems, or other approaches to developing training system interfaces.

e. This research would investigate hypertext and other innovative approaches to efficient database search, and especially the problem of providing non-programmers with the capability to create the database and related search architecture.

f. This research would investigate approaches to providing non-programmers with the capability to author device models and simulations by providing simple command languages, visually oriented programming systems, menu driven programming systems, or other approaches.

AF89-074 TITLE: Instructional Methodology for Multiship Air Combat Training

OBJECTIVE: Develop and evaluate a model methodology for team training in multiship air-to-air combat training.

DESCRIPTION: The following programs are of interest:

a. Development of a methodology (model) which accounts for the relationship and structure between individual and team training for multiship air-to-air combat training. Current approaches to training can be described as development of individual skills for specific procedural tasks at early phases with limited integrated practice of advanced multiship combat tactics at later phases. Restricted training opportunities during advanced training are the result of limited availability of simulators and training aircraft. Recent advanced, low-cost technology may afford the development of complex simulated combat environments which, in some ways, can be instructionally superior to aircraft environments because of the capability to manipulate various dimensions of training, thus overcoming some limitations in current training practice. However, a systematic training methodology is needed as a guideline to take full advantage of advanced technology. Literature on team training reviewed to date appears to offer little guidance for the development of a multiship air combat training model.

b. The goal of this effort is to develop and evaluate a team training model for multiship air combat which structures both individual and team training phases according to skill development requirements and other relevant criteria. A central issue is determination of the point (or points) in the program at which individual skills training should transition to multiship team skills training and also how programs should be structured. The research will investigate: (1) skill development hierarchies progressing from individual basic tasks thru group or team multiship combat scenarios; (2) transition from individual skill development to team skills (identification of principles which help determine points within the program at which training should transition from individual to team training methodology); (3) identification, definition, and development of performance criteria and measurement approaches for individual-to-team performance; (4) identification of methodologies which are effective for multiship training; (5) determination of the influence of team membership upon training effectiveness; (6) identification of feedback methods/media which are most effective for individual and team training situations; (7) determination of the influence of task structure and complexity upon the efficiency of team training; and (8) development and evaluation of a training model for air combat multiship training.

c. Phase I will be limited to concept formulation, literature review, and definition of research requirements for investigation of issues such as those listed above. Recommendation from the Phase I effort will include additional issues and design requirements for development of the multiship team training model. Phase Ii will be devoted to the development, validation, and demonstration of a team training model.

AF89-075 TITLE: Unified Life Cycle Engineering (ULCE)

OBJECTIVE: Develop technologies for computer-aided designers to better integrate design for supportability, performance, and producibility.

DESCRIPTION: Today's computer-aided designer (CAD) environment offers bench-level designers the potential to identify many supportability problems that previously remained undiscovered until much later in the acquisition process. To take advantage of this potential, the following research areas are of interest:

a. Determine and develop new reliability, availability, and maintainability applications within CAD environments that will aid designers in performing design processes or evaluating design products. Models and/or programs should be compatible with typical design phases of major weapon system acquisition and with ongoing Reliability, Availability, and Maintainability in Computer Aided Design (RAMCAD) integration efforts.

b. Determine and develop new applications of decision science methodology that allows design engineers to trade-off various design attributes such as performance, cost, schedule, supportability, and producibility within CAD environments. Attributes may have logical measures of merit which are either qualitative or quantitative in nature, or measures of merit may have to be derived as part of decision support systems. The goal of the decision models is to provide design engineers with capabilities to judge relative merits of various design options and to evaluate final designs with respect to life cycle implications.

c. Develop new methodologies and automated tools for information system design and construction which will provide data integration in an increasingly complex, heterogeneous, and distributed environment. Such information systems will support the information requirements of designers as well as other functions throughout a major weapon system's life cycle. Current techniques such as IDEF 0 and IDEF 1 have proven to be too manpower and time intensive and lack the semantic richness and developmental framework required for future, large-scale, integrated information systems.

d. Determine and develop new ways of presenting information concerning human cognitive and psychomotor performance capabilities within CAD environments. Better ways of portraying large existing knowledge about human abilities developed from basic and applied research are necessary in order to develop decision rules and design criteria for use by design engineers. Meta-analysis, a technique found useful in several behavioral and social science disciplines, could prove beneficial where the knowledge base is known to be diffuse (psychomotor ability) or very dynamic (cognitive psychology).

AF89-076 TITLE: Enhanced Crew Interface Designs

OBJECTIVE: Devices and technologies which improve mission performance through enhanced design of crew interfaces to systems.

DESCRIPTION: The following projects are of interest:

a. Create new optical designs for night vision goggles. Phase I: Develop several first order optical design approaches with: Non see-through system, low weight, center of gravity close to head CG, minimum size, helmet mountable to HGU-55P, and optical port for head-up display imagery injection. Traces showing optical elements, image intensifier, and folding methods around wearer's head should be drawn for each optical design approach.

b. Investigate feasibility of a fighter attitude indicator which requires less cognitive interpretation, improves aircraft attitude situational awareness, and uses peripheral cueing so as not to interfere with display or environmental view. The mounting may be either on the helmet or in the canopy structure. The indicator must be viewable in a 180 degree horizontal field of view and 90 degree vertical field of view with reference cues to the pilot's design eye point. The intent is to provide visual reference cues to the pilot's central and peripheral vision areas in such a way that minimal interpretation is necessary. Phase I: Conceptual and laboratory development of the Enhanced Unusual Attitude Indicator with proof-of-concept demonstration. Phase II: A flight demonstration system for testing with an interface adaptable to US aircraft databases and interoperability with cockpit instrumentation.

c. Determine automatic custom-fit production concepts for protective equipment and clothing. Assess and integrate technology advancements made in: digitizing of human topography, computer-aided design, and automated manufacturing methods. Arrive at production concepts which can be used effectively in the DoD equipment issue environment. Phase I: State-of-the-art review and feasibility assessment. Design/production concepts for at least one piece of equipment or clothing item. Phase II: Prototype one production system. Demonstrate design and production methods for at least one item.

d. Problem: Digital Radar Landmass Simulators (DRLMS) produce conventional 525 line rate monochrome video output. Graphics engines produce 1024 by 768 or higher resolution RGB picture element imagery. Similarly, field/frame rates may differ between the two types of devices. DRLMS video must be synchronized within the graphics video (e.g., 512 x 512 within 768 x 1024) without undue degradation. Phase I: Design a video synchronization and insertion/mixing approach for combining DRLMS and graphics processor output signals. Complete engineering analysis and cost and performance estimates. Phase II: Demonstrate proof-of-concept. Government furnished equipment available at WPAFB if required. Complete drawings, schematics, parts list, and technical report of results.

AF89-077 TITLE: Crew Performance Predictions and Enhancements

OBJECTIVE: Measurement and modeling of human mental and visual capability to understand and predict performance.

DESCRIPTION: The following projects are of interest:

a. Apply neural networks to analysis of human performance in complex tasks. Problem: Measurement of human performance in piloting combat aircraft is difficult. Sensor systems measure continuous and discrete aspects of multidimensional behavior, but analysis is extremely difficult with conventional statistical methods. Near real-time predictions of workload, situational awareness, and decision behavior are not available. Phase I: state-of-the-art review, feasibility assessment, and trial application of neural networks to human performance analysis. Phase II: Prototype neural network hardware and software for predicting an important aspect of pilot performance. Demonstrate system capabilities.

b. Problem: Manned air defenses modeled using SAINT and artificial intelligence techniques are analysis-intensive and limited to restricted cases. Neural nets may require less analysis, but still maintain fidelity and robustness, allowing modeling of less limited scenarios. Phase I: Choose a neural net architecture or combination of architectures to be used for modeling. Develop methods to train the net. Identify required commercially available or custom software and computer hardware with expected cost, performance, and development schedules. Phase II: Perform proof of concept demonstration. Compare model with current modeling techniques for robustness, handling of novel inputs, and required analysis. Computer hardware and software support is available within the Human Engineering Division.

c. To provide on-line physiological assessment of pilot workload and state in aircraft and simulators. On-line monitoring of pilot state is required now and will be essential on newer aircraft and simulator systems. A physiological monitor is required which will provide on-line information and storage of information about pilot's heart rate, heart rate variability in two bands, and if possible, eye blink rate and duration information, reliable measures of operator state and workload. The device can be modular but must be capable of being worn by pilots. It should weigh no more than currently available on body recording devices and should be small. Up to eight hours of battery operation and storage capacity are required. All amplification, signal processing, and storage must be accomplished by the device. Phase I: Design and prototype development of the device. Phase II: Fabricate and test the device in actual simulation and aircraft environments.

d. Develop and demonstrate non-canonical pictorial formats for optimized cockpit information transfer. Current trends in advanced cockpit displays favor ever-increasing levels of pictorial scene fidelity. Such displays are a Visual Natural Language Interface (VNLI) for presenting the pilot with the necessary geometric relations needed for guidance, navigation, flight control, and general situational awareness.

These displays often lack the static and/or dynamic sensitivity available from more conventional presentation formats. The development of an enhanced VNLI providing a synthesis of the natural geometry of the pictorial display with the enhanced sensitivity and precision of the non-pictorial format is needed. The synthesis should be accomplished via an appropriate transformation of the canonical pictorial format, and not via a simple overlay of pictorial and conventional formats. The Phase I effort will evaluate feasibility via four tasks: 1) selection of a candidate flight task and identification of associated display requirements; 2) development of one or more candidate non-canonical pictorial displays; 3) evaluation of task performance and pilot workload, via real-time pilot-in-the-loop simulation; 4) evaluation of overall feasibility and recommendation for further development. If feasibility is demonstrated, a Phase II exploratory development effort will be supported in a full-mission simulator.

AF89-078 TITLE: Advanced Biocommunications Transducers

OBJECTIVE: Develop advanced transducers that overcome current limitations and surpass state-of-the-art devices.

DESCRIPTION: Specific transducers with enhanced performance are required to ensure effective voice communications in current and future operational systems. The following are of special interest:

a. Very Near Field Speech Measurements. Measurements of near field acoustics speech signals for use in the design of new voice transducers. Phase I: Develop approach and plan; conduct measurements on an acoustic manikin and a few subjects at existing government facilities. Phase II: Expand measurements over all American English phonemes on 50-100 subjects.

b. Fiber Optic Microphone. A fiber optic microphone that is resistant/insensitive to radio frequency, electromagnetic interference, and pulse. Phase I: The basic concept, analysis, and design. Phase II: Fabrication performance demonstration, and delivery of the voice microphone.

c. Array Microphone. Multiple component, array microphone with greater speech-to-noise ratio and voice communication than current devices. Phase I: Analysis, paper design, and critical element measurements using existing government facilities. Phase II: Fabricate laboratory demonstration prototype.

d. Improved Infrared Transducers. IR transducers that expand current distance, angle of coverage, and noninterference characteristics. Phase I: Focus on improvements that include tuned reflectors and IR bandpass filters. Phase II: Applying promising transducers to a personal IR voice communication system.

e. Performance and Communications Effectiveness Task. Develop time dependent, integrated voice communication and performance task. Phase I: Analysis, hardware and software design with detailed design task analysis. Phase II: Install task in an existing government facility and verifying reliability and validity of test methodology.

AF89-079 TITLE: Innovations in Aeromedical Applications

OBJECTIVE: Develop/Adapt tools, techniques, and data management methods applicable to medical determinations of flying fitness.

DESCRIPTION: USAF aircrew personnel are a unique segment of Air Force personnel in general. They are subject to special selection and retention standards broadly described as fitness to fly, which includes not only fitness across the full clinical medical and life sciences spectrum, but also issues related to flying safety. The standards are under continuous review, on one hand, to accommodate the flying stress as new aircraft/missions come on line, and on the other hand, to keep as many trained, experienced aircrew members eligible for the cockpit as possible. These reviews use data from large databases from which prospective and epidemiologic studies can be conducted. The sources of data are the aircrew personnel themselves. A subject who has an abnormal finding in periodic flight physicals may be examined at the USAF school of Aerospace Medicine (ASAFSAM). These are not typical patients encountered in clinical practice; they are younger, healthier and, for the most part, asymptomatic. Examining such

patients presents unique diagnostic challenges. In addition, data are sent from all over the world to USAFSAM for consideration for individual aviation status.

AF89-080 TITLE: Chemical/Biological Defense Protection

OBJECTIVE: Develop equipment and techniques for USAF forces survival and effective operation in chemical/biological toxic environment.

DESCRIPTION: The following programs provide improvements and alternatives to current USAF protective systems:

a. Both air and ground crew chemical defense gloves need to be streamlined. Current systems are bulky, need dexterity and tactile improvements, and impose thermal burden. For some tasks more durability is needed. Phase I will deal with preliminary material and/or design functions which will improve performance and maintain current levels of protection.

b. This effort is for ensense development where the primary focus is on human performance without compromising protection. Performance domains include psychomotor, communications, infantry/security tasks, air base group tasks, flight line, and maintenance tasks at a minimum. Protection concepts should include chemical/biological, thermal hazards, and physiological status in general. Phase I is envisioned as a requirements analysis, a small design effort for demonstration purposes, and an initial identification of off-the-shelf options.

c. Needs for improvement in chemical agent filtration systems include the following: (Phase I includes a study to assess alternatives and perform initial tests).

    i. Personnel will be required to function in a toxic environment without a filter life indicator. A system or device is needed to indicate the lifetime expiration of a filter.

    ii. Moisture degrades the performance of charcoal filters and charcoal impregnated materials. Systems or procedures to eliminate or reduce this degradation is needed.

    iii. Alternatives to standard charcoal and charcoal impregnated materials are needed.

    iv. Substances or procedures which reduce skin irritation from masks, gloves, and other chemical defense equipment is needed.

d. Also needed are specific accessories for improving performance and safety as follows: (Phase I assesses materials, technologies, and preliminary testing.)

    - Enhanced protection through modified ventilation system or other means will reduce the chance of exposure and contamination for vehicle operators and maintenance personnel. Systems, strategies, and analysis are needed.

    - Two-way communication for flightline personnel is impaired by chemical gear as well as flightline noise. A system is needed to enhance communication capability without compromising the protection factor.

    - Current procedures require individuals to process into collective protection facilities for rest and relief (R&R). Strategies or systems are needed to reduce the number of inprocessing and egress cycles to or from fixed shelters, by providing portable R&R facilities for use which do not compromise protection.

    - Develop nontoxic/noncorrosive decontamination reagents for the chemical agents decontamination. Design and develop procedures for field application of these reagents for equipment and personnel contamination problems.

- Develop low cost fit assessment equipment and procedures for field use for chemical protective respirators. Quantitation is required with protection factors (ratio of outside to under the mask agent concentrations) of 10,000 and better to be demonstrated.

- Any innovative concepts or applications of technology to improve performance or protective factor in chemical defense equipment are welcomed.

AF89-081 TITLE: Decision Aid Process for Investment Strategy

OBJECTIVE: Develop an analytic framework for quantifying benefits of research and development in human systems technologies.

DESCRIPTION: In the design, development, and utilization of the hardware component of weapon systems, the concept of measuring the benefits of the systems is well founded. Objective measures exist on such factors as speed and ability to deliver a weapon payload and costs of development, manufacturing and operation can be estimated and weighed against the system's performance. However, in the conduct and delivery of human centered research and research products, defining and measuring the benefits are much more difficult tasks. Often benefits are expressed in such terms as improved training, better job performance, or increased job satisfaction. When they are quantified, the benefits, at best, are expressed in terms of reduced costs in such areas as recruiting, training, and sustaining, or retaining the force. Very seldom is the manpower, personnel, and training research community able to make strong, positive, supportable statements about the value of its research products. The Human Systems Division is constantly faced with decisions about the proper mix of diverse research efforts including selection and classification, job restructuring and determination, decision aids and models, life support systems, toxic material evaluation, etc. These decisions allocating limited R&D resources among competing projects are greatly complicated by the inability to measure potential benefits in a manner that is equally meaningful to the different types of R&D programs.

This research would be divided into two distinct phases. Phase I of this project would review the current status of cost/benefit analysis and assessment of utility/worth, concentrating on R&D project selection and benefit determination. The intent of Phase I will be to develop a model which will permit the estimation of benefits from manpower, personnel, and training R&D (areas in which it has traditionally been difficult to determine dollar values) and facilitate the comparison of such efforts with hardware-oriented R&D/engineering efforts. Relevant research and cost/benefit models from the private sector as well as other government and military studies will be reviewed. Data definitions, data availability, and alternative measures (dollars, time, etc.), use of the model in allocating resources, and other factors will be considered in this phase. The contractor shall develop a prototype model which shall be used to quantify the value of two specific research projects to be selected by the contract monitor. Phase II of this effort will further develop the prototype to permit R&D managers to allocate resources across many different projects and estimate the comparable worth of each effort. An interactive cost/benefit allocation and valuation software model will be developed.

AF89-082 TITLE: Parallel Processing for Artificial Intelligence (AI) and Graphics Applications

OBJECTIVE: To modify and implement an inference engine on an existing parallel processor and/or investigate the effects of mapping graphics algorithm onto parallel architecture.

DESCRIPTION: The following programs are of specific interest:

a. Current AI types of systems are implemented as rule-based systems where facts are asserted into the knowledgebase by a portion of the system called the inference engine. This inference mechanism controls the manner in which knowledge-based systems accomplish there given task. To achieve "real-time" operation of these types of systems, this normally serial process needs to be parallelized. There are several classes of parallel processors in existence today; and as part of this effort, a trade study will be done to determine each processor's adaptability to real-time knowledge-based systems. This study will also

determine which class of parallel processors will give the greatest gains in speed and performance and then determine the ability to adapt an inference engine to that processors available under DARPA's Strategic Computing Program and determine the adaptability of each for implementing complex AI applications for avionics with the potential of achieving real-time operations. While several inference engines are based upon the Rete algorithm, there are modifications to this algorithm which attempt to improve the inherent serial nature of the algorithm. Also, part of this Phase I activity should be the familiarization of algorithms used for inferencing. This should lead to Phase II activities of modifying and implementing an inferencing mechanism for a parallel processor identified in Phase I. Phase II should target an existing airborne application to show potential real-time operation as a result of this effort.

b. Currently, there exists a variety of algorithms dealing with the generation of graphics primitives. For example, Bresenham's and Digital Differential Analyzer algorithms are principally used for generating "lines" and "circles". The program will investigate the adaptability of these algorithms to parallel processing architectures. Algorithms will be investigated for each primitive as defined in the evolving PHIGS graphics standard. Phase I should examine these algorithms and determine which ones lend themselves, as is, to parallelism, which ones can be modified or if new algorithms need to be written. The primary metric to be used in evaluating the potential for each candidate algorithm is speed. Each algorithm will be investigated from the standpoint of its current execution speed to that which can be achieved using parallel processing techniques currently under development. If the algorithms can be modeled and executed in a parallel fashion, they will provide the software framework for use in a subsequent effort investigating the hardware requirements needed to generate complex graphics images in real-time. Phase II will consist of mapping these algorithms onto an existing parallel processor. This will demonstrate the potential of parallel processing for real-time graphics generation.

AF89-083 TITLE: Abductive and Inductive Reasoning Applied to Advanced Avionics System Diagnostics

OBJECTIVE: Develop and demonstrate the technology required to increase substantially the on-aircraft diagnostic capabilities of advanced avionics systems.

DESCRIPTION: Current aircraft avionics systems have false alarms and cannot duplicate rates in excess of 20 percent and retreat okay rates over 30 percent. Built-in-test (BIT) requirements have been steadily increasing and have become a major cost in the development of avionics systems. In addition, inaccurate and incomplete diagnostic information results in unnecessary mission aborts and can cause loss of aircraft and pilots. The increased complexity and operational and maintenance requirements of advanced weapon systems make it unlikely that the required diagnostic capability will be achieved through conventional BIT methods. To diagnose future avionics systems and reduce built-in test equipment (BITE) necessitates a capability to reason about faults at a system level in much the same manner as pilots or maintenance technicians perform diagnostics. Humans are able to cope with many of the deficiencies of current BIT systems through their ability to reason effectively about the intended design behavior of the system given system-level information that is often uncertain (unreliable, incomplete, and/or contradictory). Abductive and inductive reasoning provide the means to deal with the uncertainty and combinatorial problems, associated with performing diagnostics from system-level information and provide techniques to reason at a much "deeper" level than can be accomplished using current production rule or model-based systems.

Phase I should include a study of the diagnostic problems anticipated for advanced avionics systems, the limitations of conventional BIT and artificial intelligence approaches, and the applicability of abductive and inductive reasoning to diagnosis of advanced avionics systems. The study should also include an investigation of the relationship between abductive reasoning and reasoning from first principles. In addition, a feasibility demonstration should be performed illustrating the capability to synthesize inductively abductive models to perform diagnostics at a system level given uncertain information. Phase II should result in a prototype system and demonstration that conclusively illustrate the capability to increase fault detection and isolation, validate failure indications, and substantially reduce BITE requirements for advanced avionics using a combination of abduction and induction. Phase II should also result in the design and prototyping of a generic system for diagnosing advanced avionics systems.

AF89-084 TITLE: Integrated Information Signal Processing

OBJECTIVE: To develop and analyze innovative concepts for combining aircraft communications, navigation, and identification (CNI) functions into a single covert radio frequency (RF) anti-jam signal/waveform.

DESCRIPTION: The CNI capability desired would include some combination of voice, relative navigation, and digital data composed of target tracks, housekeeping, and electronic warfare information. This waveform will be utilized by tactical and strategic platforms. Multifunction modulations have existed for more than thirty years. The most commonly known is television, which uses phase modulated signal for color information, and a frequency modulated subcarrier for audio. A second example is the Joint Tactical Information Distribution System, which uses a frequency hopped, time hopped, pseudo-noise modulated waveform to provide a CNI capability for multiple platforms. Phase I will study and propose integrated modulation waveform concepts to provide an airborne, integrated CNI capability which has low probability of detection, low probability of interception, low probability of exploitation, and jam resistant properties. Preliminary concepts will be theoretically analyzed to determine the most feasible approach. Phase II will develop a top level system specification and vulnerability/susceptibility data for the most feasible conceptual designs developed under Phase I.

AF89-085 TITLE: Language Implications for Real-Time Artificial Intelligence (AI) Systems

OBJECTIVE: To address the issue of language (e.g., Lisp vs Ada) for AI applications for avionics with the capability of real-time operation in an embedded avionics environment.

DESCRIPTION: Many current AI approaches to avionics applications are written for laboratory-based prototype systems. These applications are written in Lisp and are hosted on an AI workstation. On the other hand, DoD has mandated that the language of choice for Air Force applications is Ada. Before we can pursue the actual implementation of AI technology into embedded avionics, we need to address the issues, such as the language, for these types of applications. Some of the language issues which need to be addressed include (1) the adaptability of Ada to large complex real-time AI applications, (2) can applications written in Lisp achieve predictable real-time operation, and (3) which language can achieve the parallelism and capability required for the operation of embedded AI systems in real-time. Phase I should consist of a feasibility study addressing the issues listed above. Phase II should extend the efforts started in Phase I with the focus on an existing, or developed, AI embedded avionics AI applications.

AF89-086 TITLE: Complex Integrated Circuit Technology

OBJECTIVE: To develop higher speed, higher density circuit, and interconnection techniques to address the higher throughput and reliability requirements of future aerospace systems.

DESCRIPTION: Research is needed to advance the state of the art in the area of complex monolithic integrated circuits and take maximum advantage of novel approaches to circuit configuration and point to point interconnect. To accomplish this objective will require dedicated efforts in such areas as (1) optimized interconnect concepts which achieve high speed through enhanced conductance and controlled parasitics; (2) the use of multi-level metal and/or three dimensional structures to achieve higher functional density; (3) modeling techniques to lower the risk of accurately predicting functionality of devices, interconnect, and packaging concepts which address power distribution and thermal management; and (5) fault tolerance and yield improvement approaches to lower final assembly costs. The above description defines a broad area of interest, and proposals addressing individual or combined areas are strongly encouraged as long as they are clearly targeted to the final objective. Phase I activity will identify the limitations of present interconnect and packaging approaches and determine those areas which offer the greatest potential for improvement. Phase II will select one or more interconnect or packaging concepts based on modeling results, demonstrate the improvement in total performance, and identify further development necessary for transition to system applications.

AF89-087 TITLE: Miniature Broadband Circulator

OBJECTIVE: To develop small broadband circulators suitable for use in solid-state phased array radar and electronic warfare applications.

DESCRIPTION: System designers are investigating the use of broadband solid-state arrays for radar and electronic warfare. Circulators are needed in these arrays to provide isolation between the radiating elements and the solid-state transmit/receive circuits. Arrays operating at 18 GHz require a module spacing of 0.325". Circulators currently do not exist that can meet performance requirements over the 6-18GHz band and physically fit within a 0.16" high by 0.325" wide module. The circulator length can be up to 0.75" long, if necessary; but the specified height and width are not negotiable. The subject program will investigate approaches for developing miniature circulators with less than 1dB insertion loss, a minimum of 15dB return loss, and 15dB isolation. Phase I will be limited to the development of circuit models and analysis. Phase II will include validation of the circuit approach by hardware development testing and model refinement.

AF89-088 TITLE: Holographic Lithography for Microcircuits

OBJECTIVE: To investigate holographic techniques for lithography in the fabrication of integrated circuits with sub-micrometer features.

DESCRIPTION: Low cost techniques are needed to form microcircuit patterns for the next generation of semiconductor devices without the use of very expensive optical lenses, electron beam machines, or X-ray machines. Optical imaging techniques for lithography of 0.3 micrometer features are near the maximum of resolution, depth of focus, field size, and homogeneity for practical wavelengths down to about 193 nanometers. Electron beam lithography machines are limited throughout and proximity effects on exposure. X-ray lithography requires expensive machines, such as synchrotrons, and is limited by resists and the stability of masking materials.

Recent theoretical studies have indicated lensless holographic techniques may be useful for lithography. Preliminary experiments, using simple test patterns, have shown that 0.3 micrometer features can be obtained with greater than 50 micrometers depth of field, and over a field size greater than 10 millimeters using G-line wavelengths at 436 nanometers. The feasibility as a practical lithography for integrated circuits needs to be determined. Items of concern are the limits of field size, resolution, power requirements, power distribution and uniformity, aberrations, limits on magnification/demagnification at various wavelengths down to 193 nanometers, and the cost of implementing this technique into a practical tool.

Phase I for this effort should extend the theoretical studies and experimentally determine the limits of this approach and the feasibility of a practical lithography machine for integrated circuit applications. Phase II of this effort should culminate in the fabrication of a prototype model for test and evaluation in an actual integrated circuits fabrication facility and provide for estimate of cost for a production tool.

AF89-089 TITLE: Picosecond Pulse Semiconductor Diode Laser

OBJECTIVE: Explore and develop techniques for demonstrating high energy, picosecond pulse, semiconductor lasers.

DESCRIPTION: A simple, compact, efficient, and reliable source of picosecond optical pulses is needed for optical probing of high-speed circuit/device operation, optical switching, and signal processing. Typically, flowing dye lasers pumped by Nd;YAG or Arion lasers are currently used. These instruments are large, expensive, difficult to operate, and require considerable maintenance. This program will investigate techniques to develop a compact, easy to operate, low maintenance, picosecond pulse laser. The laser should be capable of stable output (low jitter in pulse timing and energy per pulse), near diffraction-limited beam quality, and greater than one MHz repetition rate. In addition, the proposed technique should allow the combining of diode laser arrays for average power greater than 20 watts. The goal of Phase I is to demonstrate feasibility of key technologies in development of a picosecond pulse,

semiconductor laser. The goal of Phase II is demonstration of a laser device with the potential for scaling to the 20 W average level and the potential for commercial development.

AF89-090 TITLE: On-Chip Information Processing for Aerial Electro-Optical (EO) Sensing with FPA's

OBJECTIVE: To develop promising new technique for increasing the reliability and rate of information processing in air-to-air EO systems utilizing focal plane arrays.

DESCRIPTION: Twenty-first century aerial EO avionics systems will merge the functions of pilotage, acquisition, tracking, identification, and warning. Whether such systems utilize full staring arrays or scanned arrays, it is likely that adequate throughput will depend on Focal Plane Array (FPA) detector chip architectures which involve some preliminary on-chip information processing. Under this topic, innovative approaches are solicited to on-FPA information processing which enhances the quality and rate of throughout of such EO systems. The product of Phase I will be a collection of techniques whose promise is illustrated with performance models and perhaps limited empirical evidence. Phase II will be a breadboard demonstration of selected techniques.

AF89-091 TITLE: 3-D Target Modeling, Representation, and Perception

OBJECTIVE: Develop new concepts in signature modeling, geometric representation, and perception of 3-D objects.

DESCRIPTION: The following programs are of specific interest:

a. Decomposed Infrared (IR) modeling for Model-Based Vision (MBV). New approaches to IR signature modeling under transient conditions for both active (laser radar) and passive electro-optical sensors are needed which can support the following requirements: (1) explicit representation of phenomenological cause and effect to facilitate reasoning about energy exchange mechanisms between target and background and among target subcomponents; (2) prediction of target features at coarse, medium, and fine levels of resolution, accuracy and computational complexity; (3) modeling code that is decomposed into as many separable, simple submodels as possible to support radiation signature uncertainty estimation and distributed control in the prediction process; and (4) prediction of aggregate target features (such as target subarea shape, intensity, and spatial location) as opposed to a visual rendering of the complete target (i.e., pixel based 'picture' prediction). Phase II effort will consist of a computer implementation in the government supplied Sensor Algorithm Research Expert (SAR Expert) System MBV test-bed.

b. 3-D target model representation using massively parallel connectionist architectures for MBV applications. MBV approaches attempt to match observed sensor information to reference model information. This effort will explore implementation approaches for the model component of baseline serial architecture MBV approaches in advanced parallel computing environments such as neural networks for 3-D imaging applications (e.g., laser radars). Specifically, this effort will examine techniques for representing 3-D object geometry models in a distributed parallel processing environment to facilitate the process of matching sensed 3-D information with stored 3-D geometry models. Phase II effort will consist of implementation of the model representation strategy developed in Phase I directly or via simulation in a massively parallel connectionist architecture.

c. Perceptual grouping and motion analysis. The human visual system is adept at organizing local, disconnected events into coherent, meaningful global perceptions (e.g., grouping edges into curves) while under motion, itself, and while observing moving objects in a scene. Algorithmic processes to perform such groupings are sought in the context of MBV research to facilitate the process of describing the objects in the scene in terms of stored models. The perceived groupings would serve as key indicators for indexing into a stored database of potential models for the object underlying the groupings in question. Phase II effort will consist of a demonstration of Phase I techniques via implementation in supplied SAR Expert System MBV test-bed.

AF89-092 TITLE: Agile Coherent Laser Radar

OBJECTIVE: To develop a diode-pumped solid state coherent laser radar, an agile electro-optic controller, or other novel laser radar improvement.

DESCRIPTION: Laser radar is key technology for Air Force missions requiring a high performance sensor, for example, air-to-ground targeting, space-based strategic defense, and target recognition sensors. A solid-state laser offers improvements over present CO2 systems, both in performance due to shorter wavelength and in reliability due to elimination of gas apparatus and seals. For maximum efficiency, the laser radar should include coherent detection for the receiver and diode pumping of the solid-state source. There is a need to demonstrate coherent laser radar with a diode-pumped source at output energy of at least 100mj. Nd:YAG is the most mature technology, but holmium and thulium are of interest because of their eye-safe wavelengths. Materials with long upper-state lifetimes are also of interest because of the possibility of continuous wave diode pumping. Another possible improvement is in the beam control devices. Optical wavelengths inherently produce a narrow beam which is desirable for high angular resolution; however, the narrow beam requires precise stabilization for pointing control and rapid steering to search a target area or image with a reasonable frame time. An electronically-controlled grating written on a suitable electro-optical material could provide non-mechanical beam stabilization without gimbals and rapid optical response times on the order of a millisecond or faster and be capable of being ferroelectric liquid crystals have the required fast response and may be suitable for this application. In this program, the contractor will develop an improvement for target-tracking laser radar. The contractor will study his proposed laser radar improvement in Phase I and define critical technology demonstrations to be carried out in Phase II.

AF89-093 TITLE: Advanced Measures of Effectiveness (MOEs) for the Strategic Relocatable Target Attack (SRTA) Mission

OBJECTIVE: Develop and evaluate a set of effectiveness measures that can be used to evaluate advanced weapon system concepts for the SRTA mission.

DESCRIPTION: A consistent and useful set of MOEs are needed to provide analysis for evaluating advanced weapon system concepts for the SRTA mission. Most MOEs used for mission analysis have been somewhat inadequate in providing relative features of merit that satisfy the needs of the technical and operational communities simultaneously. Some recent work has improved the overall usefulness of certain MOEs. Specifically, the Damage Expectancy (DE) MOE was modified to include a cumulative Probability of Engagement (Pe) term. This term was derived from numerous target attributes, weapon system characteristics, and sensor parameters. The modification to the DE MOE permits its use in SRTA mission analysis. A second major benefit derived from the DE modification is that a MOE that originally provided operational utility now provides useful information to the technical community as well. There is still a need to provide additional modifications to the DE MOE so that advanced concepts, such as those that suggest the use of multiple targeting assets for the SRTA mission, can be evaluated. Thus, single platform concepts, which can be evaluated by the present DE modification, could be compared to advanced multiple platform concepts that require another form of the DE MOE. Phase I of this effort would be used to develop the appropriate DE and Pe methodologies and provide “best case” estimates of advanced concepts performance. Phase II would be used to examine more detailed bomber/multiple targeting concepts and to modify or develop an appropriate simulation tool.

AF89-094 TITLE: Transition and Connectivity Between Electronic Combat Digital Models and Hybrid Simulators

OBJECTIVE: To develop and implement a methodology which promotes a positive transition between the effective use of Electronic Combat (EC) digital models and hybrid simulators.

DESCRIPTION: The development of modern day EC systems pose formidable challenges for: (a) the analyst to certify study accuracy early in the development cycle and (b) the test engineer to ensure system integrity prior to deployment of the system. The difficulty of these tasks increases exponentially as a function of both system complexity and threat diversity. While considerable advances have been made in the development of digital models

and hybrid simulators, the uniqueness and point design nature of these tools in their present state precludes the transition of information and/or interconnection of complementary features. Since commonality between digital models and hybrid simulators is high and, in general differs only in level fidelity, methods to connect or transition information between complementary functions of the digital models and hybrid simulators would yield high payoff for both the analyst and test engineer. Examples include correlation between study results and test and evaluation data, standardization of threat and EC system parameters, and verification of digital model accuracy. In addition, the growing complexity of advanced power managed electronic countermeasure (ECM) systems require a level of hybrid simulator sophistication that is presently cost prohibitive. The integration of real-time digital models with hybrid simulators would enable a more cost effective solution to this problem and provide a more reconfigurable simulation. The Phase I effort will consist of concept formulation and the development of a methodology to provide an effective transition of information and improved connectivity between EC digital models and hybrid simulators. The Phase II effort will implement the methodology described by the Phase I effort by developing the necessary hardware and software, adapting existing government furnished EC digital models and hybrid simulators, and demonstrating the resulting product at the Integrated Defensive Avionics Facility in Building 620, W-PAFB OH.

AF89-095 TITLE: Optical Filtering for Infrared Target Detection

OBJECTIVE: To investigate clutter suppression techniques for infrared threat warning receivers.

DESCRIPTION: Tactical infrared missile warning receivers require intensive spatial, temporal, and spectral filtering of the received radiation field to permit reliable separation of targets from backgrounds and false alarm sources. Current practice is to measure the intensity from the detector array in each spectral band of interest, bring the signals out, and perform the filtering in a signal processor. The purpose of this research is to investigate ways to perform at least some of the filtering functions optically or within the detector array structure in order to improve discrimination efficiency and reduce the load on the external processing. Candidate filtering functions include (1) extracting point sources from structured background, (2) suppression of dc background radiation levels and measurement of transient events, and (3) spectral signature matching. Phase I will be an analysis of the proposed techniques against system requirements and definition of a feasibility demonstration. Phase II will include further definition of the technique and the development of feasibility demonstration hardware.

AF89-096 TITLE: Mathematical Analysis of Linear Feedback Shift Register Sequence Generators

OBJECTIVE: To apply the shift-and-add property and other properties of linear sequences to determine the generator configuration.

DESCRIPTION: improved reception and synchronization to wideband communication signals of unknown parameters are desired. The sequence these signals are based on can be too complex to analyze in a reasonable processing time with a physically small processor. Improved methods would allow construction of cheaper, more reliable communication links as well as enhancing jamming capabilities. However, the mathematical theory of pseudorandom sequences is not sufficiently developed to support his objective. Phase I activity will consist of mathematical research to find useful relationships between shift-and-add data and the associated sequence generators. Phase II will involve computer simulation involving analysis of sample bit streams from long sequences.

AF89-097 TITLE: Artificial Intelligence (AI) and Parallel Processing Technologies for Electronic Combat Applications

OBJECTIVE: To derive maximum benefit for electronic combat applications from advanced AI technologies and distributed parallel processing systems.

DESCRIPTION: The opportunity exists, with low to medium risk, to incorporate AI and advanced information processing techniques into electronic combat systems and attain medium to high mission payoffs. A blend of advanced AI technologies (e.g., expert systems, knowledge based systems, neural networks) and multiprocessors and distributed processing systems combined with conventional approaches is suggested. The ideal situation would

be to incorporate the best features of each method to tackle a current electronic combat problem in the electronic support measures, threat identification, and/or electronic countermeasures response areas. Specific technologies should be chosen along with the specific electronic combat problem to be addressed. The system should allow potential for practical application to a current or projected Air Force aircraft electronic systems. The challenge is to derive maximum benefit from these emerging technologies and provide proof of principle with potential to transition a resulting new system or provide current system improvement for the users within the next five to fifteen years. Phase I includes assessment of electronic warfare system functional description and identification of high payoff hardware and software technologies. Phase II would result in the simulation and validation of the system/subsystem approach fostered in Phase I to the extent that further development and transition to advanced programs would be considered. Laboratory demonstrations on government integrated test beds and processors is applicable for Phase II.

AF89-098 TITLE: Low Probability of Interception (LPI) Milstar Modulator

OBJECTIVE: To study and develop a design for a modulator, which will produce a phase continuous, frequency-hopped waveform for use in Milstar terminals.

DESCRIPTION: The normal implementation of a frequency-hopping modulator results in transients which occur when switching from one frequency to another. These transients are due to the discontinuity in the waveform during the switching period. By minimizing the transient during switching, the resulting side lobe or out-of-band energy can be significantly reduced. This would significantly reduce the probability of intercept. Milstar is a multiple access system. This approach would allow more users in a given bandwidth; and, thus, reduce the possibility of interference among the users. Various implementations will be evaluated. Considering trade-offs, one design would be selected which provides an optimum signal formation during switching. The technology derived from this effort would not only be of benefit to the Milstar program, but the LPI attributes of such a modulator would be useful in communication systems using frequency-hopping or phase modulation. This would lead to Phase II and the actual construction of a prototype modulator and demodulator.

AF89-099 TITLE: Threat Identification Error Reduction Techniques

OBJECTIVE: To study and develop a design for a modulator, which will produce a phase continuous, frequency-hopped waveform for use in Milstar terminals.

DESCRIPTION: Current methods of processing radar warning receiver data require high quality receiver data. As the signal density increases, the percentage of missing and corrupted signals increases dramatically, causing conventional pulse-by-pulse processing techniques to falsely detect and identify emitters from the set of data as received from the radar-warning receiver. The approach to be investigated for this program is to transform the digital output words from the radar-warning receiver into a low level image by histogramming. The histograms are then processed using image-like algorithms. The approach provides a global view of the emitter environment and the ability to localize areas of ambiguity. These results can be compared to the results of the pulse-by-pulse processing operation using expert system analysis techniques to reduce to an acceptable level erroneous emitter detections and identifications and improve overall system performance. Phase I will address the image-like algorithms that will be required to process the histograms and to locate obvious emitters and areas of probably ambiguity. Phase II will develop a set of rules for comparing the results of Phase I with the results of other processing operations, including those of other sensors to resolve ambiguous results and to validate threat emitter identifications. The algorithms will be developed on commercially available computers and tested at the Avionics Laboratory using Air Force owned receiver/processors.

AF89-100 TITLE: Optical Interconnects for High Temperature Superconductors

OBJECTIVE: Explore and develop techniques for optical data transfer to/from high temperature superconductor circuitry.

DESCRIPTION: Optical interconnect techniques may allow superconductive devices to be more compatible with existing electronics technology. As high temperature superconductive circuits of the future become complex, interconnection will play a significant role. Techniques to be considered include optical switching of superconductors and monitoring nonlinear interactions of an optical beam with a superconductor. Bulk, surface, and field wave coupling need to be addressed. Other possible approaches include the optical interrogation and excitation of spectroscopically sensitive atoms and radiation coupling via surface structure. The basic research activity of Phase I should include a feasibility demonstration and assessment of the potential of the technique for further exploratory development. The Phase II development goal is the validation of the technique by the demonstration of high-speed optical data transfer to/from superconductive circuitry. By the end of Phase II, the technique should be developed to the extent that transition to advanced programs can be considered.

AF89-101 TITLE: Improved Strength Carbon-Carbon Faceplate Heatshield For Phased Array Antenna Windows

OBJECTIVE: To develop and demonstrate a viable multi-dimensional reinforced carbon-carbon faceplate heatshield concept for phased array button antenna windows.

DESCRIPTION: The Air Force is studying numerous hypervelocity systems with a common requirement for phased array scanning radars with large "button" antenna windows necessary for navigation, midcourse guidance, terminal guidance, and target acquisition and tracking. Because of the large size of these antenna windows, which is dictated by the radar system's performance requirements, they will have to perform both as a structural component as well as an avionics component. Carbon-carbon is one of the leading materials for the faceplate material because of the severe aercheating environment and structural loading these windows will experience. Current state-of-the-art window concepts call for machining numerous closely spaced holes in the two-dimensional reinforced carbon-carbon for the phased array radar "buttons". This process cuts through a large number of the reinforcement fibers greatly reducing the structural capability of the material. Phase I will develop and demonstrate an innovative multi-dimensional reinforced carbon-carbon antenna window concept that minimizes or eliminates fiber cutting to provide greater structural load carrying capabilities. Phase II will scale up the concept and fully characterize it's performance capabilities in preparation for subsequent advanced development.

AF89-102 TITLE: Time Domain Approach to Random Dynamic Response And Fatigue

OBJECTIVE: To simulate distributed random dynamic excitations by a time domain technique and predict fatigue life by employing a cumulative damage theory.

DESCRIPTION: The prediction of random dynamic fatigue life is based on the assumption that the structural response is adequately represented by a single mode and the peak stresses obey a Rayleigh distribution. Since most turbulent flow and aeroacoustic excitation are random in nature, the standard procedure is to infer a statistical value of stress response which can then be used to invoke the Palmgren-Miner rule for fatigue like prediction. However, this procedure becomes ineffective if the instantaneous stress response departs significantly from the underlying assumption. The fatigue like prediction has over the peak stress statistics for multiple mode and nonlinear responses. To obtain a more accurate prediction, it is necessary to follow the detailed process of structural response excited by random pressure fluctuations. The ultimate goal is to simulate aeroacoustic excitations by a time domain technique and thereby calculate statistically representative response time histories by directly integrated the equations of structural motion or other approaches. Phase I activity will include demonstration of feasibility for linear structures and structures with simple geometric nonlinearity. This will lead to the Phase II activities of final development and verification of techniques valid for stationary and non-stationary processes and transition to advanced structural design.

AF89-103 TITLE: Landing Gear Component Design Verification and Durability

OBJECTIVE: To develop methods to measure and apply landing gear component full field strain values for rapid, low cost component design verification, and durability determination.

DESCRIPTION: Advanced methods, including innovative techniques and apparatus, are needed to measure and apply full field strain values for high performance landing gear components design verification and durability determinations. The methods to measure full field strain must be non-contacting, require minimal surface preparation, and be usable both in a laboratory and an operational environment. The methods developed may incorporate the use of a limited number of strain gages. These methods must facilitate fast, accurate, and low cost establishment of full-field strain under various simulated or actual operating conditions. Applications of the methods must result in significantly improving the reliability and confidence level for design validations and durability determinations. Optical methods such as holographic interferferometry, shearography, and speckle interferferometry appear to possess the potential of being developed into acceptable methods for full-field strain measurement. For the purpose of the Phase I effort, activity will be primarily aimed at demonstration of the feasibility of advanced methods for aircraft wheel design verifications and durability determinations. This will lead to Phase II activities consisting of techniques and apparatus final development for aircraft wheel design verification and durability determination including methods validation and methods transition for application to other high performance landing gear components.

AF89-104 TITLE: Automated Design of Global Fault Detection and Isolation

OBJECTIVE: Rapidly design and redesign aircraft flight control system fault detection and isolation algorithms to adapt to control system modifications.

DESCRIPTION: Fault tolerant flight control systems compensate for damage by distributing signals and control forces and moments among available resources. Redistribution of commands is based upon information from the Fault Detection and Isolation (FDI) algorithms. A global FDI isolates failures by monitoring overall system dynamic performance. With this approach, it can also protect the flight control system from generic hardware and software failures. However, since it monitors overall system dynamics, it is sensitive to the control law from and performance. Sometimes even minor changes to the control laws will require significant change in the global FDI. Therefore, these two processes are normally done serially, as the global FDI is more difficult to change. Ideally, both the control laws and the global FDI would be designed simultaneously. At present the design of global FDI algorithms is labor-intensive and time consuming. By automating the algorithm design, the development time, cost, and risk advanced flight control systems will be reduced. Work in Phase I should show feasibility of automating major portions of the design using either explicit or implicit FDI techniques. Explicit FDI techniques can include hypothesis testing or other parametric approaches; implicit FDI technique can include neural networks, polynomials, or other nonparametric approaches. Phase I should also specify the architecture of a complete software development environment. This environment should be developed in Phase II and demonstrated on one or more contemporary design and redesign problems.

AF89-105 TITLE: Computational Aerodynamic Models of Aircraft and Weapons

OBJECTIVE: To develop an Air Force-wide database of computational aerodynamic models for aerodynamic analysis of aircraft and weapons.

DESCRIPTION: Aerodynamic analysis of US Air Force aircraft and weapons is accomplished at various Air Force Systems Command Laboratories, Centers, and Product Divisions for many different purposes (e.g., performance, flight, loads, airframe/weapons carriage, aircraft modifications, and test planning). Each activity obtains or develops it's own computational aerodynamic model, consistent with the sophistication of the numerical aerodynamic analysis method employed (e.g., Panel, Potential, Euler, and Navier-Stokes methods). The objective of the Phase I effort is to examine in detail the development and use of computational aerodynamic models of aircraft and weapons and determine if it is feasible to organize a centralized function to obtain, develop, modify, evaluate, certify, and apply those models in an efficient way throughout the Air Force. Consideration will be given to the development of methods that enable models of varying detail, using a master model as a primary reference. The contractor shall also develop estimates of the cost to develop the database and the potential tangible benefits of developing a centralized system. If the Phase I effort shows the required feasibility, Phase II could demonstrate the program for one or more aircraft, paving the way for subsequent adoption throughout the Air Force community.

AF89-106 TITLE: Numerical Determination of Aerodynamic Coefficients Using a Gas Hydraulic Analogy Water Table

OBJECTIVE: To investigate and develop topographic mapping techniques for surface waves of gas hydraulic analogy water table experiments.

DESCRIPTION: The development of advanced supersonic and hypersonic aerospace vehicles with predicted performance beyond today's operational fleet requires the utilization of enclosed emergency escape capsules to successfully protect the crew during emergency escape. An inexpensive opportunity to investigate escape system separation effects in terms of modified aerodynamic coefficient tables is available with the utilization of gas hydraulic analogy water table testing techniques valid from low speed conditions through approximately Mach 7. The acquisition of numerical data from such experiments would be enhanced by technical advances in the area of real time topographic mapping techniques whereby the entire water table surface would be scanned by measurement devices, i.e., sound waves, light waves, laser light stereo cameras, etc., thus making digital numerical data available for computer processing of CAD color coded images for raster video animation display and hydraulic analogy data for reduction into useful aerodynamic coefficients. During Phase I, real time mapping techniques would be investigated with respect to gas hydraulic analogy water table designs and specifications developed for the mapping and display system hardware. A prototype sensing and topographical mapping display system is to be developed and shown capable of sensing and water surface waves using simple key element hardware and inexpensive data display for verification. This demonstration is expected to involve available off-the-shelf components. During Phase II, a complete gas hydraulic analogy shallow water table shall be designed, developed, fabricated, and installed complete with the three-dimensional cross-translational motion of three separate bodies relative to an analogous freestream flight direction. Testing under simulated decelerated flight is desirable.

AF89-107 TITLE: Cryocooler Technology

OBJECTIVE: To improve both spacecraft and aircraft sensor system cryocoolers by reducing input power, weight or volume, or increasing reliability.

DESCRIPTION: The Air Force requires closed cycle cryogenic coolers to cool sensor systems for spacecraft, aircraft, and missiles. Typically, these coolers are inefficient and limit the life of the systems they cool. Consequently, there is a requirement to improve cooler performance and life. We are interested in innovative methods of improving cryogenic coolers and/or individual components in closed cycle cryocoolers. The improvements should result in reduced system input power, longer system life, smaller system weight and volume, or reduced system vibration (either cooler vibration or vibration transmitted to the sensor). Concepts which may be considered are: new refrigeration cycler using the magneto caloric effect, non-moving parts components, and hybrid arrangements. Components which may be considered include: compressors, expanders, regenerators, heat exchangers, seals, or bearings. Improvements to the cryocooler-sensor interface are also of interest. Both functional design and material selection may be considered. During Phase I, concepts will be developed and feasibility will be demonstrated. A successful Phase I effort will lead to a Phase II effort to build and demonstrate the performance of the concepts designed during Phase I.

AF89-108 TITLE: Real-Time Polynomial Network Synthesis

OBJECTIVE: Develop real-time polynomial synthesis algorithms using parallel processing architectures and heuristics.

DESCRIPTION: Polynomial network synthesis algorithm has been successfully applied for many years to create real-time solutions to guidance and control problems in the form of polynomial networks for otherwise intractable problems. The synthesis of these networks, however, does not occur in real-time and must be performed off-line based on simulated and/or other data. For advanced systems such as the Aerospace Plane, the Advanced Launched System and the Advanced Tactical Aircraft that must operate at extremely high probability of success, synthesis algorithms will be required on-board to periodically resynthesize the networks. Because of the number of networks and the magnitude of the data that must be processed, real-time synthesis will become a major issue in successfully

implementing these algorithms on-board. Phase I should consist of the adaption of existing polynomial network synthesis algorithms or the design of new synthesis algorithms to support real-time computation and massively parallel processing. As part of the Phase I effort, various heuristics should be explored to decrease the network synthesis time and an examination of existing parallel processing architectures should be conducted to determine the most suitable architecture(s) to pursue in Phase II. Phase II should implement a prototype of the synthesis algorithms designed in Phase I and real-time demonstration for a specified Air Force application.

AF89-109 TITLE: Vortex Flows and Their Control

OBJECTIVE: To define and experimentally quantify techniques for controlling vortex strength and breakdown.

DESCRIPTION: Vortices generated by slender fuselage forebodies, wings, and strakes are important element in attaining high levels of fighter aircraft subsonic and transonic maneuverability. However, these vortices result in highly non-linear aerodynamic characteristics at moderate and high aircraft angles of attack. Contributing to the complexity of the flow field are vortex trajectory asymmetries, vortex breakdown, interaction of multiple vortices, and vortex wing/tail interactions. A basic understanding of the vortex flow phenomenon that dominates combat aircraft maneuver performance is required. Because of the importance of vortex breakdown on aircraft high angle-of-attack performance and controllability, particular emphasis should be placed on experimental quantification of the vortex breakdown process including its dependence on Reynold's number. Similarly, the effect on breakdown of adding energy to the vortex by blowing or vortex cambered surface interaction should be experimentally explored. Phase I should include an analysis and actual experimental quantification of the flow physics occurring during vortex breakdown, and include concrete ideas for delaying vortex breakdown by blowing and interaction with cambered surfaces. Phase II should include an actual experimental quantification of the flow mechanisms that delay vortex breakdown. The pneumatic and mechanical schemes for delaying vortex breakdown, identified in the Phase I effort, should be tested in Phase II through a range of Reynolds numbers and ranked according to their effectiveness.

AF89-110 TITLE: Life-Enhancement Techniques for Fatigue Life at Elevated Temperatures

OBJECTIVE: To develop innovative concepts for life-enhancement of aerospace structures for a combination of thermal and mechanical loading conditions.
DESCRIPTION: Currently, several life-enhancement techniques for an increased crack initiation period and reduced crack growth rates are available. Such techniques include cold working, shot peening, stress rolling and interference fit. However, the beneficial effects of these techniques on life diminish in the presence of elevated temperatures. Therefore, new innovative concepts and techniques are required to increase the structural life of flight vehicles at high velocities in order to assure low mass fraction structures. Phase I effort will require demonstration of the feasibility of the proposed concept of identifying new methods for extending the time periods to fatigue crack initiation and propagation to either a repair crack size or total catastrophic failure. A follow-on potential for a Phase II effort exists to develop the hardware needed to provide improved fatigue life benefits for the new methods identified in Phase I for both existing and new aircraft. A quantitative assessment of life benefits will be made based on crack growth tests.

AF89-111 TITLE: Surface Crazing Measurement Technique for Aircraft Acrylic Plastic Transparencies

OBJECTIVE: To develop a measurement technique and preferably portable apparatus for quantifying the intensity of crazing deterioration on the surfaces of aircraft acrylic plastic transparencies.

DESCRIPTION: Manifestations of the degradation mode known as surface crazing represent the single most frequent cause for removal from service of aircraft acrylic plastic windshields and canopies. Investigations of proposed accelerated laboratory test to induce crazing on the acrylic surface of coupons cut from an aircraft transparency reveals that crazing is a function of surface tensile stress and length of time in contact with a chemical reagent with only the time to incipience of crazing being noted in the test. It is a goal to establish a relationship between the time to reach a given degree of crazing in the laboratory and the time to reach an equivalent degree of crazing of the same transparency surface in operational service. Also, no known, preferably portable, technique has

been demonstrated that will produce a quantitative measurement of crazing in acrylic plastics on a scale which orders the various varieties of crazing with respect to their negative impact on the optical performance of the transparency. Such as measurement technique and implementation in a portable configuration is desired in order to validate buying aircraft transparencies based on their cost per year of service life. Some principles that have been suggested for measuring crazing are based on light or surface acoustic wave transmission, reflection or scattering. These techniques remain to be implemented and proven. Phase I should demonstrate feasibility and validity in a laboratory setting. Phase II should develop a portable production prototype to be demonstrated in an operational environment.

AF89-112 TITLE: Cockpit Situational Awareness – Flight Experiment Design

OBJECTIVE: To design and conduct flight test experiments to determine the causes of pilot disorientation in Head Up Display equipped single seat fighter aircraft.

DESCRIPTION: The US and Allied Air Forces are experiencing the loss of many single seat fighter aircraft due to what is believed to be pilot disorientation. Conferences have been held, ground simulations conducted, and results published, but as yet, no in-flight experiments have been performed to verify the causes and solutions to this problem. The Air Force has now instrumented a T-38 aircraft with an F-16 Head Up Display and associated equipments and will be conducting in-flight experiments in an attempt to verify the causes and evaluate proposed solutions to pilot disorientation. It will be the task of this SBIR effort to design innovative flight test experiments in Phase I and to conduct those experiments, reduce data, and document the results in Phase II.

AF89-113 TITLE: Methodology Development for Verification of Flight Critical Systems Software

OBJECTIVE: To develop and evaluate an integrated software development environment which focuses on the generation and test of software for highly coupled critical system applications.

DESCRIPTION: Advanced methods to enable the synthesis, development, and test of software for highly integrated flight critical systems, such as a vehicle management system (VMS), are needed where fault tolerance and flight safety are major driving factors. The VMS type system is characterized by the integration of flight and propulsion controls with mission avionics functions and includes the integration of utility functions such as electrical power, environmental controls, fuel management, and hydraulics. A development environment is required to cope with the complexities of such systems with emphasis in the areas of requirements specification, synchronization and timing, logic validation, complexity metrics, and automated testing. Phase I will provide the design of the environment and identification of available tools and additional tools which need either development or enhancement. The Phase II activities will enhance or develop needed tools, and integrate the tools into an environment feasibility demonstration using a suitable baseline system for comparison. The feasibility demonstration will lead to the transition of the environment to an advanced development program for demonstration and engineering refinement, if required.

AF89-114 TITLE: Fatigue Crack Growth Retardation/Acceleration Effects In Elevated Temperature Environments

OBJECTIVE: To develop analytical techniques for modeling crack growth behavior during overloads and under-loads in elevated temperature environments.

DESCRIPTION: Advanced aerospace vehicles encounter thermo-mechanical loads due to aerodynamic heating. Since these vehicles require low mass fraction for there mission performance, the durability and damage tolerance become increasingly important areas of structural concern. The airframe structures experience tensile loads, compressive under-loads, and combinations of overloads and under-loads in addition to cyclic fatigue and variable temperatures. Such environmental and loading conditions affect the crack growth behavior of an existing crack in a structure. Current empirical techniques do not satisfactorily account for these efforts. Most importantly, a technique for fatigue crack growth modeling for retardation and acceleration effects in a thermal-mechanical environment does not exist. The Phase I effort for this program will involve the development and demonstration of the predictive

capability of such a new technique. The Phase II program will emphasize model verification and correlation with experimental crack growth data under flight simulated (thermal-mechanical) loads. The end product will be a software package for predicting fatigue crack growth behavior that accounts for the effects of crack growth retardation and acceleration.

AF89-115 TITLE: Two-Phase Fluid Heat Transfer at Low and High Acceleration

OBJECTIVE: To develop methods for predicting two-phase fluid flow regimes, pressure gradients, and heat transfer rates during boiling, condensation, and adiabatic flow in zero gravity and high acceleration environments.

DESCRIPTION: Hypervelocity aerospace vehicles and future satellites operating at high power levels for surveillance and other defense missions will require use of circulating fluid systems for heat transfer/thermal control functions and propellant transfer. Use of two-phase fluids with evaporation at heat sources and condensation at heat sinks will provide effective and efficient transport capabilities. Cryogenic and normal temperature fluids will be involved for specific applications. However, data from ground testing of these systems must be translated into expected flight conditions for accurate prediction of operating parameters. Spacecraft and aerospace vehicle fluid heat transfer systems require additional work to predict flow regime boundaries, pressure gradients, and heat transfer rates. Equal density, immiscible liquids can simulate micro-gravity liquid-vapor flow conditions when the liquids are properly selected and data properly presented. In addition to this approach, careful analysis and possible experiments are needed to determine micro-gravity and acceleration effects on void-quality relations and the boundaries of flow boiling regimes in both cryogenic and higher temperature systems. Further development is also needed to control flow regimes in components such as heat exchangers, evaporators, and condensers. Methods to suppress flow instabilities must be evaluated and well understood for the intended applications. Determination of feasible methods and approaches in Phase I efforts could provide a basis for Phase II work which may include design and fabrication of experimental packages for future space or aircraft flight-testing.

AF89-116 TITLE: Abductive and Inductive Reasoning Applied to Intelligent Missile Defense

OBJECTIVE: Develop and demonstrate decision models that recommend optimum responses to single and multiple missile threats in real-time.

DESCRIPTION: There are numerous factors associated with determining the optimum missile evasion maneuver and/or electronic countermeasures for various missile attacks. Many of these factors involve substantial uncertainty because of variability of the factors and the limits of sensor and processing capabilities. Conventional approaches such as the use of look-up tables and/or decision trees necessitate numerous assumptions and simplification to cope with the uncertainties and the number of possible combinations of factors. These simplifications and assumptions may result in adequate laboratory systems that have limited applicability in the real world. Abductive and inductive reasoning methods offer an approach to dealing effectively with combinatorial problems, including linear and nonlinear interactions between a large number of factors, and uncertainty. The primary inductive modeling method of interest is neural network synthesis. The Phase I effort should demonstrate the application of a neural network synthesis algorithm to generating evasive maneuver decision models from a database of sample scenarios. The training base can be generated based on surveys or experienced pilots and/or from an Air Force provided database of simulated engagements. The Phase I effort should illustrate the ability of neural networks to deal with the combinatorial, multivariate interaction, and uncertainty problems associated with intelligent missile defense. The Phase II effort should result in a prototype capable of addressing both single and multiple missile attacks using a combination of evasive maneuvers and electronic countermeasures.

AF89-117 TITLE: Mobile Autonomous Robot Simulation (MARS) – Second Generation

OBJECTIVE: Improve existing MARS by incorporating creation of irregular shaped obstacles, enabling the use of different algorithms for robot exploration and incorporating real sensors data.

DESCRIPTION: The existing MARS includes generation of regular shaped obstacles in a two-dimensional work space, and uses an ever increasing spiral path to explore until it finds some obstacle before moving sideways to clear the obstruction and then continue it's spiral path again. This has an ideal sensor at the present time. To develop the second generation of MARS, the natural progression will be to enhance the capability to create irregular shaped obstacles, incorporate other algorithms for space exploration, and use real sensor feedback data. This will result in the next generation of MARS platform. The present MARS is compatible with Digital Microvax II and requires over 40 MB of memory. The Phase I effort will incorporate irregular shaped objects, develop alternate algorithms for exploration in the robot work space, and incorporate real sensor data. The Phase II effort will involve three-dimensional objects, incorporate additional sensor data, and provide the interface with user supplied algorithms and sensor data.

AF89-118 TITLE: Mission-Oriented Flying Qualities

OBJECTIVE: To develop aircraft flying qualities design parameters and criteria which directly reflect the requirements of specific missions.

DESCRIPTION: MIL-STD-1797 and MIL-F-8785C (Flying Qualities for Piloted Vehicles) contain the flying qualities requirements presently used by the Air Force. These requirements are defined by measurable characteristics (parameters) and bounded by criteria. The present standard does not differentiate between similar tasks, for example, air-to-air gunning and bombing. This effort will develop new flying qualities parameters/criteria which are optimal for specific fighter tasks. As a minimum, the following missions shall be addressed: low-altitude bombing to achieve precise solutions quickly and low-altitude automatic flight control operation addressing pilot adjustment of automatic inputs, pilot override of automatic systems, and system disengagement transients. Ride qualities in this environment should also be considered. Phase I activity will identify the critical missions and the flying qualities parameters which impact mission performance capability. This will lead to Phase II work directed toward developing the corresponding criteria, validation and incorporation into future revisions of the flying qualities standard and handbook. The work will be analytic in nature but will require extensive ground-based simulation with additional future in-flight simulation validation.

AF89-119 TITLE: Attachment Techniques for High Temperature Strain

OBJECTIVE: To characterize strain sensor attachment techniques on metallic and composite structural materials in elevated temperature environments.

DESCRIPTION: New transducers for strain measurement at elevated temperatures are being developed. Investigations of sensor attachment techniques are needed to determine adhesive qualities, strain transfer capability, and failure modes as a function of temperature under tensile and compressive loading. Emphasis will be placed on the testing of small samples. Typical material systems include titanium aluminides, nickel aluminides, ceramic matrix composites, and metal matrix composites. Phase I activity will include demonstration of feasibility of various strain measurement sensors and compatibility with selected materials. This will lead to Phase II activities of investigative tests of various attachment techniques on a variety of materials used for advanced structures for aerospace applications.

AF89-120 TITLE: New High Performance Polymers

OBJECTIVE: To investigate the synthesis, characterization, methodology, processing and properties of new polymer systems.

DESCRIPTION: Investigations are sought to discover new polymeric materials with potential for development of improved structural materials, nonlinear optical materials or conductive materials. Polymer systems with exceptionally high use temperatures and reasonably low processing requirements are of primary interest. Areas of investigation to be addressed include: (a) synthesis routes and methods to improve processing of rigid-rod polymer molecular composites which give rise to very thermally stable (600 deg F to 700 deg F use temperatures) structural

materials under reasonable processing conditions and without the evolution of impractical quantities of volatiles, (b) theoretical chemistry to provide fundamental understanding of the molecular requirements for achieving nonlinear optical or conductive properties in organic and semi-organic polymer systems, (c) processing, morphology and mechanics of rigid-rod polymers to discover approaches for achieving superior compressive strengths, and (d) polymer structure-property correlations to elucidate processing options for achieving desired morphologies and mechanical properties in (a) and (c) above. The establishment of viable approaches to obtaining improved nonmetallic materials are sought in Phase I efforts which can be pursued in Phase II follow-on efforts to establish their merits.

AF89-121 TITLE: Modeling of Stresses in Coated Solids

OBJECTIVE: Develop methods for assessing and understanding the behavior of solid lubricant coatings and their interaction with substrate surfaces.

DESCRIPTION: The Air Force is initiating a fundamentals oriented program in tribology with emphasis on novel deposition techniques of thin lubricating films on solid substrate surfaces. The primary purpose of this program is to enhance the understanding of tribological phenomenon of surface interactions and behavior of the thin lubricating films. One are related to these studies which requires investigation and greater understanding is the role of stresses within the thin coatings. Under extreme operating environments, favorable friction and wear behavior between two interacting solids is often achieved by applying one or more coatings of suitable materials to the mating surfaces. Since bulk properties of coating materials are generally quite different in comparison to those of the substrate, the design of a substrate-coating system is dependent on realistic modeling of stresses in the coatings as a function of the prescribed operating conditions. For a prescribed temperature field and boundary loading on the surface, analytical models to predict the following are currently needed: Stress distribution in coatings; stresses at the interfaces between the coatings and between coating substrate; thermal stresses introduced by the difference in thermal coefficient of expansion of the coating and substrate materials; adhesive and “break away” stresses between the coating and substrate; fatigue or endurance limits of the coatings when cyclic stress are imposed on the surface. Aside from design of coated solids, in forms of coating thickness and application techniques, the predictive strengths of the models will play a vital role in materials selection and screening. Thus, in addition to the design of current applications, these models should offer substantial guidance for materials development for advanced systems application in the future. Phase I goals include feasibility demonstration and approaches for establishing mathematical computer models for stresses in coatings on solid substrates. Phase II goals are to fully develop the models, apply them to actual coatings and validate the models with stress data taken from experiments performed on both metal and ceramic substrate materials.

AF89-122 TITLE: High Performance Carbon-Carbon Composites for Advanced Applications

OBJECTIVE: Development of high strength, oxidation resistant carbon-carbon composites for advanced applications at temperatures from 1000 deg F to 4000 deg F.

DESCRIPTION: A variety of future Air Force systems such as high performance turbine engines and multi-mission hypersonic vehicles will require lightweight, structural materials that operate in the 1000 deg F – 4000 deg F temperature range. Advanced fiber reinforced composites are ideal for these applications due to their specific properties and flexibility in tailoring composite laminate design. Carbon-Carbon Composites have excellent mechanical and thermal properties at elevated temperatures, but require oxidation protection at elevated temperatures. Innovative and unique ideas are sought on advanced Carbon-Carbon Composites in the following subject areas: 1) Unique oxidation protection methods for Carbon-Carbon Composites such as tough, low Coefficient of Thermal Expansion (CTE) coatings, or molecular/finely dispersed inhibition. 2) Analytical methods for mechanical/thermal property estimation or oxidation resistance determination. 3) Ultra high strength, thermally stable greater than 500 ksi, up to 4000 deg F use temperatures graphite fiber development. 4) Fabrication and processing of thin (less than 0.1 inch), structural Carbon-Carbon Composites. Phase I of this program would address application requirements and goals as well as an initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II goals of enhanced evaluation of Phase I concepts and additional refinement to yield optimized concepts would be followed by trade and design studies for future efforts.

AF89-123 TITLE: High Temperature Materials for Advanced Systems

OBJECTIVE: To develop, characterize, test and/or evaluate the performance of advanced high temperature structural materials for Air Force needs.

DESCRIPTION: New approaches to the development and characterization of advanced high temperature (2500 deg F-4000 deg F) structural ceramic composites, and advanced high temperature (2000 deg F-3000 deg F) structural intermetallic materials and composites, are needed for potential Air Force applications in advanced gas turbine engines and advanced transatmospheric flight vehicles. New, unique high temperature matrix/reinforcement materials, configurations, and oxidation protection systems must be developed, and evaluations conducted to determine matrix/reinforcement interactions during manufacture and during application of composites. Test systems must be developed and applied for use in small samples to determine mechanical and physical behavior, such as failure modes, crack and void growth, oxidation, stress strain and cyclic stress-strain behavior as a function of temperature and loading histories. Modeling mechanical and physical behavior in terms of composite constituent materials must be implemented, and applied to prediction of mechanical behavior, failure characteristics, and response to environmental exposure of structural concepts for potential application in future advanced system designs. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would develop and refine those feasible concepts to the point where an assessment could be made of ultimate potential to help meet Air Force advanced materials needs.

AF89-124 TITLE: High Performance Light Metal Alloys and Metal Matrix Composites

OBJECTIVE: Develop improved light metal alloys based on the Aluminum Beryllium, Titanium, and Magnesium systems.

DESCRIPTION: Unique approaches which result in new aluminum, beryllium, (BE), magnesium (Mg) and titanium alloys are required to support the technology system requirements identified in the Air Force Systems Command Forecast II study. Incorporated are ultra high temperature aluminum alloys to replace titanium for applications to 900 deg F and ultra high temperature titanium alloys to replace superalloy applications to 1800 deg F. Environmentally stable, ultra light magnesium and beryllium alloys are also desired. Included is the response of all alloys to secondary processing. Titanium alloy requirements are directed for improvements in three areas: temperature stability to 1800 deg F, strength to 210 ksi, and high modulus/density ratio. Research is now needed to explore property improvements, especially in the corrosion resistance of Mg alloys. Improvements in strength, stiffness, and a reduction in density may be possible using novel alloying additions. Metal matrix composites (MMC) offer considerable promise for aerospace applications because of their strength to density ratio and potential use at high temperatures. Low cost scaleable approaches are needed for fiber wetting, composite compaction and assembly. Matrix metals considered should take advantage of unique property improvements available through MMC. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would optimize chemistry and processing and also produce larger amounts of material for a full spectrum of mechanical property evaluation. It would also include preliminary evaluation of trade and design studies to give an early indication of future application potential.

AF89-125 TITLE: Improved Nondestructive Evaluation

OBJECTIVE: Identify and evaluate new nondestructive evaluation techniques for advanced aerospace applications.

DESCRIPTION: Advanced, innovative approaches are needed for the development of new and improved nondestructive inspection and evaluation (NDI/E) techniques for the detection and characterization of flaws in airframe and engine materials, including metals and metal-matrix and ceramic-matrix composites, and for use in the real-time monitoring of the manufacturing processes used to fabricate aerospace components from these materials. In particular, innovative technical approaches are needed for the detection and characterization of bulk and surface

defects in both metallic and nonmetallic structures, for the evaluation of the integrity of bondlines in structures containing adhesives and metal-metal bonds, for the determination of the condition of matrix and reinforcing substructures in advanced composite structures, for the quality of high-temperature material coatings, and for the inspection electronic device materials and components. Technical approaches proposed must either achieve clearly significant improvements in the standard techniques currently being used in factory and field inspections or must identify new inspection and evaluation technologies which have capabilities far superior to those currently used and which have the potential for ultimate use in realistic manufacturing or in-service environments. Phase I of this program would address the initial formulation, fabrication, and evaluation of specific NDE techniques for demonstration of proof of concept. Phase II would perform enhanced development which would include equipment or software development for optimization and demonstration of the advanced NDE techniques investigated in Phase I.

AF89-126 TITLE: Nonlinear Optical Materials

OBJECTIVE: To demonstrate approaches for obtaining materials with large nonlinear optical coefficients in useful configurations.

DESCRIPTION: Nonlinear optical materials are required for a variety of potential Air Force applications including optical switching (e.g., switches, limiters, and attenuators) as well as optical data processing (e.g., spatial light modulators, frequency shifters, and guided wave optics). Proposed material studies should include data and discussion showing potential for improving some currently available set of properties relevant to the appropriate application in a submicrosecond time range. Approaches applicable to inorganic and organic materials will be given consideration both in thin films and bulk media. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform optimization of the device(s) and material(s) that show the most promise in order to promote rapid development.

AF89-127 TITLE: High Temperature Superconducting Materials

OBJECTIVE: Development of high temperature superconducting thin film materials that can be used for sensing and modifying electromagnetic radiation.

DESCRIPTION: The recently discovered high temperature superconducting ceramic (HTSC) materials offer a variety of application opportunities. Detection of infrared (IR) radiation can potentially be improved through the use of these HTSC materials. For example, sensitivity, operating temperature, and signal processing speed are functions that need to be increased over present technology. The properties of the materials must be established and detection techniques evaluated (e.g., bolometers and Josephson junctions) in order to fully assess their value in electromagnetic sensing. Work including modeling of the superconducting mechanisms, phase diagram studies, development of unique thin film processing methods, opto-electronic response and temperature dependent noise measurements, thermal conductivity and heat capacity analysis, and electrical and magnetic measurements are examples of topics considered appropriate for this program area. Phase I would address application requirements and goals as well as initial formulation, fabrication, and evaluation specific subjects for proof of concept. Phase II would explore in depth the approach identified as most feasible in Phase I and carry out a design and trade-off studies. This will include comparison to present semiconductor-based detection technology.

AF89-128 TITLE: Ultrastructured Materials

OBJECTIVE: Development of improved processes to fabricate ultrastructured materials for electronic and optical applications.

DESCRIPTION: Ultrastructured materials describes a broad technology area where the unifying theme is control of chemical composition or spatial order at or near the atomic level, in the range of 10 nanometers or less, thereby obtaining dramatic improvements in desirable materials properties. Emphasis of this task is on semiconductors, but

other “electronic” and “optical” materials will be considered. Development of improved processes to fabricate ultrastructures is within the program scope. Possible processes include atomic layer epitaxy, ion cluster beam deposition, pulse laser evaporation (laser assisted deposition), metal organic chemical vapor deposition and molecular beam epitaxy. New and/or novel techniques will also be considered. Processes for fabricating improved electronic and optical materials for solid-state high frequency microwave, infrared detection, and optical signal processing, and nonlinear optical materials, are of high interest. Process modeling development applications are considered appropriate for this program area. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for the proof of concept. Phase II goals include enhanced development of ultrastructured material fabrication and characterization techniques formulated in Phase I. Phase II programs will optimize prototype systems to show potential for commercialization.

AF89-129 TITLE: Aircraft Accident Investigation Techniques for Electronic And Electrical Systems

OBJECTIVE: Establish techniques to identify failure causes of electronic/electrical systems involved in aircraft accidents.

DESCRIPTION: The increasing reliance of aircraft on electronics has resulted in these systems being prime candidates for contributing to aircraft accidents. These systems typically are poor in condition after an accident due to impact damage and/or exposure to intense fires. The ability to discriminate post-accident damage from possible system failures contributing to the accident will aid investigators in establishing accident causes. It is expected that data will be collected to develop approaches and investigation techniques for electronic and electrical related aircraft accidents. Areas which are of particular interest include wiring failures which may be masked by post-accident arcing or damage, evaluating printed wiring boards and components that have been exposed to post-accident conditions, and evaluation instruments and display panels (lamps) for pre-accident states. Phase I activity will collect data to develop approaches and investigation techniques for electronic and electrical related aircraft accidents. This will lead to Phase II activities which will result in a handbook that provides specific examples and interpretation of findings. Special failure modes and how they can be distinguished from post accident damage should be addressed in the handbook.

AF89-130 TITLE: Metallic Adhesives for Structural Composites

OBJECTIVE: To demonstrate the use of metal alloy adhesives in the joining of heat resistant composite materials for use in the 350 deg F to 1500 deg F service temperature range.

DESCRIPTION: Polymer base structural adhesives for use in the 350 deg F to 1500 deg F service temperature range suffer from lack of toughness (low peel strength and poor resistance to flaw propagation) and very difficult processability. Polymer base high performance structural adhesives for use above 600 deg F for any length of time in air presently do not exist. Preliminary work with polybenzimideazole (PBI) carbon fiber composites and carbon/carbon composites has shown the metallic alloys formulated to melt, flow and wet these composites can form structural adhesive bonds, far stronger that the inter-laminar shear strength of the composites, even at temperatures approaching the melting point of the metallic adhesive. Work needs to be accomplished to develop and demonstrate a bonding system based on metallic alloy materials, organic and carbon base adherent pretreatments (including metal priming or infiltration) and processing conditions required to produce bonds having reproducible mechanical properties. Phase I activity will include demonstration of feasibility through melting studies involving the composites and adhesives of interest and candidate surface modification treatment for the composites. Success here will lead to Phase II activities for optimization of adhesives, surface preparations and processes as well as engineering test and evaluation prototype bonded joint.

AF89-131 TITLE: Contactless Electrical Testing

OBJECTIVE: Develop techniques for probing complex integrated circuits (IC) without physical contact.

DESCRIPTION: Complex very large-scale integrated (VLSI) circuits presently contain several hundred thousand transistors and very soon will contain millions of transistors. In general, signals on internal nodes can be measured by using mechanical probes. This straightforward technique has two drawbacks. First, we cannot locate probes on lines with dimensions of 1 micron or less. Second, if the probes make contact they load the circuit capacitively, resulting in false measurements and possible temporary malfunction of the integrated circuit (IC). Techniques utilizing voltage contrast and electron beam induced currents must be developed so that contactless electrical testing of complex IC's may be accomplished. These procedures are applied on the Scanning Electron Microscope (SEM) with electrical feedthroughs to the device under test. Phase I activity will include connecting the VLSI chip into a circuit so that the chip may be viewed in the SEM. Phase II activities will include development of voltage contrast, electron beam induced current (EBIC), and timing techniques for IC characterization.

AF89-132 TITLE: Unified Life-Cycle Engineering Design Aid

OBJECTIVE: To develop a design optimization aid which autonomously interacts with a feature-based modeling system to analyze and synthesize optimal or near optimal designs of mechanical parts.

DESCRIPTION: The design of most real life (in lieu of idealization academic problems) engineering systems is characterized by the following descriptive sentences: The problems are multi-leveled, multi-dimensional, and multi-disciplinary in nature. Most of the problems are loosely defined, open-ended, virtually none of which as a singular, unique solution, but all of which must be solved. The solutions are less than optimal and are called satisficing solutions. There are multiple measures of merit for judging the "goodness" of the design, all of which may not be equally important. All information required may not be available. Some information may be hard, that is, based on scientific principles and some information may be soft, being based on designer's judgment and experience. The ultimate engineering scheme must be based on life-cycle considerations to include both the "process-of-design" and the many "disciplines" which must be invoked during the process. The goal of life-cycle engineering is to design "optimum" or "near-optimum" systems. Optimum is defined as a design that is feasible and also superior to a number of other feasible alternative designs. A superior design can be obtained in two ways: By an iterative process or by or by solving an optimization problem. The Phase I goal is the investigation of new advanced computer technology as applied to the design process. The result of Phase I will be a report. Phase II will focus on he development of a system for demonstration with metrics for showing ULCE performance improvement.

AF89-133 TITLE: Low Cost Composite Structures Fabrication

OBJECTIVE: To reduce the cost to fabricate thermo-set composite structures by 30% while maintaining or improving present quality levels.

DESCRIPTION: Research is desired on innovative, low cost methods and approaches to the automated fabrication of thermo-set airplane composite primary and secondary structures. Present composite structures produced by the current level of fabrication automation exhibit fly-away costs of 20-30% greater than conventional aluminum structures, but are required in today's systems due to their reduced weight and improved performance. Phase I of this effort should identify fabrication concepts which offer significant improvement over current practices and reduce both the cost to fabricate attendant in-process and final part quality control and inspection. Phase II should demonstrate a preferred concept on a laboratory scale against simple structural concepts.

AF89-134 TITLE: Common Memory Data Processor

OBJECTIVE: Automatically resolve and process data to applications requiring the data regardless of the data source.

DESCRIPTION: Database management machines have increased the user's ability to store and retrieve data faster. This advancement in technology has not solved the inherent data management problems of accuracy, quality, and uncontrolled duplication of data. This effort should explore the use of database machines for processing "common memory data" and the administration of common data. The state management of data as it is processed through the

business enterprise is not well understood and requires this research. The developer should demonstrate the Common Memory Data Processor technology using parallel processing technology attached to an open systems interconnection (OSI) network to provide the independence and widest possible application support for engineering and manufacturing. Phase I goals will be to establish the CDMP requirements, establish conceptual alternative design, and to conduct a feasibility demonstration of the concept. The anticipated Phase II goals will include demonstrations and a technology transfer plan and business strategy with partnerships.

AF89-135 TITLE: Biotechnology for Aerospace Materials Requirements

OBJECTIVE: Apply biotechnology to obtain improved materials design concepts, useful materials with structural complexity not otherwise obtainable, and lower cost methods of materials preparation or removal.

DESCRIPTION: The Air Force is interested in research and development directed toward the following potential applications of biotechnology to aerospace materials requirements: (a) Modeling the chemical or morphological design of natural systems with structural applications such as fiber reinforced composites which might provide optimization of strength, stiffness, toughness, weight, and subsequent reproduction of the designs using high temperature resistant chemistry. (b) Utilization of materials with chemical and morphological structures of a complexity obtainable practically only from natural sources for aerospace application requiring specific properties. Examples would include carbon matrix composite precursors with high char yields, ceramic precursors, and materials with nonlinear optical or electromagnetic properties. (c) Biological preparation methods for aerospace materials, which might include the biosynthesis of chemical intermediates for matrix resins for organic matrix resin composites, ceramic materials, lubricants, elastromeric materials, electro-optical materials, etc. This area might also include bioleaching or bioaccumulation for obtaining or purifying rare metals aerospace applications. (d) The use of biodegradative methods for the removal of materials such as sealants and paint or other coatings from aircraft, or for integrated circuit etching. Phase I would address application requirements and goals as well as an initial formulation, fabrication, and evaluation required for proof of concept. In Phase II, the process or design concepts from Phase I would be developed through optimization and scale-up efforts in order to establish feasibility for manufacture. Either process or design concepts would lead to marketable product for Phase III.

AF89-136 TITLE: Phenomenology & Effects of Materials/Laser Interactions

OBJECTIVE: To analyze, model and experimentally characterize known/new properties under laser irradiation.

DESCRIPTION: Understanding the interaction phenomenology and effects of continuous-wave and repetitively pulsed laser radiation on materials is required for development of survivable systems. Basic material properties and responses that vary as a function of wavelength, temperature, heating rate and other parameters are critical to the understanding. Emphasis will be placed on basic irradiation effects experimentation, theory and modeling, innovative target and beam diagnostic development and attempts to develop unusual methods to counter laser radiation damage. Materials of interest include: innovative materials, composites and structures, in-situ processed high temperature materials, carbon-carbide materials coatings and thin films, and detectors sub-elements. Phase I activity includes demonstration of feasibility, whether experimental or theoretical. Phase II efforts will usually lead to a validated process or product with market/inherent potential for the DoD; although such process or product need not be fully developed but must, at least, fully demonstrate it’s principle. Proposal inputs are to be unclassified.

AF89-137 TITLE: Epistemic Planning for Management and Manufacturing

OBJECTIVE: To develop a logical theory and computational model for multi-agent reasoning about various epistemic, model, and intentional concepts needed to model management and manufacturing operations.

DESCRIPTION: Most automated systems, with few exceptions have not attempted to deal with multiple agents with multiple epistemic states. Worse, most automated systems require detailed specifications as to the preconditions and results of actions. These restrictions are clearly intolerable in a management or manufacturing enterprise where one is dealing with the thousands of employees, each with their own epistemic states, and with thousands of potential

actions that may be performed concurrently or in an overlapped manner. Consider the following three actions: A manager orders and employee to make a part; the employee makes the part and then reports to the manager that the part is made. Initially, the manager's goal is to make the part. After the order is given this goal becomes the employee's goal and the manager has the expectation that the part will be made. After the employee makes the part, the employee has the belief that the part was made, and when this belief is reported to the manager it becomes the manager's belief. Unfortunately, these fairly obvious descriptions of the consequences of these actions do no explain a number of subtleties; such as why the manager should continue to expect that the part is being made during and after the period in which it was made, as this was not explicitly stated as a result of making that part, and also as to why the manager no longer has the goal of making the part once the expectation that the part will be made is acquired. The first subtlety is known as the frame problem in plan formation and the second involves the use of general constraints defining allowable situations. What is needed are general mechanisms and laws for propagating facts from one situation to another as actions are performed. This would involve both forward planning systems to predict new epistemic states as actions are performed and also allow for concurrent sequences of actions to be found which satisfy specific goals, expectations, and beliefs. It would also involve planning systems for dealing with histories of events, where certain facts are known and one is being asked to reconstruct a plausible explanation of what happened. It is expected that these systems should involve generic solutions to these problems rather that the hand coding of each situation/action/fact as is done in most current systems which use lists which are coded separately for each action. A general theory should be given for specifying the propagation of arbitrary sentences of first order quantificational logic supplemented with a wide variety of epistemic, model, and intentional concepts involving defaults. Phase I goal is to model and simulate a viable solution. Phase II goal is the development of a prototype system in a manufacturing environment.

AF89-138 TITLE: Determination of Mechanical Properties of Materials Subjected to Severe Environments

OBJECTIVE: Determine fracture, fatigue, creep, and constructive characteristics of newly developed advanced materials.

DESCRIPTION: Advanced methods including innovative test techniques and unique apparatus, are needed to determine fracture, fatigue, creep, and constitutive characteristics of newly developed materials for high performance turbine engines and advanced structures for aeronautical and space applications. Emphasis will be placed on he testing of small samples to determine characteristics such as failure modes, crack growth, damage accumulation, creep, stress rupture, stiffness, and damping, as functions of temperature frequency and other environments under tensile, compressive, and shear loads, both monotonic and cyclic. Typical material systems include: (a) high temperature titanium alloys; (b) titanium aluminides, and nickel aluminides; (c) ceramic matrix composites; and (d) metal matrix composites. Phase I activity will include demonstration of feasibility through assessment of correlating parameters on selected materials. This will lead to Phase II activities of final development of techniques and apparatus including validation of database for further material development and transition to advanced structural design.

AF89-139 TITLE: Space Power Technology

OBJECTIVE: To develop survivable, lightweight power technology for space applications at the 5-100 kilowatt level.

DESCRIPTION: Development of one or more of the following technologies is in the area of space power, including thermal management, power conditioning, energy conversion, and energy storage: (a) fault-tolerant, lightweight power distribution; (b) high frequency (greater than 400 hertz) power distribution; (c) high voltage (100-1000 volts) direct current distribution; (d) insulations and dielectrics; (e) high efficiency (greater than 30% hardened, solar photovoltaic energy conversion; (f) high temperature (600 degrees C) photovoltaics; (g) autonomous power system operation; (h) high energy density (greater than 50 watt hours per pound) electrochemical energy storage; (i) thermal energy storage; (j) low area lightweight, survivable 100 degrees centigrade radiators; (k) high efficiency heat transport (heat pipes); (l) high efficiency solar thermal concentrating technology; (m) heat receivers and (n) heat to electrical conversion technologies. Phase I goals include study results, analytical derivations and proof of concept experiments. Phase II goals include detailed analytical derivations and prototypical hardware demonstrations.

AF89-140 TITLE: Missile Electrical, Thermal, and Mechanical Power (Nonpropulsion)

OBJECTIVE: To develop advanced sources of onboard and ground support power for missiles.

DESCRIPTION: Innovative nonpropulsion, power technology advances are sought that offer revolutionary reductions of life cycle cost, weight, and/or volume, and/or increases of active and/or inactive operational lifetimes. The power technologies of interest are hydraulics, actuators, auxiliary power units, ram air turbines, airborne generators and/or electric power systems, thermal control, batteries, and fuel cells. The application areas of interest are onboard sources of power and/or power generation technology, as well as hydraulics and actuation for tactical, strategic and cruise missiles and ground support power for missile silos and/or transporters. The power source goals/desired characteristics are: (a) strategic and tactical onboard power: peak power 22 kw/kg in pulsed mode, active lifetimes from 1-60 minutes; shelf life of 25 years without maintenance; 1 second delay or less from initiation to full load; operation over altitude range from sea level to 1500 km; operation over temperature range from –54 degrees C to +74 degrees C without power from an external heat source; gravimetric energy density from 25 wh/kg for one-minute lifetimes to over 220 wh/kg for 60-minute lifetimes; volumetric energy densities from 0.1 wh/cc for one-minute lifetimes to over 1 wh/cc for 60-minute lifetimes; size average power range from .1 to 10 kw; (b) silo power source; 15 years inactive lifetime; active lifetimes up to 10,000 hours; 900 wh/kg or greater; 1.5 wh/cc or greater thermal efficiency of 90%; 500 kg or greater modules; (c) silo energy storage: 15 years lifetime; round-trip energy efficiency 80%; 220 wh/kg; 1 kw/kg peak power capability; 1000 discharges/charges; 0.6 wh/cc; minimum self discharge rate of 10,000 hours; size 50 kwh or larger; and (d) cruise missiles: dynamic power sources up to 5,000 watt with energy densities approaching 0.6 kw/kg and lifetime of 10s of hours; electrical actuator systems in the integral horsepower arena. Phase I goals include study results, analytical derivations, and proof of concept experiments. Phase II goals include detailed analytical derivations and prototypical hardware demonstrations.

AF89-141 TITLE: Pulsed Power for Airborne/Spaceborne Applications

OBJECTIVE: To develop pulsed power component technology for airborne/spaceborne applications.

DESCRIPTION: Development of one or more of the following advanced pulsed power component technologies is needed for future airborne/spaceborne high power applications: (a) advanced lightweight power sources with power densities less than .02 kilograms/kilowatt; (b) capacitive energy storage devices with energy densities approaching or exceeding 3 kilojoules/kilogram, output voltage of greater than 10 kilovolts, response time of less than 10 nanoseconds, and lifetimes of greater than 10 million pulses per device; (c) inductive energy storage devices with energy densities approaching or exceeding 100 kilojoules/kilograms; (d) repetitive opening switches capable of hundreds to thousands of cycles when interrupting 2-4 megamperes at several hundred volts; (e) closing switches for repetitive switching of average currents of 10-100 amperes at voltages of 100-500 kilovolts; (f) advanced lightweight pulse forming networks for peak power pulses at tens to hundreds of gigawatts with rise times of tenths of nanoseconds, pulse widths of 10-1000 nanoseconds and repetitive rates of 10 hertz to 10 kilohertz; (g) high current density pulse conductors that are lightweight with high tensile strength and are suitable for airborne and spaceborne operating environments; (h) advanced lightweight, high voltage, high temperature, radiation tolerant insulations suitable for airborne or spaceborne operating environments; (i) high temperature, high dielectric strength, low dissipation factor, radiation tolerant power semiconductor devices with a maximum junction temperature exceeding 500 degrees Kelvin and the ability to switch tens/hundreds/thousands of amperes at 5-20 kilovolts per device; (j) high permeability, ultralow loss ferromagnetic materials for application in passive and active magnetic systems; (k) development of control algorithmsand philosophies for the autonomous or quasi-autonomous operation of high power systems in conjunction with their power sources for a variety of pulsed loads such as microwave sources and lasers; (l) RF power generator; (m) high power density sources including batteries, fuel cells, turbogenerators, and thermionic energy conversion systems; and (n) superconductivity as applied to pulsed power componentry. Phase I goals include study results, analytical derivations and proof of concept experiments. Phase II goals include detailed analytical derivations and prototypical hardware demonstrations.

AF89-142 TITLE: Power Technology for High-Performance Aircraft

OBJECTIVE: To develop electrical, mechanical, fluid, and energy storage system and component power technologies.

DESCRIPTION: Development of one or more of the following advanced power technologies is required for future aircraft: (a) high temperature (greater than 500 centigrade) components, fluids, and seals for hydraulic systems; (b) energy-efficient hydraulic technology; (c) cold weather (-55 centigrade) energy storage technology (batteries, hydraulic accumulators, capacitors); (d) fault-tolerant power technology; (e) solid-state power controllers; (f) high temperature (200-1000 centrigrade) wire, cable, connectors, power semiconductors, and filter capacitors; (g) high temperature (300 centigrade, 30 million Gauss-Oersted permanent magnets; (h) innovative converter/inverter capabilities for producing high quality three-phase 400 hertz power; (i) lightweight shafts, gearing clutches, housings, and gearboxes with special emphasis on advanced materials; (j) high performance small turbine technology; (k) electromagnetic actuator and other electrically-driven systems such as fuel pumps; (l) cooling techniques for power componentry and hot aircraft surfaces; and (m) 20 kilohertz power generation and distribution technology. Phase I goals include study results, analytical derivations and proof of concept experiments. Phase II goals include detailed analytical derivations and prototypical hardware demonstrations.

AF89-143 TITLE: Thermionic Energy Conversion Technology

OBJECTIVE: Develop key technologies for compact, survivable thermionic nuclear power supplies in the 5-25 range.

DESCRIPTION: The Air Force requires nuclear power supplies for evolutionary power needs in the range of 5-25 KW for space use in the late 1990's. The perceived advantages of nuclear power in this range are that it facilitates use of electric propulsion for attitude control; reduces payload moment of inertia, reduces radar cross section, facilitates use of power hungry electronic devices which would otherwise not be used, etc. Lifetime requirements are in the range of seven to ten years. Examples of key technology items include long-lived thermionic electrodes, innovative candidate electrical insulators, innovative converter geometries and configurations, innovative plasma operating modes for converters, compact accident-proof reactor core designs, and so on. Phase I activities will normally include experimental demonstration of basic feasibility for specific components, with external life testing occurring as part of Phase II.

AF89-144 TITLE: Combined Cycle Propulsion Technology

OBJECTIVE: To develop combined cycle propulsion system concepts which involve the elements of ramjets, scramjets, rockets, turbojets, turbofans, and ejectors in various combinations.

DESCRIPTION: New and novel concepts and approaches are sought for combined cycle propulsion systems which involve the elements of ramjets, scramjets, rockets, turbojets, turbofans, and ejectors in various combinations. Combined cycle propulsion systems are designed to operate over a wide range of flight Mach numbers from 0 to 8 or above. Both manned and unmanned vehicles are involved. The aim of combined cycle propulsion systems is to maximize the overall system efficiency by exploiting the attributes of the various elements in their respective best operating speed regimes. In addition to maximum efficiency, emphasis is also placed on low weight, volume, and cost. Phase I goals are to identify concepts and to conduct preliminary performance assessments. Phase II goals include detailed propulsion flight vehicle integration.

AF89-145 TITLE: Flight Test Instrumentation

OBJECTIVE: To develop concepts and approaches for instrumenting engines installed in hypersonic vehicles to measure engine component performance and durability.

DESCRIPTION: Advanced engines for high speed vehicles such as the National Aero-Space Plane (NASP) will not be tested on the ground above approximately Mach 8. Therefore, engine operation, performance, and durability must be verified during flight tests. Techniques are needed to instrument the engine in non-obtrusive ways, if possible, to document performance, operability, and structural integrity. Measurements desired include pressures, gas and wall temperatures, gas species, and wall strains and deflections. The extreme hypersonic environment offers the main obstacle to overcome. The lack of available space on the hypersonic vehicle mandates the design and development of miniaturized flight equipment and systems. Phase I goals are to identify instrumentation concepts and to conduct feasibility studies. Phase II goals are to establish detailed designs of an instrumentation system and perform experiments of critical elements.

AF89-146 TITLE: Micro-computer Based Earth-to-Orbit Trajectory Optimization Program

OBJECTIVE: To develop an optimizing Earth-to-Orbit Trajectory code capable of being used on a micro-computer.
DESCRIPTION: A method is needed to perform optimized Earth-to-Orbit Trajectory (3 degree of freedom) simulations using preliminary design data, including aero and propulsion performance curves. This is to be used on an AT class micro-computer. Emphasis will be placed on time-step results and final conditions. Phase I is to include development and demonstration of algorithm. Phase II will include prototyping of computer code and associated documentation.

AF89-147 TITLE: Micro-Sample Analysis of Aviation Turbine Fuels

OBJECTIVE: Develop methods to determine a wide variety of fuel properties from a small sample amount.

DESCRIPTION: Fuel specifications require measuring a substantial number of physical and chemical properties for each batch of fuel produced. Some of these methods are quick and simple, while others involve a detailed test procedure and substantial amount of fuel sample. There have been tremendous gains in recent years to replace some of the older test methods with modern analytical techniques such as simulated distillation by gas chromatography. Several newer methods are in various stages of development, and may become standard practice in the near future. Recently a group in Australia has been able to determine nine fuel properties based on results on high performance liquid chromatography (HPLC) and either gas chromatography or carbon-13 nuclear magnetic resonance (NMR) procedures. Others have used near-infrared spectroscopy to determine key properties of gasoline. Of great interest is the further development of such techniques which may be used to determine as many as possible of the physical and chemical properties of fuels such as JP-4, JP-5, JP-7, JP-3, and newer hydrocarbon fuels produced from various sources. Investigation of test methods, instrumentation, and chemometric relationships which will calculate properties based on one or two tests conducted on an extremely small amount of sample will constitute the Phase I program. The Phase I product will be the proposed method/instrumentation to be further pursued in detail in Phase II, along with preliminary results which led to the proposed method. The Phase II product will be a detailed instrumental procedure and chemometric data reduction package which will produce fuel property values with an acceptable level of correlation with measured values.

AF89-148 TITLE: Fuel Combustion Technology

OBJECTIVE: To demonstrate advances in the combustion of fuels for aviation turbine engines.

DESCRIPTION: Improved performance of subsonic, supersonic, and hypersonic flight vehicles will require advances in fuel combustion technology. Specific topics of interest include: Fuel-air mixing techniques for increased combustion efficiency, reduced pressure losses, and smaller and lighter combustors. Fuel atomization and droplet dispersion techniques to increase control over the fuel vaporization and the local fuel-air ratio. Unique techniques to predict and extend the lean blow-off limits of combustors and to improve their low temperature starting and high altitude relight performance when using high viscosity, low volatility fuels. Advanced non-intrusive diagnostics to make simultaneous, multiple point measurements of temperature, pressure, species types and concentrations, and other parameters of interest in turbulent, reacting flows. A Phase I program in this technology should result in a concept demonstration. This could take the form of a small-scale experiment or a sound numerical analysis that

demonstrates the potential for successfully enhancing the combustion process or the measurement of such a process. A successful Phase II effort would demonstrate the concept at full scale, illustrating the utility of the concept for applications of interest to the Air Force.

AF89-149 TITLE: Determination of Thermal Stability Characteristics of High Mach Fuels

OBJECTIVE: Determine the thermal stability/degradation of hydrocarbon fuels when subjected to high heat loads.

DESCRIPTION: The thermal stability of hydrocarbon fuels is influenced by temperature, time, pressure, and the materials in contact with the fuel. Advanced test methods and techniques are needed to measure and predict the formation of deposits within fuel system components resulting from the degradation of fuels in the liquid, vapor, and supercritical states. Of particular interest is the development of predictive mathematical codes that accurately integrate the combined effects of fluid flow, thermodynamics, heat exchange, and fuel degradation reactions within aircraft and engine fuel systems. The successful development of this code will tie together the results of small-scale thermal stability test devices and part scale and full-scale fuel simulators. The proposed mathematical code will be useful in the design of future aircraft and engine fuel systems. The Phase I goal is to successfully demonstrate a fluid flow/heat exchange/fuel deposition model. A simple one-step chemical reaction equation for deposit formation may be used to define where fuel deposits are generated and deposited. The Phase II goal is the development of the complete mathematical code that includes all important fluid flow effects, heat exchange, multi-step chemical reaction equations, and accurate models of the quantity of fuel degradation products that deposit on surfaces. The mathematical code is to accurately identify the locations within complex heat exchangers and fuel system components where fuel deposits will collect.

AF89-150 TITLE: Solid Lubricants and Their Distribution for Advanced Aircraft Gas Turbines

OBJECTIVE: To design a solid lubricant system (including on-board storage, distribution, control, and reclamation) suitable for installation in a fighter aircraft.

DESCRIPTION: Future aircraft turbine engines will gain much of their performance from higher cycle temperatures. Current liquids, used to lubricate bearings and other components, will not be able to survive the cycle-imposed temperatures. Protection of the liquid lubricant will incur severe aircraft performance penalties. One potential solution to this temperature problem is to use a solid lubricant (e.g., powered MoS2) to minimize bearing friction and wear. That solution requires a distribution and control system to be incorporated into the engine and/or aircraft. Phase I of this effort shall result in the definition of system concepts for lubrication of turbine engine components with low coefficient of friction solid materials. The materials and system concepts shall be capable of supporting fighter aircraft installed, turbine engine needs over full operating envelope. For each engine system, only a single lubricant material and form is to be considered. The system shall provide for on-board aircraft storage, distribution, control, and (if appropriate) reclamation/scavenge for recirculation. Materials/concepts posing a hazard to the aircraft, environment and/or personnel are not acceptable. Phase II of this effort shall result in the completion of a preliminary design of a selected material and system. The design shall fully satisfy the requirements of a gas turbine engine, installed in an advanced fighter. The preliminary design shall be sufficiently defined to enable ready transition to Phase III, concept demonstration. Phase II shall also include limited experimental development of key hardware concepts to reduce risks associated with Phase III system development.

AF89-151 TITLE: Development of Improved High Temperature Solid Lubrication Concepts

OBJECTIVE: Investigate high temperature solid lubricants and lubrication concepts for gas turbine engines which would be capable of operating from temperatures of –65 deg F up to 1500 deg F.

DESCRIPTION: Advanced limited life small turbine engines will require large increase in thrust to weight ratio and specific fuel consumption. To achieve this goal and meet high engine operating temperatures, solid lubrication concepts must be further developed. In addition, the lubricants must be capable of withstanding temperature transitions from low to high and environmental effects. Phase I activity will include the study of surface chemical

effects of high temperature lubricants and an investigation of their tribological performance. This will lead to Phase II activities of development and fabrication of the most promising concepts.

AF89-152 TITLE: High Temperature Magnetic Bearing Development

OBJECTIVE: To develop high temperature magnetic bearing technology for man rated high performance turbine engines.

DESCRIPTION: Studies conducted under the Integrated High Performance Turbine Engine Technologies (IHPTET) Initiative show turbine engine performance can be improved by increasing engine operating temperatures. To meet IHPTET goals, advancements in high temperature bearing technology will be required. Magnetic bearings may have potential for long life support of the engine mainshaft in IHPTET applications.

Phase I of this program will establish the necessary criteria to design a high temperature magnetic bearing. The end product of the Phase I effort will be a high temperature magnetic bearing design capable of supporting both axial and radial loads. Two areas that should be addressed in performing the Phase I program are: physical properties of magnetic materials at temperatures up to 1000 deg F; and a trade-off study between weight, envelope dimensions, and input power for a 650 deg F and a 1000 deg F operational bearing.

Phase II of this program would be to fabricate the Phase I design and test at turbine engine operating conditions. If successful, this technology would have Phase III potential in high temperature turbine engines as well as other high technology applications.

AF89-153 TITLE: High Temperature Gas Turbine Lubrication System Wear Monitoring

OBJECTIVE: Develop new techniques for the analysis of wear debris in the lubrication systems of high temperature engines.

DESCRIPTION: The subject of operating gas turbines at very high temperatures is one of increasing interest as the Armed Services look forward to propulsion systems for the year 2000 and beyond. The successful development of high temperature engines will depend on use of techniques which will permit a study of wear mechanisms occurring in the bearings, gears and other rotating lubrication system components. Ferrography and various spectrographic techniques are now widely used for the analysis of wear in current engines, but new concepts or processes will be required to extend the capabilities of these techniques to paramagnetic and diamagnetic materials so that wear debris may be studied in ceramic engines. Consideration also needs to be directed toward the development of new in-line concepts for monitoring lubrication system wear at lubricant temperatures up to 400 deg C. Phase I activity will include concept and design studies for advanced condition monitoring techniques while Phase II will include final design, construction of prototype instrumentation and demonstration of techniques.

AF89-154 TITLE: Solid Lubricants for Advanced Turbine Engine Powder Delivery Systems

OBJECTIVE: Identify, formulate and/or develop solid lubricants that are stable over –60 deg F to 1500 F range for extended use in advanced turbines utilizing recirculating powder delivery systems.

DESCRIPTION: Well known solid lubricants such as molybdenum disulfide and graphite are laminar solids that function successfully by carrying high normal loads while permitting shearing under only small tangential forces. However, such materials have lower than desired temperature limits due to oxidation. Solid lubricants or compacts serviceable near 1500 deg F typically function by softening over a narrow temperature range. The softening causes deformation and agglomeration that alters and degrades the solid lubricants for the use on following cycles through the system. Thus, powder delivery systems typically have suffered from non-uniform delivery of the lubricant. The approach selected is to identify, formulate and/or develop a solid lubricant that would be chemically and physically stable in such usage and generate a low coefficient friction over the –60 deg F to 1500 deg F full temperature range for periods up to 3000 hours of engine operation. Phase I activity will include concept, identification, formulation

and/or development of suitable solid lubricants, while Phase II will include demonstration of the utility of using the selected lubricants in a model or simulated system.

AF89-155 TITLE: Augmentor Acoustic Instability

OBJECTIVE: To identify the physical causes of acoustic instability and methods of suppression and avoidance for high performance aircraft gas turbine engine augmentors.

DESCRIPTION: In depth analysis and review of openly available literature shall be used to identify the causal physics of combustion driven acoustic resonances in gas turbine augmentor environments. Instabilities studied will focus on the 800-1200 Hertz range. Analysis shall include the review of both theoretical and empirical databases. From the analytical studies, methods of suppression and avoidance of resonances shall be identified. Proposed methods to eliminate resonances shall be consistent with the practical features and environmental limitations of gas turbine augmentors. A test plan shall be prepared identifying the testing and development work required to validate the physics and suppression/avoidance concepts identified. The test plan developed must be consistent with the time and funding constraints of an SBIR Phase II program. Under Phase II, the information gained under the Phase I will be used to design and fabricate a subscale test article which exhibits acoustic resonances in the 800-1200 Hertz range. Testing shall demonstrate both the resonant states of the test article and the effectiveness of Phase I proposed suppression and avoidance methods.

AF89-156 TITLE: Turbine Engine Test Instrumentation Techniques

OBJECTIVE: To develop new sensors/systems for the accurate determination of the strains and temperatures under which engine structural components must operate during engine test cell demonstrations.

DESCRIPTION: An area of ever increasing concern in the turbine engine community is the accurate determination of the strains and temperatures under which engine components must operate. Advanced engine test cell evaluation programs are limited by the problems associated with current structural instrumentation capabilities. The state of the art of structural instrumentation has many shortcomings in both the strain gage and thermocouple areas. Current turbine engine demonstration tests are particularly impaired by the fact that present instrumentation is commonly temperature limited, shortlived, inaccurate, and either protrudes into the gas flow stream or requires trenching the structural component in order to embed the sensor. For these reasons, new sensors/systems capable of surviving the harsh environment of advanced turbine engine tests while providing accurate strain and/or metal temperature data are required. Candidate sensors/systems should be capable of withstanding the temperatures and strains typical of turbine engine tests for extended periods while detecting strain to within plus or minus 5 percent and temperature to within plus or minus 1 percent. Additionally, proposed techniques should have minimal influence on blade parameters and gas flow path. The goal of any Phase I effort shall be a basic feasibility demonstration of the advanced sensing concept. Phase II goals shall include a full-scale demonstration of the technique in an environment which duplicates the anticipated conditions in the turbine engine.

AF89-157 TITLE: Compression System Design Methodology

OBJECTIVE: To develop and advance the aerodynamic/mechanical state of the art of compression systems including internal flows.

DESCRIPTION: A major trend in compression system hardware is the increased utilization of low aspect ratio blading, blisks, swept blading and three-dimensional design methodology. The primary and secondary flow system design capability must be extended fully into three dimensions to adequately exploit these trends. Therefore, there is interest in any new and innovative ideas addressing the above. Areas of prime importance include blade/vane sweep, shock/boundary layer interaction, secondary flow design (including such areas as counter-rotation, trenching, labyrinth and brush seals, and disc pumping), time unsteady features of the turbomachinery gas path, and secondary flow systems. Additionally, such phenomenological areas as water ingestion, ice ingestion, steam ingestion, dust

ingestion, and full-face overpressure area of interest. Models accurately describing the effects of external influences, such as these, are of interest.

Phase I goals will encompass conceptual ideas, computer code upgrades and preliminary design modifications. Phase II goals will encompass execution of bench tests and other verification techniques for the ideas identified as high potential in Phase I.

AF89-158 TITLE: Reliability Prediction Models For Military Avionics

OBJECTIVE: To develop a reliability model for avionics which utilizes environmental, storage, shipping, and other components necessary for a complete reliability analysis.

DESCRIPTION: Equipment which supports the operations of military interests must have the capability to consistently perform its intended tasks under various extreme conditions. The ability to accurately predict the probability of successful equipment operation (reliability) before its actual use in the field would enhance the Air Force's decision-making strategy. Reliability models exist in the commercial electronics sector which could be modified to a military application. Phase I activity will include identifying possible prediction models and investigating their potential military use. The targeted models should provide greater reliability insight than current military reliability models. Phase II activities will be to expand the targeted model and perform reliability testing to verify the model.

AF89-159 TITLE: Automatic Test Equipment (ATE) Requirements Specification Authoring Tool

OBJECTIVE: To reduce Air Force manpower requirements and improve the quality and consistency of ATE contractual specifications.

DESCRIPTION: Many diagnostics applications using expert system technology are being developed; however, the tools to support the development of contractual documents for specification of automatic test equipment (ATE) requirements is not available. To reduce Air Force manpower requirements and improve the quality and consistency of ATE contractual specifications, it is necessary to develop an expert system to aid in developing an ATE request for proposal. The Phase I effort will develop a prototype expert authoring system that will demonstrate the feasibility of developing ATE specifications. The expert authoring system should operate on personal computers that are readily available throughout the Air Force, such as IBM PC compatible computers. The authoring system shall reduce the technical manpower requirements by at least a factor of 100 to 1. It must also provide a low cost means to distribute the authoring capability to multiple locations. The Phase II effort will expand the prototype expert authoring system to implement the remaining revised acquisition guides as well as implementing improvements to the user interface.

AF89-160 TITLE: Modular Automatic Test Equipment (MATE) Guide Expert Presentation System

OBJECTIVE: To facilitate the rapid retrieval of information as required by the individual users to meet their acquisition planning or design requirements.

DESCRIPTION: Due to the complexity of planning, developing and acquiring built-in-test, design for testability, and off-line test equipment the Air Force developed a set of acquisition guides. The guides are currently undergoing a major update. One of the goals of the update is to make the thousands of pages of data easier to use. Artificial Intelligence and new computer technology hold the promise of making the retrieval of data easier. This Phase I effort should develop a proof of principle demonstration expert presentation system to provide access to the revised acquisition guides. The system should respond to English language queries. Access to information should be possible without extensive knowledge of the guides or the acquisition process. The system should respond to a single query with all relevant information contained in the guides. Presentation of guide information should match the cognitive model of the task at hand. It should permit the rapid retrieval of information as required by the individual users to meet their acquisition planning or design requirements. The Phase I proof of principle Expert

Presentation System shall also be used to demonstrate the feasibility of using the system to support an acquisition program office and to rapidly respond to telephone queries from various program offices that request information from MATE Program Office personnel. The expert presentation system should operate on personal computers of engineering workstations that are readily available throughout the Air Force. During the Phase II effort the proof of principle model will be expanded to enhance the man-machine interface and to provide access to all portions of the revised acquisition guides.

AF89-161 TITLE: Fiber Optic Delay Line

OBJECTIVE: To develop methods to reduce the cost of coherent memory/delay devices for countermeasures systems.

DESCRIPTION: Current Digital RF Memories (DRFM's) are limited by high cost, high power consumption, narrow bandwidths, generally poor spectral performance, and low reliability. Developments in multi-bit devices improve spectral performance but at the penalty of even higher cost and power. Recent advances in fiber optic technology, especially in dynamic range and bandwidth, make it a candidate for use as a coherent memory device. While DRFM's have unique capabilities, their flexibility often tempts the system designer to use them for many functions which can also be accomplished by conventional devices, sometimes as a penalty to overall performance. This program shall concentrate mainly on DRFm capabilities for coherent RF storage for variable durations. During Phase I, the contractor shall evaluate which DRFM functions can be achieved by a fiber optic device and propose one or more hardware configurations. During Phase II, hardware shall be built and tested to evaluate these configurations.

AF89-162 TITLE: New Concepts and Innovations for Aeronautical Systems/Subsystems

OBJECTIVE: To develop new concepts and innovations for aeronautical systems/ subsystems.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of aeronautical systems/ subsystems research, development, and acquisition. It is also intended to provide latitude to the innovator to include areas not specifically addressed by other specific aeronautical topics. This general area covers the full spectrum of Air Force aeronautical missions (ie, tactical, airlift, mobility, strategic, transatmospherics, etc). Emphasis is placed on potential long term planning concepts. Topics as diverse as new weapon system concepts and improved operational techniques can be submitted. Some other areas of interest are high-energy fuels, maintenance free systems, facility threat, countermeasures, innovative R&D organizational concepts, etc. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF89-163 TITLE: Artificial Intelligence Applied to Aeronautical Systems

OBJECTIVE: To develop Artificial Intelligence applied to all aspects of the Air Force Mission.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of artificial intelligence. It is meant to provide the innovator with latitude to include areas of application not addressed by other specific aeronautical topics. This general area covers all aspects of artificial intelligence (ie, knowledge representation, innovative architectures, expert systems, etc). This subject area is to be considered as applying to all aspects of the Air Force Mission. Therefore, it applies to office procedures, logistics, and maintenance, and as innovative applications of the science of artificial intelligence in solving Air Force problems.

AF89-164 TITLE: New Concepts and Innovations for Logistics Support

OBJECTIVE: To develop new concepts and innovations for logistic support research, acquisition, and management.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of logistics support research, acquisition, and management. It is also intended to provide latitude to the innovator to include areas not specifically addressed by other specific topics. The general area covers the full spectrum of Air Force logistics (ie, design interface, maintenance planning, supply support, technical data, etc). Emphasis is placed on potential long term planning concepts such as, logistics and maintenance support of unmanned vehicles. Topics as diverse as new technology impacts on traditional logistics planning and logistics techniques for mobile tactical Air Forces can be submitted. Some other areas of interest are impacts of new operational concepts and logistics organizations, models to assess the effectiveness of logistics planning in wartime situations, etc. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF89-165 TITLE: New Concepts and Innovations to Enhance the Cost Estimation of Aeronautical Systems/Subsystems

OBJECTIVE: To develop or upgrade cost estimating tools to evaluate the Life Cycle Cost effects of new concepts and innovations during the conceptual phase of development.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of cost estimating from the laboratory to the fielding of weapon systems/subsystems. It is also intended to provide latitude to the innovator to cover specific technologies as well as the accumulation of these initiatives into a total system/subsystems cost model. Lack of an ability to evaluate the cost of technologies being considered across the PROJECT FORECAST arena will severely impact out year budgetary planning resulting in project cancellation due to the infamous “cost growth”. High Temperature Materials; Ultra-Light Airframes; Smart Skins; High Performance Turbine Engines; Combined Cycle Engines; STOVL/VTOL Technology; Advance Manufacturing Technology; every imaginable new system (Hypersonic, supersonic VTOL, special operations, etc.) are all beyond today’s cost estimating capability and should be addressed individually and in combination. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF89-166 TITLE: New Concepts and Innovations for Special Operations Aircraft Systems/Subsystems

OBJECTIVE: To develop and access the operational utility of new concepts and innovations related to Special Operations.

DESCRIPTION: Special Operations forces are interested in new concepts and innovations related to future air transport of special operations forces elements. This effort is intended to develop and assess new concepts in the area of special operations aircraft, and it is intended to cover all facets of special operations aircraft research, development, and acquisition. The innovator has latitude to include trade-offs at the subsystem and major component area. Emphasis is placed on weapon system concepts and improved operational techniques/concepts. Areas of interest are propulsion, avionics, flight control, insertion/extraction devices, and other subsystem concepts. Innovative ideas for the logistics, supportability, reliability, and maintainability areas are important considerations. Work will require access to storage and creation of classified data, and personnel with security clearances.

AF89-167 TITLE: Primary Aircraft Trainer System (PATS)

OBJECTIVE: Identification of alternatives and trade-offs for the PATS to include criteria justification and training media selection.

DESCRIPTION: The justification for this effort comes from a validated need for an Air Force primary flight training system. PATS is envisioned to replace the aging T-37B fleet within the future Specialized Undergraduate Pilot Training (SUPT) System. It is concerned with teaching and developing primary flight skills through a multi-media program which might include computer based instruction, ground training devices, and a primary aircraft trainer. Possible alternatives include further modifications to the T-37B, off-the-shelf acquisition of a new existing primary trainer and associated training system, and a new development primary trainer and system.

Phase I will deliver a listing of specific alternatives meeting the need and methods of evaluating or comparing them. Included will be possible criteria which are relevant, such as life cycle cost or training effectiveness. Alternatives will include specification of all required elements of the PATS.

Phase II will evaluate the alternatives in terms of the criteria identified in Phase I and will conclude with the specification of the best alternative. Specification will include relation of training objectives to training medium, phasing of training in a general sense, and possible innovative mixing of media to enhance overall training effectiveness. The purpose is to allow creativity; hence, the ground rules for this effort will not be limited in scope.

AF89-168 TITLE: Mission Opportunities for Airship Technology (MOAT)

OBJECTIVE: To examine various aspects of Lighter-Than-Air (LTA) systems to support Air Force missions.

DESCRIPTION: This effort will be used to assist the Air Force in understanding and determining the capability of LTA systems to meet Air Force needs. Tasks could involve one or more of the following: (1) Review and analyze USAF Tasks requirements that could be fulfilled by LTA systems, (2) Define specific LTA missions and concepts of operation, (3) Assess technology opportunities for LTA systems, (4) Investigate potential LTA developmental and operational risk areas such as survivability, ground operations, human factors, and design factors, (5) Determine cost/benefits of LTA systems, and (6) Develop computer models to simulate or analyze any of the above areas. Other appropriate tasks may be submitted for consideration. The effort should be oriented toward the 1994-2014 time period. All types of LTA concepts and missions may be considered – including free and tethered balloons, traditional airships, hybrid airships, manned or unmanned systems, and low, medium, or high altitude missions. All USAF mission areas may be considered.

Phase I may be structured in any manner which considers the above tasks commensurate with the submitter's background. The Phase I product will be a report that describes the selected areas of research, methodology, conclusions, recommendations, and proposed Phase II follow-on efforts. The Phase II should consist of an in-depth investigation of LTA capabilities and may include computer analysis and modeling, test programs, etc.

AF89-169 TITLE: Determination of Panel Flutter Characteristics of Kevlar-Polyester Composite Panels

OBJECTIVE: Determine vibration, damping, and failure characteristics of Kevlar-Polyester composite panels under air-loads of locally subsonic, transonic, and supersonic airflow.

DESCRIPTION: Some work has been done in determining the vibration, damping, and failure characteristics of metal panels. In contrast, no published references were found for composite panels during the expensive literature search. A thorough investigation of the vibration, damping, and failure characteristics of flat and curved composite panels is required, particularly panels made of the Kevlar-Polyester composite. This composite is being used in large randoms and antenna fairings used by satellite communications terminal equipped aircraft. The Phase I research should include a survey of possible analysis techniques and a final recommended technique to predict flutter in composite panels and/or shells. Phase II activities will consist of developing a computer program to predict panel flutter and its characteristics. Validation of the algorithm with a wind tunnel test at transonic Mach numbers should also be included.

AF89-170 TITLE: 3-D Numerical Windflow Model

OBJECTIVE: Develop a mesoscale 3-D numerical windflow model suitable for predicting windflow patterns in the complex terrain of Vanderberg Air Force Base.

DESCRIPTION: A computer model is needed for predicting windflow patterns at Vanderberg Air Force Base. Vanderberg Air Force Base is located on the central California coast in terrain consisting of flatlands, valleys, canyons, ridgelines, and mountains rising to elevations of over 2,000 feet. Windflow is influenced by synoptic,

regional and local meteorologic factors and interaction with the terrain. A strong inversion often affects windflow in the area.

This complex natural environment necessitates use of a 3-D numerical model for predicting dispersion of clouds originating at ground and elevated levels. The model will be used in combination with existing diffusion models. The area of interest is approximately 15 miles by 15 miles in size. Model horizontal and vertical resolution should be adequate to represent important windflow intricacies. Meteorologic and terrain data will be provided.

The desired Phase I product is a preliminary computer code suitable for evaluation. The desired Phase II product is a completed and validated computer code capable of providing windflow information.

AF89-171 TITLE: Personal Hydrazine Vapor Dosimeter

OBJECTIVE: To develop a toxic vapor dosimeter for monitoring worker exposure to hydrazine rocket propellants.

DESCRIPTION: Hydrazines are widely used as a rocket propulsion fuels in space launch operations. Because they are extremely toxic compounds, categorized as suspected human carcinogens, the propellant handlers must be protected from exposures to hazardous levels The threshold limit values (TLVs) of the three amine fuels, N2H4 (hydrazine), MMH (Monomethylhydrazine), and UDMH (Unsymmetrical Dimethylhydrazine), are 0.1, 0.2, and 0.5 ppm (parts per million), respectively. A reliable yet inexpensive device capable of detecting hypergol vapor below the TLV level is required toward propellant handlers of the presence of hydrazine at sufficiently low concentrations to alert them of impending danger.

The dosimeter, which may be passive or an active device, shall possess sufficient sensitivity to indicate a response upon ten minutes or less exposure at 50% of the TLV. The response shall be readily observable in real time such as an obvious change in color without having to wait for analysis results obtained in a laboratory at a later time. An incorporation of an audio alarm system would be highly desirable. It shall be lightweight and compact (shirt pocket size) and exhibit interface free behavior that will not yield false positive response in the presence of other contaminant gases. The propellant vapor reactive component of the device shall be inexpensive and readily replaceable if not long lasting and possess a six-month storage capability without exhibiting performance degradation.

Phase I of this effort shall be a concept feasibility design and building of a breadboard prototype of the device to be developed under Phase II. Although several approaches and propellant vapor reactive systems may be initially investigated, one will be selected based on demonstrated potential for further development into a viable device having field applications. The selection will be supported by experimental data substantiating the sensitivity, reproducibility, selectivity, and quick response features inherent in the system. At the conclusion of Phase I, the contractor shall conduct performance tests to show that all requirements or the personal propellant vapor dosimeter have essentially been assigned. If any of these features fall short of requirements, the contractor must show how and why the specific shortcoming could be alleviated if not eliminated.

During Phase II, the dosimeter device developed in Phase I will be developed, modified, and adjusted to improve the performance of the device. No major research effort shall be conducted in this phase but rather the work shall emphasize improving the prototype device and designing the various individual components into a compact total device. Sufficient quantity of prototype dosimeters shall be fabricated and a field evaluation carried out at an operational facility. The field test results will be reviewed for additional minor modifications to be incorporated into the final design of a personal propellant vapor dosimeter.

AF89-172 TITLE: System to Measure Cloud Meteorological Parameters

OBJECTIVE: Develop a prototype (working lab model) of an optimum system to measure clouds meteorological parameters.

DESCRIPTION: This effort should concentrate on the MJCS (Memorandum from the Joint Chiefs of Staff) 154-86, Meteorological Requirements for Defense Environmental Satellites, 1 Aug 86, Clouds section (available through the Defense Technical Information Center). In particular, clouds, precipitation, and liquid/solid water content and cloud droplet size distribution parameters should be addressed. One or more MJCS 154-86 parameter may be investigated in the proposed effort.

Phase I should address the conceptual design of an optimum clouds data collection system. The system should satisfy the clouds (imagery, coverage, type, layers) precipitation, and/or liquid/solid water content and cloud droplet size distribution requirements of MJCS 154-86, Military Requirements for Defense Environmental Satellites. The Phase I design should consider satisfying as many of the clouds parameters as possible in a single, cost effective system. Pros and cons of systems should be addressed.

Phase II shall include furthering the Phase I concept into development of a prototype (working lab model) of the optimum system to measure clouds meteorological parameters.

AF89-173 TITLE: System to Measure Atmospherics Meteorological Parameters

OBJECTIVE: Develop a prototype (working lab model) of an optimum system to measure clouds meteorological parameters.

DESCRIPTION: This effort should concentrate on the MJCS (Memorandum from the Joint Chiefs of Staff) 154-86, Meteorological Requirements for Defense Environmental Satellites, 1 Aug 86, Atmospheric section (available through the Defense Technical Information Center). In particular, vertical temperature profile, absolute humidity (moisture profile), wind (horizontal and vertical components), visibility, pressure profile, and Albedo parameters should be addressed. One or more MJCS 154-86 parameter may be investigated in the proposed effort.

Phase I should address the conceptual design of an optimum atmospheric data collection system. The system should satisfy the vertical temperature profile, absolute humidity (moisture profile), wind (horizontal and vertical components), visibility, pressure profile, and/or Albedo requirements of MJCS 154-86, Military Requirements for Defense Environmental Satellites. The Phase I design should consider satisfying as many of the atmospherics parameters as possible in a single, cost effective system. For example, possible areas of investigation for wind include, but are not limited to, lidar and millimeter wave candidate systems. Pros and cons of systems should be addressed.

Phase II shall include furthering the Phase I concept into development of a prototype (working lab model) of the optimum system to measure atmospherics meteorological parameters.

AF89-174 TITLE: System to Measure Terrestrial or Solar Geophysical Meteorological Parameters

OBJECTIVE: Develop a prototype (working lab model) of an optimum system to measure Terrestrial or Solar Geophysical Meteorological Parameters.

DESCRIPTION: This effort should concentrate on the MJCS (Memorandum from the Joint Chiefs of Staff) 154-86, Meteorological Requirements for Defense Environmental Satellites, 1 Aug 86, Terrestrial and Solar Geophysical sections (available through the Defense Technical Information Center, see Reference A). In particular, soil moisture, snow cover, land-locked ice cover, land surface temperature, vegetation, radiation backgrounds, surface pressure, electron density profiles, neutral density, solar spectral imagery/flux, auroral emissions and airglow, solar wind, geomagnetic field, precipitating electrons and ions, in-situ electric fields, cosmic rays (solar and galactic), trapped particles, and ionospheric scintillation parameters should be addressed. One or more MJCS 154-86 parameter may be investigated in the proposed effort.

Phase I should address the conceptual design of an optimum terrestrial or solar geophysical data collection system. The system should satisfy the soil moisture, snow cover, land-locked ice cover, land surface temperature, vegetation, radiation backgrounds, surface pressure, electron density profiles, neutral density, solar spectral imagery/flux,

auroral emissions and airglow, solar wind, geomagnetic field, precipitating electrons and ions, in-situ electric fields, cosmic rays (solar and galactic), trapped particles, and/or ionospheric scintillation requirements of MJCS 154-86, Military Requirements for Defense Environmental Satellites. The Phase I design should consider satisfying as many of the Terrestrial and Solar Geophysical parameters as possible in a single, cost effective system. Pros and cons of systems should be addressed.

Phase II shall include furthering the Phase I concept into development of a prototype (working lab model) of the optimum system to measure Terrestrial and Solar Geophysical meteorological parameters.

AF89-175 TITLE: System to Measure Oceanography Meteorological Parameters

OBJECTIVE: Develop a prototype (working lab model) of an optimum system to measure Oceanography Meteorological Parameters.

DESCRIPTION: This effort should concentrate on the MJCS (Memorandum from the Joint Chiefs of Staff) 154-86, Oceanography section (available through the Defense Technical Information Center, see Reference A). In particular, sea ice, sea surface temperature, sea surface topography, ocean waves (sea, swell, surf), ocean vertical temperature profile, bathymetry (deep ocean and near shore), salinity, near shore currents, ocean currents (surface and subsurface), insolation, ocean tides, heat flux, sediment transport, turbidity, ocean color (photosynthesis pigments), and bioluminescence parameters should be addressed. One or more MJCS 154-86 parameters may be investigated in the proposed effort.

Phase I should address the conceptual design of an optimum Oceanography data collection system. The system should satisfy sea ice, sea surface temperature, sea surface topography, ocean waves (sea, swell, surf), ocean vertical temperature profile, bathymetry (deep ocean and near shore), salinity, near shore currents, ocean currents (surface and subsurface), insolation, ocean tides, heat flux, sediment transport, turbidity, ocean color (photosynthesis pigments), and/or bioluminescence requirements of MJCS 154-86, Military Requirements for Defense Environmental Satellites. The Phase I design should consider satisfying as many of the oceanography parameters as possible in a single, cost effective system. Pros and cons of systems should be addressed.

Phase II shall include furthering the Phase I concept into development of a prototype (working lab model) of the optimum system to measure oceanography meteorological parameters.

AF89-176 TITLE: Innovative Concepts for Improved Space Object Surveillance and Classification

OBJECTIVE: To develop new technologies and innovative applications of existing technologies to improve space object surveillance and classification.

DESCRIPTION: New technologies and innovative applications of existing technologies need to be investigated to improve space object surveillance and classification. Classification should include a determination of the mission and potential hostile intent of space objects. Topics of particular interest include, but are not limited to: optical design for high off-axis rejection of visible light in centered telescopes for space object surveillance; decontamination of optics on space sensors for visible light applications; sun and earth shades on space sensors for visible light applications; nuclear event detection; improved resolution and cloud penetration techniques for ground based systems; and radar and laser techniques for classification of space based systems.

Phase Ii will define the concepts and establish the technology and methodology requirements to validate the concept. The contractor shall provide a rough estimate of anticipated improvements over the existing systems, as well as projected cost savings. Phase II will develop a laboratory model, validate the technology and demonstrate in the laboratory the concepts proposed in Phase I.

AF89-177 TITLE: Innovative Concepts for Space Systems and Launch Systems Cost Reduction

OBJECTIVE: To develop innovative concepts to help reduce costs associated with access to space and the development and the production of space systems.

DESCRIPTION: The Air Force is looking for innovative concepts to reduce costs or launch operations, launch vehicle production, space system manufacturing and space operations. Space systems include both on-orbit satellites and associated ground stations and user terminals. Phase I will define the concepts and establish the technology and methodology requirements to validate each concept.

AF89-178 TITLE: Innovative Space Systems Survivability Concepts

OBJECTIVE: To develop new approaches for ensuring the survivability of DoD space systems to support U.S. and allied combat forces.

DESCRIPTION: Air Force space systems enhance the war fighting capability of strategic and tactical forces by providing communications, navigation, meteorological, and other support functions. As US military forces become more and more dependent on satellite support there is increasing interest in investigating innovative approaches for achieving satellite survivability. These include, but are not limited to satellite maneuvering, tethered decoys, mirror shields, radiation-hard electronic components, and assorted materials for laser protection. The ultimate outcome of this effort will be the implementation of an innovative survivability concept into a DoD space system. Phase I will define the approach and describe the feasibility of developing the survivability enhancement concept.

AF89-179 TITLE: Innovative Concepts for Force Support from Space

OBJECTIVE: To identify new and/or improved methods of supporting military forces from space.

DESCRIPTION: Space systems provide critical support for operational military forces, including navigation, communications, meteorological data, and surveillance data. The Air Force seeks innovative improvements in these capabilities for providing support to all military operations. This support may include current or new types. Current types of support may be accomplished with new approaches or technology. New types of support should be described in sufficient depth to permit evaluation. New technology, for example in computer and data links, can improve our capabilities. To better support terrestrial forces, innovative, small, inexpensive, and user friendly equipment is required. Phase I will define the concept and describe the feasibility of developing force support from space. Phase II will develop a laboratory model, validate the technology and demonstrate in the laboratory the concepts proposed in Phase I.

AF89-180 TITLE: Techniques to Perform Military Space Capability Modeling and Cost Estimation Modeling

OBJECTIVE: To develop space systems modeling techniques for deployment trade-offs or develops space system cost estimation modeling techniques.

DESCRIPTION: There exists a need to: 1) Model satellite architectures and constellation descriptions in order to minimize deployment costs, and 2) estimate space costs by requirement in order to analyze system requirements versus the costs before the design phase. The information should be easily interpreted by the user. The space capability model should show the effects on the mission if satellites in the constellation become inoperative. Input parameters should include coverage, size of satellite, position, weight, number of vehicles, type of technology used, and mission requirements. The cost estimating techniques should address the costs associated with each mission requirement. The model should be able to relate mission requirements through visual means, such as flow and block diagrams. These models must run on an IBM Personal Computer (PC) or micro-VAX compatible systems. The model must identify input parameters prior to running and be capable of accepting changes to input parameters prior to execution. This allows for a continual updating of the program with new technologies or ideas. Accompanying

this model must be the documentation and listing of the program. Offerors may respond to either the cost estimation modeling or the space capability modeling tasks or both. Phase I will describe the feasibility of developing satellite architecture models. Phase II will develop, demonstrate and validate the concepts of Phase I.

AF89-181 TITLE: Innovative Applications of Emerging and Mature Technologies for Air Force Space Capabilities

OBJECTIVE: To identify innovative applications of emerging and mature technologies for military space missions.

DESCRIPTION: Innovative applications of emerging and mature technologies and bold new concepts for the 21st century and in basic physical and engineering sciences are needed for military space missions. Relevant 21st Century areas include, but are not limited to; physics, chemistry, energy conversion, propulsion, space power, and signatures. New technology areas of particular interest include low thrust electric propulsion high power density (greater than 10/kilowatts/cc) solid core, gas cooled fission propulsion reactors; and non-propulsive space transportation. Phase I will define the concept and establish the technology and methodology requirements to validate and demonstrate the Phase I proposal. Phase II will develop, validate, and demonstrate the Phase I proposal. Proof-of-concept feasibility is the product of Phase II.

AF89-182 TITLE: Concepts for Improved Satellite Communications Support to Theater Commanders

OBJECTIVE: Identify and evaluate new approaches for deploying satellites, which will provide theater commanders with dedicated communications support.

DESCRIPTION: The current military satellite communications architecture is based on a time-sharing system using a few large, multi-band, multi-channel satellites, which may not be available to quickly relay urgent messages from a theater commander to a deployed unit, or vice versa. However, in a crisis, theater commanders must have guaranteed access to communications channels to effectively monitor and control the immediate situation. Hence, approaches to provide alternatives or improvements to the current architecture are needed. Proposers are requested to identify one or more satellite support improvements and propose an approach. Phase I will define the approach and describe the feasibility of improving satellite communication support to theater commanders. Phase II will develop a laboratory model, validate the technology and demonstrate in the laboratory the concepts proposed in Phase I.

AF89-183 TITLE: Global Positioning System (GPS) Translator Data Recording and Relay

OBJECTIVE: Develop innovative techniques to interface GPS translator data with conventional telemetry receive/record sites; and relay the data using conventional microwave channels.

DESCRIPTION: Test vehicles are being equipped with GPS translators that relay GPS satellite signals and a pilot carrier on S-band (2200-2400 MHz). The signals are then received, recorded, and processed at range telemetry sites. Currently, extensive hardware additions must be made at each telemetry site to provide real time recording and processing. Large cost savings would be realized if hardware could be developed to interface the translator signals to telemetry analog recorders; and to relay the data to a central processor via microwave.

In Phase I of the effort, one or more system concepts shall be developed, and systems level descriptions of recorder and microwave relay interface hardware shall be developed. Cost effective alternatives shall be addressed. A particular requirement is to relay the GPS translator data on a microwave channel that has a 7.5 MHz sub-carrier, a 3 MHz bandwidth, and 3-degree phase jitter at the receiver. Another requirement is to reduce interface hardware cost and size to a small fraction of the current processing equipment that is presently being purchased by the Government (S-12 racks).

In Phase II, one of the approaches defined in Phase I will be chosen by the Government and developed by the contractor into prototype units. The prototypes will be demonstrated by the contractor at a Government test range facility and performance verified by the Government.

AF89-184 TITLE: Optical Measurement of Small Angular Displacements in a Dynamic Environment

OBJECTIVE: Develop techniques enabling very accurate angular measurements from a mobile platform. Successive measurements must be rapidly repeatable.

DESCRIPTION: Future space-borne on-orbit testing of weapon systems will require scoring and miss distance measurements. In cases where on board vehicle instrumentation is not feasible an off board measurement approach from an airborne or space borne platform appears applicable. Potential methodologies should include but not be limited to gated video systems and laser radar techniques. A key element in the determination of position between two vehicles approaching each other at a high velocity is the measurement of sub-microradian angular displacements in a dynamic (mobile) environment to less than 0.3 arc sec accuracy. The type of instrumentation to be tested in the dynamic environment are optical sensors which include optical encoders equal to or greater than 22 bits (less than or equal to 0.305 sec/bit or 0.0015 microradians/bit). These measurements not only need to be highly accurate but also need to be very frequent (greater than or equal to ten times per sec).

Phase I will develop the design and test methodology to measure angular displacements on a dynamic airborne platform. Considerations should be given to environmental factors such as aircraft vibration and thermal contraction and expansion.

AF89-185 TITLE: Millimeter Wave Electronic Beam Scan Technology

OBJECTIVE: Develop a new millimeter wave beam technology for phased array applications.

DESCRIPTION: Satellite-to-satellite communications in a fixed geosynchronized orbit can take advantage of line-of-sight narrow beams for high data rage secure communications. With the increase in space activities, multi-link or internetted communications may be required through the use of narrow beam scanning technology. Millimeter wave beam scanning offers the advantage of narrow beam communications in space with small antennas. Current millimeter wave electronic beam switches are based on phased array concepts with millimeter wave phase shifters using either ferrite devices or semiconductor devices. Ferrite phase shifters are bulky and lossy, about 6 deciBels (dB) per 360-degree phase shift at 60 GHz. Gallium Arsenide (GaAs) phase shifters also have high losses, i.e. 10 dB per 360-degree phase shift. Another major limitation for the 60-GHz phased array is its heat dissipation capability due to a large number of elements required for a very small area. Typically, a four-inch array at 60-GHz will have 3600 elements. This no only creates a severe heat dissipation problem, but also makes it extremely difficult to implement a large number of active devices in each element.

Innovative concepts are solicited to develop a 60-GHz electronic beam scan technique to minimize the aforementioned problems. In Phase I the contractor shall conduct phased array design and design analysis. In Phase II the contractor shall construct a 2 x 2 sub-array and demonstrate 90-degree two dimensional electronic beam steering at 60-GHz.

AF89-186 TITLE: Implementing Expert Systems Onboard Satellite Systems

OBJECTIVE: Address problems with using expert systems onboard satellites. Problems center around DOD-STD-1750A processors, mission recovery, fault tolerance, and reliability.

DESCRIPTION: New and future satellites may benefit from the use of onboard expert systems to increase survivability and autonomy. Problems associated with using expert systems onboard satellite systems are of interest. Specifically:

1. Implementing expert systems on DOD-STD-1659A processors. How can expert systems be effectively hosted on the 1750A architecture? What approaches would be used to implement an expert systems code efficiently on a 1750A computer system?

2. Using expert systems to aid in satellite mission recovery. Ideas are solicited for the recovery/reestablishment of a disabled or damaged satellite's mission(s). Identification of failed or damaged subsystems, selection of work-arounds, data and software reloads, satellite location and recontact procedures are example of challenges to be considered.

3. Strategies for satellite knowledge base fault tolerance. As increasing use is made of onboard expert systems, the problem of validating and verifying the knowledge bases becomes acute. Latent errors in the knowledge bases can lead to unprecedented complex system behaviors. As strategies for tolerating such latent errors are proposed, a methodical approach for evaluating those strategies in required.

4. Reliability of satellite onboard expert systems. Many years of experience with the effects and causes of errors on traditional software and databases have resulted in strategies for both assessing and projecting their reliability. Strategies for assessing or projecting the reliability of onboard expert systems are not as assessable. Bold new and innovative strategies and approaches for evaluating and projecting the reliability of satellite onboard expert systems are solicited.

   SBIR Contractors are asked to address only one of the above areas in detail. Phase I will develop the proof-of-concept and analysis of the proposed approach. Phase II will formalize and document the approach and apply the approach to at least one test case. The use of actual data from operational satellites will be used if possible for the test case(s). Particular attention will be given to revolutionary approaches based on state-of-the-art technology and implementation techniques.

AF89-187 TITLE: Novel Concepts for Survival Space Power and Supporting Technologies

OBJECTIVE: Develop lightweight space power and thermal management components, which provide enhanced survivability against the natural space environment and hostile threats.

DESCRIPTION: As the required electrical power level increase to the 10 to 1000 KWe range for Air Force space missions, the power system takes up an increasingly larger portion of the spacecraft mass. One of the primary technical issues for future space power systems will be to achieve significant reductions in system mass. Power systems also need to be hardened against anticipated hostile threats while still providing reliable long life operation. The Air Force is interested in developing lightweight survivable space power and thermal management components. Areas of particular interest are: 1) solar photovoltaic arrays, 2) large solar concentrators, 3) dynamic power cycles, 4) high efficiency thermal storage systems, 5) lightweight direct contact heat exchangers, 6) advanced radiators, and 7) thermal management fluid control.

For solar photovoltaic arrays, the primary technical issue is to minimize or eliminate power losses due to environmental interactions and hostile threats. Innovative uses of materials, geometries and other survivability enhancing techniques should be used. Design parameters: array power of 10 to 100 Kwe with array specific power greater than 25 W/kg. For large solar concentrators advanced concepts that are easily deployable and able to stay on orbit for years with minimal losses of concentration efficiency is the technical challenge. Design parameters: equivalent solar dynamic power of 100 to 1000 KWe with concentrator mass of less than 2 kg/m2. For dynamic power cycles, identifying innovative alternatives to the conventional power cycles (Sterling, Brayton, and Rankine) is the technical challenge. Power cycles and working fluids should be specifically optimized for operation in the space environment. Design parameters: power of 10-100 KW with cycle specific power of greater than 25 W/kg. The primary technical challenges for the practical application of thermal storage concepts are: high equivalent specific heat capacity, temperature matching, effective thermal conduction into and out of the thermal storage material, and long term stability in the space environment. For lightweight direct contact heat exchangers, a key technical issue is high separation efficiency of the heat exchange media in a microgravity environment while minimizing heat exchanger mass. Applications of these heat exchangers to the Brayton and Rankine power cycles are of the greatest interest. For advanced radiators concepts, specific masses should be less than 1.0 kg/kw at a 300

deg K radiating temperature, and/or 0.2 kg/KW in the 500 deg K temperature range while maximizing survivability. In any active thermal management subsystem, there exists the requirement for fluid flow management at minimum weight, long service life, and high reliability.

An offeror may submit more than one proposal in response to this topic, but each proposal should cover only one area of interest. For each effort, Phase I should produce a complete analysis of the concept's feasibility, a prediction of performance characteristics, and a design of a proof of principle model. Technical issues such as high efficiency, lightweight, long life, and high reliability are of prime interest. In Phase II, small-scale models will be fabricated and tested under simulated operational conditions.

AF89-188 TITLE: Self-Deploying Space Structures

OBJECTIVE: The objective of this project is to determine the feasibility of fabricating a roll up self-deploying laminate antenna reflector for space applications.

DESCRIPTION: Technology needs to be developed to enable the Air Force (AF) to have simplified deployment of specialized structural components in a space environment. Composite materials can be fabricated so that they are pliable and can be folded or rolled into low weight, small packages. This project will demonstrate that an antenna reflector can be fabricated in such a way that, when rolled up, it will deploy into its original constructed shape without the use of actuators. Thus a network of antenna reflectors or other similar structures could be launched into space and deployed for communications or energy focusing. Various laminate constructions will be studied and fabricated to determine the proper laminate orientation for memory retention. In Phase I the contractor will perform design analysis to determine the optimum laminate designs, and will then fabricate subscale panels. Material systems to be explored for this program should include graphite epoxy and thermal plastic materials, along with other promising material systems. The contractor will determine how to best measure various constructions and materials for rollability, compaction, and memory retention. In Phase II using the data obtained in Phase I from the subscale components, larger panels simulating space antenna reflectors will be fabricated from the most promising designs and materials. The contractor will also measure the rollability, compaction, and memory retention of these structures using the techniques developed in Phase I. One of the most promising Phase II structures should be demonstrated in a simulated space environment.

AF89-189 TITLE: Development of Acceptance Criteria in Carbon-Carbon Materials for Space Structures

OBJECTIVE: The objective of this task is to develop material models with capabilities of treating non-uniformities present in Carbon-Carbon Materials with respect thermomechanical properties and strength of Carbon-Carbon Materials.

DESCRIPTION: Carbon-Carbon (C-C) Materials, due to the nature of their fabrication and processing, frequently contain flaws. These flaws typically consist of broken fibers, bowed or misaligned fibers, matrix cracks, and other inhomogeneities such as extremely porous regions resulting from poor impregnation and carbonization. To date, there is little understanding of the effects of these flaws on the thermomechanical properties and strength of Carbon-Carbon Materials. The development of imperfection acceptance criteria for C-C materials is of prime importance to the successful utilization of these materials in space structures. The expense of C-C materials precludes a comprehensive test program from being performed to develop the acceptance criteria. Consequently, a successful acceptance criteria development program must utilize mathematical material models which will allow the effects of imperfection to be determined. In the Phase I of the program the contractor will develop material models with the capabilities of treating non-uniformities in composite materials. The contractor will look at the C-C material structure and determine the types of anomalies to model. Material models will be developed which will allow evaluation of the effects of various types and sizes of imperfections upon the thermal and mechanical properties and strengths of C-C composite structural elements. In the Phase II of the program the application of these models to generate quantitative information to allow the development of acceptance criteria should be addressed. The contractor should look at verifying his analytical models through fabrication, inspection, and mechanical testing if necessary. A first-cut imperfection criteria for C-C composites for space structure applications is a Phase II deliverable item.

AF89-190 TITLE: Dynamic Computer Tomography

OBJECTIVE: The objective of this program is to demonstrate the feasibility of obtaining computed tomography (CT) data of solid propulsion system while it is being fired.

DESCRIPTION: There is currently no method of obtaining CT data on a motor or nozzle assembly while it is being statically test fired. The designers and users of propulsion system depend upon analytical models to describe motor burning characteristics and to describe the charring and erosion of ablative insulators and liners. A dynamic CT system would provide actual experimental data in place of postulated model data. If dynamic CT ability is achieved, the solid propulsion designers, scientists, and engineers will have a tool that can provide information about localized grain burn rates around the motor within slot and fin cavities, and the capability to study anomalous burning and charring in a solid rocket motor. Overall this tool would yield a better understanding of motor performance. The advantage of "real time" CT over real-time-radiography (RTR) is that the data is quantitative in nature. Position of the events are recorded in three dimensions. The basic theory of CT and experience inspecting rocket motors and nozzle components indicates that CT should provide the desired data. In Phase I the contractor will determine the feasibility of obtaining dynamic CT and the contractor will design the dynamic CT system in Phase I for use in the Phase II demonstration. The contractor will work with the AF project manager to determine what AF facilities are available to be used in Phase II feasibility demonstration. Phase II will consist of feasibility demonstrations of the dynamic CT concept, data reduction, and reporting. The results from this project will be used to provide direction on future technology programs to achieve a real-time CT capability integrated into a motor test stand.

AF89-191 TITLE: Hydrogen Storage in Metal Hydrides

OBJECTIVE: To develop a rechargeable hydrogen storage system employing metal hydrides as the storage medium.

DESCRIPTION: Hydrogen has long been recognized as an attractive energy source. It's high energy output per unit mass makes hydrogen not only a desirable alternative energy source in an internal combustion engine to power motor vehicles, but an ideal fuel for space applications and rocket propulsion where a high energy density is particularly important. Such a use relates to Project Forecast II's High Energy Density Matter effort. One to the problems with hydrogen's wide spread use as an energy source is the difficulty associated with storage. Container weight and safety considerations are problems with gas storage and large amounts of energy are consumed in the liquidfaction process if the hydrogen is stored as the liquid. The use of metal hydrides may provide a safe and effective storage medium. The hydride formation is reversible, produces a stable product, and a unit volume of the metal hydride can hold more hydrogen than gaseous or liquid hydrogen. A metal hydrogen storage system would be appealing for space applications in two ways. First, a stable method of hydrogen storage would eliminate problems associated with cryogenic storage, such as tank leakage and required weight/volume ratio of tanks. Secondly, the metal hydride storage system itself could be used as an energetic fuel for propulsion or power generation. The research to be performed is in this area of hydrogen storage using metal hydrides. Innovations need to be developed to improve the kinetics of hydrogen uptake/release, determine how to prepare the metal for maximum hydrogen loading, and examine which metals or alloys are most suitable for the stated application (e.g. have energy densities by weight and volume that surpass the current iron-titanium hydride). Success will be measured by comparison to existing space storage systems. Phase I would examine the potential for such storage schemes and would include the evaluation of several different metals as a storage medium. Phase II work would involve experiments using selected metals in developing storage and release methods. The work would lead to a storage system that could be employed as an energy source.

AF89-192 TITLE: Technology for Storage, Handling, or Use of Antimatter

OBJECTIVE: Develop technology in the area of: 1) analysis of matter-anti-matter annihilation radiation; 2) prediction of its products and effects; or 3) safe long-term, high-density storage systems for antimatter.

DESCRIPTION: Antimatter is composed of quantum mechanical particles which have reverse properties of their normal matter counterparts. When antimatter and matter are allowed to interact, the entire mass of both is converted into energetic radiation, mostly charged pion and gamma rays in the near field. The property of antimatter has led to

concepts for the use of stored antimatter as an analytic radiation source in the near term, and as an energy source for rocket propellant in the far term. Proposals are sought to design and demonstrate an element of the technology needed to use antimatter which: 1) can be developed within the funding and time limitations of an SBIR procurement, 2) can be demonstrated using an appropriate for of normal matter (a normal matter analog) to simulate antimatter. For instance, solid hydrogen could be used as a normal matter analog of solid antihydrogen in a magnetic suspension system. Examples of the technologies sought include: wide angle, high-resolution x-ray fluorescence, annihilation gamma ray, or charged pion detector arrays to locate and characterize annihilation sites within normal matter; storage systems for charged or neutral solid antihydrogen; computer models and software for predicting annihilation products and their effects; and other innovative technologies. The first phase of this effort shall consist of a design for the proposed technology element. In Phase II, the selected item shall be built and demonstrated with a normal matter analog. Designs shall consider (as applicable): radiological safety with respect to annihilation rates; vaccum requirements; temperature requirements (solid antihydrogen storage will probably require a 1 deg Kelvin radiative heat sink); proposed uses of the technology uses of the technology; and other appropriate constraints.

AF89-193 TITLE: Separation and Purification of Propellant Polymers

OBJECTIVE: To develop innovative separation and purification techniques for propellant polymers with the use of gases that are super critical solvents at laboratory pressures and temperatures.

DESCRIPTION: Solid rocket motors are composed of a powered fuel and granular oxidizer which are held together by a polymer called a binder. There are numerous examples in the solid rocket propulsion community where rocket motor failures can be traced to the presence of very low molecular weight contaminants. Traces of monomer and dimmers that form in the initial production of the binders are thought to be the cause of some of the problems. Most binders are cured with an isocyanate curative, hence, water can interfere with the cure reaction and can also cause the cast rocket motor to fail. Super critical fluid extraction has been shown by M. McHugh and V. Krukonis to be a valuable technique of extracting low molecular monomers and dimmers from certain polymer systems. This liquid can then be used to extract different components depending upon the pressure of the systems. The high molecular weight polymer is virtually insoluble in this compressed heated gas while the low molecular weight material is easily removed when the gas is vented to another container.

Phase 1: Super Critical Extraction Parameters. Develop innovative methods of containing viscous propellant polymers in a high-pressure extraction cell. Determine the solubility parameters for various propellant polymers in super critical fluids. Measure the relative purification and molecular weight fractionization of propellant polymers.

Phase 2: Design of Extraction System for Propellant Ingredients. The solubility data from Phase I will be used to design an extractor that can be used for binders and other propellant ingredients.

AF89-194 TITLE: High-Sensitivity Short and Medium Wave Infrared Cameras

OBJECTIVE: Design of ground and space based short and medium wave infrared cameras of high sensitivity.

DESCRIPTION: Short wave infrared (SWIR)/medium wave infrared (MWIR) measurements are needed to characterize (1) emissions produced in space by shuttle surfaces, particulates, other spacecraft contaminants, and engine plumes, and (2) the spatial variability of atmospheric infrared emissions. The expected military consequences of these emissions include degradation of optical and infrared surveillance sensors by local background emissions and failure to discriminate targets against a structured infrared atmospheric background, as well as the betrayal of space assets to hostile forces. New cameras for direct imaging and analysis of these infrared signatures can be based on recent technological advances, with platinum silicide or other materials, that have produced infrared detectors characterized by high sensitivity, low noise, and large high-density linear and mosaic arrays. This abstract has two separate tasks, which can be responded to either separately or jointly.

Task A: Space-Qualified Camera for Optical Emissions in Space. Cameras that employ large-array detectors can have high sensitivity because they are staring instruments; that is, the whole image is recorded at once rather than over an interval during which the object is scanned. Prototypes have been very successful, and the advantages of this

technology should now be extended for use in space. The objective of this task is to design and build a camera for a series of space experiments aboard the space shuttle and shuttle-borne spacecraft. It should be adaptable to almost any flight opportunity by designing for compatibility with typical shuttle and spacecraft support platforms. The Phase I product is to be a preliminary design. It will start with existing detector technologies, laboratory model, and flight-feasibility study; include an assessment of the sensitivity required to match the expected brightness of emissions to be studied; progress to selecting and optimizing detector material and type, maintaining the detector cryogenic temperature, handling the large volume of digital images, and assuring space-qualified mechanical and optical designs; and result in meeting the requirements of a typical spacecraft preliminary design review. Phase II will produce the final design and construction of a prototype flight instrument, for which the Air Force Geophysics Laboratory will seek an actual flight opportunity in which it will be used to study spacecraft environmental interactions.

Task B: Ground-Based Camera for Atmospheric Emissions. This task proposes the design of a sensitive high-resolution infrared camera for the direct measurement of atmospheric emissions in observational programs using both ground and aircraft-based sensors. The camera is to observe auroral and airglow emissions in the wavelength region extending from approximately one to six microns. The Phase I product is to be a feasibility study of different experimental approaches and the presentation of a proposed camera design. Design consideration should be given to providing high sensitivity, high spatial resolution, subsecond temporal resolution with a time-averaging capability for weak emissions, flexibility in the observation of a series of different wavelengths, radiometric precision, and a wide dynamic range. Particular emphasis should be given to approaching the theoretical limits of measurement capability in signal-to-noise ratio and spatial resolving power. The Phase II effort will construct a prototype camera, test and calibrate it against laboratory sources, and perform demonstration measurements of ground-based night-sky airglow emissions.

AF89-195 TITLE: Ultra-Narrow Band, Tunable, Super-Sensitive IR Detector

OBJECTIVE: To develop a prototype Ultra-Narrow Band, Tunable, Super-Sensitive Infrared (IR) detection system.

DESCRIPTION: Satellite-based, infrared surveillance and tracking systems must discriminate infrared targets from spatially and temporally structured backgrounds in the upper atmosphere. In many applications, the performance of the surveillance system is limited by the brightness of the target signature relative to the brightness of the background. The signal to background limitation is particularly severe in the nuclear-disturbed atmosphere. With a sufficiently sensitive infrared detector, narrow band techniques can be used to maximize the ratio of the target signature (from a missile plume for example) to that of the bright background. In the past, detector sensitivity has limited the applicability of narrow band techniques. However, the development of the super-sensitive, solid-state photomultiplier (SSPM) permits the detection of single infrared photons. In addition, 56x1 and 6x6 arrays of SSPM detectors have been fabricated and tested. The unprecedented level of sensitivity makes possible the development of Ultra-Narrow Band, Tunable, Infrared detection system which operate in the SWIR-LWIR wavelength range. The objective of this program is to design, fabricate, and test an Ultra-Narrow Band, Tunable, Infrared detection system using a single SSPM detector element will be designed. The sensor will be fabricated and tested to verify the projected performance of the sensor in Phase II.

AF89-196 TITLE: Development of Remote Sensing Algorithms for Atmospheric Path Variables from Radiometric Data

OBJECTIVE: Provide innovative framework in which to design/optimize inversion algorithms for arbitrary spectral data, so as to include particulates, scattering, non-local thermodynamic equilibrium (NLTE), etc.

DESCRIPTION: DoD’s reliance upon successful operation of existing and proposed Electro-optical (E/O) sensors from surface, air and space platforms requires optimized descriptions of the environmental path. Path parameters that can influence signatures include the conventional variables (temperature, pressure, and molecular constituent profiles) and a host of non-standard but critical elements (multiple scattering, aerosols, clouds, rain, surface properties, and NLTE). This complement of path parameters can potentially provide the largest source of error in predicting the performance and success of E/O systems.

Phase I for SBIR should explore the feasibility of incorporating non-standard atmospheric elements into line-by-line path characterization (inversion) algorithms. Innovative approaches for defining the required physical parameterizations of one or more of these components, evaluating signature levels, accuracies and information content, will be required. Special emphasis should be placed on implications for multi-spectral instrument design to isolate spectral signatures that are slowly varying (i.e. spectral dependence of aerosol size distributions, cloud identification, polarization effects, etc.), as well as the more rapidly varying molecular line signatures (absorption cross sections and NLTE).

Phase II would then entail the implementation of these new algorithms for direct inversion of non-standard variables in conjunction with existing state-of-the-art high resolution spectral radiance modeling using the AFGL Fast Atmospheric Signature Code (FASCOD3). FASCOD3 currently models exact forward radiance predictions basedon "complete" picture of the path variables, including the non-standard elements. (In addition, significant advances in inversion algorithm development already allow generic inference of atmospheric content for conventional variables (path characterization) in conjunction with FASCODE.) Coding concepts developed under this SBIR will enable the DoD community to improve design specifications and interpret critical signature definitions. These algorithms should incorporate state-of-the-art interactive analysis and programming schemes.

AF89-197 TITLE: Cloud-Free Conditions Specified From Satellite

OBJECTIVE: Determine the extent to which cloud-free lines-of-sight and paths-of-travel can be specified using radiometric data from satellites.

DESCRIPTION: Interactions between military systems (friend-friend or friend-foe) which must take place through the potentially cloudy portions of the Earth's atmosphere are in many cases significantly impacted by the presence of clouds within the operating line-of-sight or path-of-travel. (Path-of-travel is the track made upon any intervening plane, e.g. a cloud layer, by the unbroken interaction for some time period between two systems layer, by the unbroken interaction for some time period between two systems moving relative to one another). Attempts have been made to quantify the probability of these cloud-free conditions during such interactions based upon cloud observations made at surface locations or, to a lesser extent, from aircraft. The input to such techniques is invariably a surface-based estimate of sky-cover. These assessment schemes are suspected of being site-specific and are known to deal poorly with the situation of interaction from orbit to within-atmosphere, or vice versa.

Since the advent of environmental satellites more than 25 years ago, the possibility of quantifying cloud-free conditions from orbit has, to some extent, existed but the technical challenge is still the exploitation of that possibility. The compelling reasons for utilizing satellite data for this purpose are: (1) the close comparative nature of environmental orbital sensors to orbital surveillance systems, (2) the global scope of coverage offered only by satellite platforms, (3) the high refresh-rate afforded by orbital remote sensors, (4) the nearly equal ability for making cloud-free assessments during day or night. The satellite is the only alternative data source in areas where conventional meteorological information is nonexistent or can be denied. At present no technique for assessing cloud-free conditions based solely on satellite data exists.

During Phase I, a detailed specification will be made of what can be determined in regard to cloud-free assessment using present (and planned) satellite measurement systems. Considered must be domestic (both civilian and military) and foreign (e.g. SPOT) satellite imagers. The topics of sensors resolution, cloud/no-cloud discrimination, multi-channel detection and off-nadir data correction must be addressed. In addition, prototype assessments of cloud-free conditions using examples of satellite images containing varying amounts and types of clouds (total number of such images, at least 30) taken from at least 4 different satellite platforms will be accomplished during Phase I. The main thrust of the Phase II effort will be the quantitative inter-comparison of satellite cloud-free specifications with similar assessments accomplished from the Earth's surface using digital whole-sky cloud images will be provided as Government Furnished Equipment (GFE). The other major Phase II task will be the development of optimal techniques for specifying (analytically or in probability terms) cloud-free lines-of-sight and paths-of-travel under various cloud conditions using satellite data only.

AF89-198 TITLE: Programmable Signal Processor for Real-Time Doppler Lidar Wind Measurements

OBJECTIVE: Design and build a programmable processor for computing real time estimates of atmospheric winds from Doppler lidar signals.

DESCRIPTION: Air Force applications of Doppler lidar wind sensors range from space-based global wind measurements to airfield wind shear detection. One requirement that many of these proposed operational systems share is the need for real-time data processing. The Doppler shifted backscatter signal contains information about the winds, turbulence, and aerosol content of the scattering volume, but these parameters must be estimated by time consuming spectral analysis. Conventional computer architectures are simply not well suited for performing these computations in real-time for most Doppler lidar applications. Furthermore, wide signal dynamic range, typically up to 80 decibels, presents problems for many off the shelf processors. The purpose of this contractual effort will be to apply new advances in signal processing technology to the design and construction of a high-speed programmable signal processor for a CO2 Doppler lidar system (outlined below). Such a processor will have application in numerous ground and space-based Doppler lidar applications. This processor must be programmable to allow for the development of new data reduction algorithms and must be capable of computing estimates of mean wind speed, turbulence, and backscattered power. These computations must be done in real-time for the following ground-based lidar system:

Laser Transmitter:	Pulsed CO2 TEA laser
Laser Wavelength:	10.6 microns
Pulse Width:	1 microsecond
Pulse Repetition Frequency:	up to 100 pulses per second
Receiver:	Heterodyne, 40 MHz offset
Maximum Measurement Range:	30 Kilometers
Doppler Wind Bandwidth:	20 MHz (-50 to +50 meters/sec)

Inputs to the proper Doppler processor will be the in-phase and quadrature (I and Q) components of the received backscatter signal. These signals will be centered at baseband and have a half bandwidth of 10 MHz. Output of the processor will be digital data passed to a VAX Unibus computer via a parallel direct memory access (DMA) interface.

Phase I should result in a complete processor design, which is viable, will be built and tested under Phase II. Final testing will be performed with the processor connected to the working lidar outlined above. While this processor will be used for a specific ground-based application, some attention should be given to how the results of this effort could apply to other lidar applications, such as space-based lidar wind sensing.

AF89-199 TITLE: Tunable Narrowband Optical Filters (TNOFs)

OBJECTIVE: Design and construct narrow bandwidth optical filters.

DESCRIPTION: Two specifications are possible within this topic: TNOFs for solar telescope application or for daylight lidars. This abstract has two separate tasks, which can be responded to either separately or jointly.

Task A: Solar Telescope Application. The forecasting of solar activity and its impact on space weather and DoD systems and operations relies on the observation of solar spectral lines which are used to deduce spatial and temporal distributions or temperature, pressure, velocity, and magnetic fields and their relationship to solar activity. By introducing computer controlled operation of a suitable optical filter system, it should be possible to achieve very rapid spectral tuning across not only one but several spectral lines in sequence. If the lines selected are formed at different heights in the solar atmosphere, information concerning the physical properties of the atmosphere across a three-dimensional grid could be obtained. While optical filters yielding high quality two-dimensional images for computer-controlled rapid scanning across one or more spectral lines represents a challenge to current technology, the solution to which would be of considerable value to many electro-optical projects and laboratories. Phase I would explore the problem of rapid computer-controlled scanning across a single spectral line and the development of a prototype system. Provided Phase I is successful, Phase II would concern the development of a prototype

system capable of scanning across several spectral lines and its replication for installation at a number of ground-based solar observatories.

Task B: Daylight Lidar Application. Air Force Lidars are used to measure neutral density and meteoric atomic species in the middle atmosphere (30-100 km altitudes). However, the strong radiance of the daylight sky contributes to the background noise of the optical signal and typically limits Lidar to a night-only operation. To block out this background radiation a novel filter with a narrow bandwidth is required. Requirements for the optical filter are as follows: a characteristic response time smaller than 100 ns; a bandwidth equal to or less than 0.001 nm; and a quantum efficiency greater than 10%. The filter must be designed an packaged so that it can be coupled to a signal-limited detector (e.g. cooled photomultiplier) with a high combined efficiency. Noise power from the filter has to be negligible or comparable to detector noise. It must operate on one of the wavelengths of interest to Rayleigh Lidar: second harmonic of Nd:YAG or XeF excimer; or resonance Lidar: NaD2, Ca(II) 393 nm, or Fe(I) 372 nm. In Phase I, filter concept and a careful design of the filter-to-detector coupling will be developed. In Phase II, the offeror will optimize efficiencies, fabricate and test the filter/detector. Testing the prototype with an operating Lidar will be required.

AF89-200 TITLE: Nonlinear Materials Development for 0.8 and 1.315 Microns

OBJECTIVE: Improve nonlinear optical properties of materials that operate at 0.8 and 1.315 microns.

DESCRIPTION: Nonlinear materials that operate at 0.8 and 1.315 microns are needed. The goal of this effort is to improve the nonlinear optical properties of materials that operate at 0.8 and 1.315 microns. These materials will be used for four-wave mixing in laser systems. It is required that the materials have: 1) damage thresholds greater than 1 MC/cm2, 2) response times less than 1 millisecond, 3) high sensitivity (milliwatts of pump power), 4) high nonlinear gain (two orders of magnitude, better than Kerr-like onlinear media such as Carbon Disulfide), 5) good optical quality, and 6) have heat transfer ability.

The lasers will be either continuous wave or pulsed. Materials used in pulsed lasers must have reasonable memory. Specific properties of interest are CHI(3), response time, and high efficiency. Both organic and inorganic materials will be considered. The ability to reproduce optical properties in samples is also of interest. Phase I: Provide a conceptual demonstration of potential or give detailed analysis of the selected material. This demonstration or analysis needs to show that the material can meet the required specifications. Phase II: Develop optical quality nonlinear material, test and deliver samples of the material. Determine the effect of varying the processing parameters, material composition, and crystal structure on nonlinear material properties. Employ approved characterization and testing techniques to monitor the progress of the work and ensure that the development program yields a material with the specified properties.

AF89-201 TITLE: Far Field Radiation Patterns in the Presence of Air Breakdown

OBJECTIVE: Develop and experimentally validate an algorithm to model far field radiation patterns in the presence of microwave induced air breakdown.

DESCRIPTION: Background. Air breakdown occurs when ambient free electrons are accelerated by an intense electrical field to energies beyond ionization thresholds resulting in an exponential build-up in electron density. When this happens the build-up can block the transmission of further energy through the charged region. Air breakdown is the limiting factor in propagating an intense microwave pulse through the atmosphere. Phase I. To enhance our ability to model high power microwave propagation, the contractor shall develop an algorithm to model the far field radiation patterns in the presence of air breakdown. Consideration shall be given to both breakdown at the source and to tail erosion along the path of propagation. Any computer processing associated with this effort shall be performed using the computer facilities of the Air Force Weapons Laboratory. Phase II. In Phase I the contractor shall develop a test plan and experimentally validate the developed algorithm using a laboratory scaled device. Air Force high power microwave sources may be available if the contractor can substantiate that a lab scale experimental setup is not feasible. The algorithm, test plan, and a final report are the deliverable products.

AF89-202 TITLE: Mobile Automated High Power Microwave Diagnostic System

OBJECTIVE: Develop microwave diagnostics system which automatically acquires, stores, and reduces data from mobile, pulsed high power microwave testing.

DESCRIPTION: Testing of military systems for effects induced by high power microwaves (HPM) is carried out at a number of sites nationally, including both open air-field test sites and controlled anechoic chamber environments. Accurate characterization of the various free field electromagnetic quantities is a key prerequisite to interpretation of these effects tests. Parameters of interest include radiated power density, frequency spectrum of the radiated envelope, envelope shape, and antenna pattern. Because HPM testing is presently carried out by a wide variety of personnel and organizations in both controlled laboratory environments as well as poorly controlled field environments, there is little standardization in measurement techniques. The problem is especially severe in open air field tests because time and space limitations often prevent a full complement of diagnostics from being utilized.

A need exists for a fully automated compact, self-contained HPM data acquisition system which will operate under the direction of a personal computer to rapidly acquire, reduce, and achieve data in a harsh field environment. Because next generation HPM sources will repetitively pulse at multi-Hz rates, novel, innovative diagnostic recording, analysis, and storage techniques will be required to interpret the rapid stream of digital data. Because rapid setup and ease of transportation is key criterion, the HPM diagnostic sensors themselves should be few in number, physically robust, and adequately broadband to characterize electromagnetic environments from sub-GHz to x-band frequencies.

Phase I work will involve innovative design of a set of broadband, physically robust microwave sensors, definition of novel PC-based data reduction and archival algorithms, and selection of appropriate signal capture instrumentation. Together, the system of broadband sensors, fast signal storage, and PC based archival storage resulting from the Phase I study should allow data capture at a minimum of 2 Hz repetition rates and setup in a field test environment by 2 people in a half day. Phase II work will involve fabrication, testing, and optimization of the HPM sensor concepts, acquisition of the signal storage hardware, and implementation of the hardware and software concepts developed under Phase I.

AF89-203 TITLE: Pulse Compression Techniques for High Power Microwave Applications

OBJECTIVE: Investigate the feasibility of using advanced pulse-compression techniques to increase peak output power of high power microwave sources.

DESCRIPTION: Conventional hot cathode microwave sources, such as the klystron, have demonstrated electrical to RF energy and power efficiencies exceeding 50 percent for multi-microsecond pulse length and repetition rates exceeding 100 Hz. If the microwave energy produced from such a source in a period of tens of microseconds can be stored, and then released in a timescale of a microsecond or shorter, then potentially short pulses of gigawatt level microwave power can be produced. To date, such high power levels have only been achieved in relatively low efficiency cold-cathode field emission devices, such as the virtual cathode oscillator.

Advanced concepts related to the creation of high efficiency, high-energy storage, gigawatt output power pulse compression cavities are needed. Consideration should be given to novel and innovative solutions to the relevant physics and engineering aspects of the overall source/pulse compression cavity/antenna system. These include optimizing physical shape of the storage cavity, materials selections, and method of switching of the RF energy to the output waveguide. The newly developed class of superconducting materials which operates at liquid nitrogen temperatures offers potentially substantial increases in energy storage time and overall efficiency.

Phase I work should explore the feasibility of using advanced high efficiency pulse compression cavities for the following two potential applications: (1) creating gigawatt output power levels from existing or near term state-of-the-art hot cathode microwave sources, and (2) increasing peak output power from existing cold cathode field emission sources to the multi-gigawatt level. Phase II will involve an actual technology demonstration of the most promising concepts developed under the Phase I work.

AF89-204 TITLE: Phased Array Imaging Telescope

OBJECTIVE: Develop new optical designs for spaceborne optical phased array imaging systems having the resolution of a very large single telescope.

DESCRIPTION: The phased array imaging telescope concept has a number of advantages over traditional single telescope systems for space applications where very large effective apertures are required for high resolution. Primary mirrors may be relatively small, lightweight and easy to fabricate and test. The system may be launched either folded up or in pieces, but with individual subtelescopes fully assembled and aligned. The whole system may then be assembled or unfolded with automatic alignment systems doing the critical adjustments.

The phased array telescope must be designed so that the subtelescope positions with respect to each other are not critical. A servo system then adjusts the smaller beam combining optics to superimpose and phase the multiple images to give the resolution of a single very large telescope. This is a relatively simple problem for narrow field of view telescopes used for astronomy or for laser beam projection, but has never been done for a wide field of view.

The key problem is to superimpose and phase the images from each of the subtelescopes at the focal plane where a video sensor or a piece of photographic film resides. Doing this over the entire field of view simultaneously requires that telescope aberrations such as field curvature and distortion be reduced to levels never before required of an optical system. Heretofore, insignificant variations in the magnification of the telescopes or in the thickness of refractive elements can prevent the telescope from working properly. Alignment requirements among the subtelescopes can also become prohibitively tight.

The Air Force is interested in phased array telescope designs with the potential to be built with effective aperture sizes of ten meters or larger with a 30 arcminute or greater fields of view. The telescopes must give essentially diffraction-limited performance from visible through mid-infrared wavelengths. In Phase I of this project, the contractor should develop a conceptual optical design for a phased array imaging system. At the end of Phase II, the contractor should have an optical design for a laboratory scale demonstration project. Practical considerations such as the ease of fabrication, testing, and alignment of the optics and the requirements for the servo control system (if any) should be completed in this phase.

AF89-205 TITLE: Development of Computational Methods for Chemically Reacting Mixing Problems

OBJECTIVE: To develop robust computational methods to deal with various single and two-phased chemically reacting flows and mixing processes.

DESCRIPTION: The Air Force is interested in examining the various parameters that effect single and two-phase chemically reacting flows such as in spray reactors, subsonic and supersonic mixing nozzles and combustors, where mixing plays a very important role. Transverse injection of one of the reactants into the primary flows can enhance mixing but may not improve the chemical reaction. Two-phase flows often involve a reaction between a gas and either solid particles or liquid droplets. Decreasing the droplet or particle size increases the effective surface area for reactions to occur, but the increased number of particles and closer distribution can have a dramatic effect on the surrounding neighbors and the gas concentration. Also, smaller drops may get depleted, which may or may not be desirable depending on design consideration. When injected transverse to the primary flow, smaller particles or droplets will have less momentum than larger particles or droplets for a given initial velocity and may get swept along with the free stream before reacting entirely or collecting on an opposite boundary. A design tool is needed to address the various parameters that effect the mixing processes and single and two-phase flows. Tractable methods must be found to model these effects and explore their chemical efficiency.

The end product of Phase I will be an extensive review of existing methods for modeling single and two-phase chemically reacting flows, three-dimensional turbulent mixing, and laminar and turbulent transverse jet and/or particle injections into a free stream. In addition, there will be a demonstration, on a limited scale, of the feasibility of the proposed innovative methods.

The end product of Phase II will be the development of robust methods available for government and industrial use in various applications of combustion and spray reactor design.

AF89-206 TITLE: Video Optical Disk Characterization and Control

OBJECTIVE: Innovative approaches to characterization and control of video optical disks in image analysis system.

DESCRIPTION: Investigations of advanced tracker performance frequently require a programmable access to long time sequences of video imagery. Real-time digitization and storage of large numbers of video frames can be accomplished with specialized, high speed arrays of parallel hard disks. An alternative approach which offers potentially greater payoffs in programmability and cost is the use of analog video optical disks as interim analog signal storage devices. These disks are programmable and can be controlled by micro and mini computer systems with video digitizers to allow sequential digitization of long time series of images at greatly reduced data rates.

Phase I: Innovative approaches to the control of analog video optical disks in support of tracker imagery analysis and database management are sought. Characterization of video disk transfer functions using test video sequences are desired to allow assessment of the loss of fidelity due to the extra analog process in this approach. Studies detailing an approach to control of the video devices from both micro and mini computer systems, and integration with image processing workstations are desired. The Phase II effort would produce a demonstration system.

AF89-207 TITLE: Excited State Populations in a Neutral Particle Beam

OBJECTIVE: To determine the excited state population distribution of the hydrogen atoms in a neutralized energetic hydrogen beam and to implement the information to determine applicability of non-intrusive beam sensing techniques for neutral particle beams.

DESCRIPTION: Neutral Particle Beam (NPB) direction sensing is a critical concern for systems applications. In order to accurately implement the beam the precise direction of propagation must be known. Demonstrator systems can implement several techniques for beam sensing due to the lower duty factor, current, and energy. Laser resonance fluorescence (LRF) and Doppler shift sensing techniques, which are non-intrusive and rely upon the presence of excited state populations in hydrogen to be present, are the current candidates for the higher level systems. There are concerns regarding the predicted low level signal to noise ratios for these techniques which could cause the methods to fail. Calculations have been performed to determine the excited state populations expected following a foil neutralizer; however, the assumptions which have to be made for the calculations are significant. The excitation of the neutral hydrogen occurs through the collisional stripping in the foil neutralizer. There is a need to adequately evaluate the beam sensing techniques as applied to actual systems; therefore, a measurement of pertinent excited states should be made to provide a sound technical basis for determining viable beam sensing techniques.

In Phase I, the technique for the absolute measurement of several excited state populations in an existing neutral particle beam system (such as an ANL or BNL) will be designed. The design of the technique should be made as to be germane to the proposed designs for beam sensing, especially in the distance from the neutralizer to the point of measurement. In Phase II, the result from Phase I should be expanded to include demonstration of the technique and measurements on a range energies of the NPBs in order to determine scaling to an actual weapons grade system. Comparison with theoretical predictions shall then be made. The applications of the results to determine the feasibility of the beam sensing techniques for future application to NPBs shall be included.

AF89-208 TITLE: Passive and Active Countermeasures Against Multi-Spectral Target Illumination

OBJECTIVE: Develop and demonstrate passive systems and/or active systems that prevent laser-guided munitions from homing in on a target.

DESCRIPTION: Future battlefields will use smart munitions that are guided to their target by detecting reflected light from a laser-illuminated spot. These laser illuminators may use different wavelengths and the illuminated spot size will vary as a function of laser design and range to target. Air Force assets as surface to air missile sites, mobile air traffic control facilities, and armored vehicles will be some of the targets that an opponent will want to destroy. To improve survivability of these assets, it is proposed that innovative ideas be investigated that can passively absorb incident laser light such that there is no reflected light (laser spot is not visible to incoming smart munitions) and/or active systems that passively detect the incident radiation and, through a response action, dispense an aerosol (or other mechanism) that scatters the incident laser beam such that smart munitions can not home in on a reflected laser spot. Some of the challenges to this problem are: (a) any passive material for absorbing incident laser radiation should not enhance the ability for detection in another portion of the electromagnetic spectrum; (b) a system that uses passive sensors to detect incident laser radiation must be able to discriminate laser light from sunlight/head-lights and be in sufficient numbers to detect any illuminating laser spot (laser spot incident on target); (c) an active system that dispenses an aerosol must take into consideration vehicle velocity, wind direction, that military personnel may be near the mechanism that dispenses the aerosol when this machine is placed in action; and (d) any innovative approach taken must not interfere with the operational function of the asset it is to protect.

Phase I: This effort is to consider the threat to Air Force assets from laser guided munitions and present an effective countermeasure that can increase the survivability of an asset by reducing it's susceptibility to laser illumination from a hostile source. This effort shall result in a final report that gives the government the ability to determine the practicality and usefulness of a proposed solution and the threats that the solution was designed to counter.

Phase II: This effort shall be an actual demonstration of the passive/active system proposed in the Phase I final report. It is anticipated that two (2) two meter square targets, using the proposed passive/active system, shall be delivered with any necessary smoke/aerosol machinery to provide to the government two samples to be tested. Included with these sample targets shall be a final report addressing manufacturing costs of the countermeasure system, recommendations on the best methods to use the system, and limitations on the combat use of this system. This innovative system must at all times emphasize reliability in the combat environment (is it easy to install and maintain) and be cost effective when compared to the given Air Force asset it is to protect (is this system cheap compared to the asset it is on).

AF89-209 TITLE: Ballistic Missile Research

OBJECTIVE: To develop new concepts and innovations for ICBM systems/subsystems.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of ICBM systems/subsystems research, development, and acquisition. It is also intended to provide latitude to the innovator to include areas not specifically addressed by other specific ICBM topics. This general area covers the full spectrum of Air Force ICBM missions (i.e., basing, propulsion, guidance and control, defense penetration, target kill, etc.). Emphasis is placed on potential long term planning concepts. Topics as diverse as new weapon system concepts and improved operational techniques can be submitted. Some other areas of interest are high-energy fuels, maintenance free systems, facility threat, countermeasures, and innovative R&D organizational concepts, etc. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF89-210 TITLE: Generic Qualification of Electronic Piece Part Processes

OBJECTIVE: Develop a standard set of models, software, and test procedures to qualify processes instead of individual circuits.

DESCRIPTION: Currently contractors must qualify and maintain qualification on all individual electronic circuits which is an exhaustive task. Qualification testing is required initially and at six-month intervals. Generic qualification is the use of Standard Circuits (SC) and Process Control Monitors (PCM) to qualify a process which produces a family of circuits. Specifically, SCs are unique, large, common blocks of circuitry which also contain reliability test structures. SCs are designed to worst-case conditions and are used for initial qualification and quality conformance inspection testing of a process. The SCs are designed such that they will represent all circuits from a

given process. PCM's are also reliability test structures but are put on every production wafer which goes through the process to monitor and control process. Using SCs and PCMs will increase cost efficiency and produce a higher reliable part. Phase I will determine the feasibility of developing these tools and address the risk assessment, GFE requirements and manpower requirements. Phase II will develop tools to quantitatively evaluate failure mechanisms and determine worst-case conditions for a given process, test procedures, models to construct SCs and PCMs, reliability requirements and reliability evaluation tools. Generic qualification will not replace all the qualification testing required on individual circuits but will still produce a significant cost savings, improved reliability, and faster product development time.

AF89-211 TITLE: Propellant Sensitivity to Electrostatic Discharge (ESD)

OBJECTIVE: Examine propellant sensitivity to ESD, and develop a safe casting tool design.

DESCRIPTION: The sensitivity of high performance, aluminum loaded solid propellants to electrostatic discharge, is evidence from the recent catastrophic incidents over the past few years. The electrical charging of motor cases and propellant fin-forming hardware to several tens of kilovolts poses a serious safety risk. A subsequent potential impulsive electrical discharge could ultimately lead to propellant ignition. The channeling of electrostatic discharge energy into propellant combustion modes involves several steps. The most probable series of channels involve charge build-up, discharge, heat generation, propellant evaporation, ignition and final steady combustion.

It is desired to develop safe casting methods which minimize electrostatic charge build-up on tools which would reduce the risk of accidental propellant ignition through ESD mechanism. The study program proposed below will seek to mitigate this risk by first developing an understanding of the ESD phenomenon and then proposing guidelines for design of safe casting tools.

An examination of ESD propellant sensitivity requires a bottom-up approach. This implies that the most probable mechanistic channels will be identified using best engineering judgment so that a physics model can be developed. Uncertainty in our current knowledge of the controlling physics will probably mean that more than one model will be developed. A series of controlled experiments will be conducted to determine which model or models "best fits" the data.

The physics model of ESD will provide the engineer with an understanding of the key mechanisms underlying the accidental ignition of energetic solid propellants. This will enable the engineer to design a safe propellant-casting tool which minimizes the potential for inducing a set of conditions which could ultimately lead to a catastrophic event.

AF89-212 TITLE: Internal Insulation Materials for Future Generation of Solid Rocket Boosters

OBJECTIVE: Develop laboratory procedures for evaluating internal insulation materials for future solid rocket boosters.

DESCRIPTION: Internal insulation in a solid rocket booster is a layer of heat-barrier material placed between the internal surface of the composite booster case and the propellant. The primary function is to prevent the case from reaching temperatures that endanger its structural integrity. The insulation material contains filler or reinforcement embedded in elastomeric binder. When the insulation is exposed to the booster environment consisting of high radiative heat flux, impinging propellant gas and particle and shear flow, the ablation of insulation will occur. As the exposure continues, surface char material will be progressively eroded. Thus, a proper insulation design requires knowledge of the booster environment, the ablative characteristics of the insulation, and furthermore, a demonstrated reliability level desirable in rocket boosters.

The conventional approaches to choose insulation material and size the thickness relied either on the successful experience in previous booster programs or entirely on the full-scale booster firings to generate reliable data. The first approach has the benefits of cost saving but provides little improvement in current plate of the insulation technology. The second approach requires a costly and time-consuming developmental program.

If the application of the state-of-the-art materials technology and cost reduction in insulation development are desired, scale testing (6 inch lite motor) and the bench-scale testing, such as plasma-arc and oxyacetylene torch test are performed. However, correlations to relate ablation rate from these test data to full-scale booster firing data are often erroneous. The primary drawback of these testings is that they are too crude to simulate the actual booster environment.

In order to meet the objective, the Phase I of the project involves an extensive effort to (1) establish conditions of future booster environment and historical database, (2) identify the state-of-the-art and established insulation materials, (3) evaluate the available performance data, and (4) develop a laboratory procedure which simulates the actual firing environment. Phase II will conduct actual laboratory testing and correlation of the generated laboratory data with available firing data.

AF89-213 TITLE: Effect of Booster Acceleration on Insulation Erosion

OBJECTIVE: Develop standard procedures to characterize the effect of booster acceleration on the erosion rate of various insulation materials for future missiles.

DESCRIPTION: It is a well-known fact in the aerospace industry that internal insulation of a solid rocket motor experience different erosion rate between flight and static tests. For example, the erosion rate of the forward dome internal insulation of Peacekeeper motors have been known to be much higher for flight tests than that of static tests. The cause of this enhanced erosion phenomenon is the additional mechanical loading, such as shock vibration, tension and compression acting on the char layer induced by the vehicle acceleration loads. Once the char layer is removed by the acceleration loads, the underlining virgin material is exposed to intense heat flux which then leads to enhanced insulation erosion. To understand insulation performance under vehicle acceleration is important because insulation burn-through can lead to catastrophic flight failure. The need to characterize effect of acceleration on insulation performance is more important for future solid rocket motors, since future motor will subject to high acceleration field (e.g. fastburn booster). Phase I of this effort will develop analytical models to predict insulation performance under various vehicle acceleration levels. Additionally, standard laboratory methods will be developed to thoroughly characterize insulation with respect to physical, mechanical, and thermal properties, e.g. surface morphology, decomposition profile, density, and porosity. Phase II will include laboratory experiments to test the models made in Phase I. The final product provide a standard methodology based on which insulator for future high-acceleration rocket motors can be designed.

AF89-214 TITLE: Developing a Storable Injectant for Solid Motor Performance Improvement

OBJECTIVE: Develop a liquid or gaseous injectant which raises performance of solid motors, yet be storable.

DESCRIPTION: The ideas of injecting hydrogen into the combustion chamber to raise the performance of solid rocket motors has been proposed several times. The theoretical benefits are substantial; by depressing the molecular weight of the combustion products, the hydrogen (which does not burn or contribute any energy) can theoretically produce increases in specific impulse of ten percent or more. In recent tests at the Air Force Astronautics Laboratory, hydrogen injection was shown to cause a six percent gain in Isp in a motor firing at sea level. In addition, to raising performance, hydrogen injection would allow throttling of the solid motor over a certain range, and impulse management to deliver a very precise total impulse to an airborne vehicle.
Applications of this technique to ballistic missiles would have several benefits, such as reduced demand on post boost propulsion systems through more precise control of solid booster burnout velocity, range enhancement through higher delivered specific impulse, lower solid sliver through a slowdown of chamber pressure drop during tailoff, and possible elimination of staging side force problems by using injectant expansion to produce thrust at low levels for the staging event.

The technical challenge is to find a storable injectant, be it hydrogen or something else. Cryogenic liquids are out of the question for typical ballistic missile applications, and the use of high-pressure gaseous hydrogen, while it cannot be ruled out, entails significant storage and safety problems. A storable liquid or high-density gas which would

evolve a significant amount of hydrogen, yet not absorb so much energy upon disassociation as to lower performance, is desired. Ideally, the material found would be capable of self-pressurizing and self-feeding.

Phase I of this activity should consist of identification of a number of candidate materials, and selection of one or more which promise high performance through thermochemical calculations utilizing NASA SPP or some similar code. A literature search should be conducted to verify the storability of the candidate substances. Phase II will include a series of tests, conducted jointly by the contractor and AFAL, to verify performance improvement and throttleability.

AF89-215 TITLE: Developing a Standard Door For ACS Thrusters

OBJECTIVE: Produce a standard ACS door design which will meet ICBM NH&S requirements yet jettison reliably.

DESCRIPTION: The emergence of requirements for hardening ICBMs from nuclear effects brought about a problem for post boost vehicle designers which, while seemingly simple, has consistently proven one of the biggest engineering challenges on PBV programs. The problem is providing protection for attitude control thrusters during the boost phase, and them removing the protection so that the thrusters can fire to maneuver the PBV.

To date, the approach has been to place some sort of protective door over the nozzle exit plane, and rely on the first ACS firing to remove it. Thus, the door's fastening system must be weak enough to fail under the relatively small force provided by the ACS thruster. At the same time, however, the fastening system must be robust enough to keep the door on in the specified nuclear blast environments, not to mention during the dynamic load environments of transportation, basing, nuclear ground shock and boost. The worst of the nuclear effects is pebble impact, where a pebble of a certain size strikes the door at a certain velocity and angle without causing the door to be removed. The design task is therefore on of meeting contradictory requirements, a fact which is never fully appreciated until the first test is conducted. A standard solution to this problem is required, and it may take any form as long as it is applicable to any type of attitude control engine (i.e., nonpropellant, solid or bipropellant at any pulsewidth or thrust level). The standard door design should account for a combination of worst case loads from ICBM programs, such as HML vibration from SICBM, silo flyout acoustics from Minuteman, pebble impact from Peacekeeper or SICBM, etc.; it should then be applicable to virtually any future programs.

Phase I will result in a design or a set of designs along with supporting analysis. Phase II will consist of a development test program which will demonstrate door integrity under adverse conditions, followed by door removal on demand. A single standard design will emerge from Phase II.

AF89-216 TITLE: Thermal Protection Material Characteristics

OBJECTIVE: Develop test techniques to determine the characteristics of thermal protection materials.

DESCRIPTION: The following programs are of interest:

a. Conductivity of Carbon Phenolic: Investigate and measure the surface conductivity of carbon phenolic. Currently, a great deal of uncertainty exists in measurements of this surface conductivity. Factors of 2 to 10 between measurements are not uncommon. This has significant implications for electromagnetic calculations involving antenna windows which are imbedded in heatshields composed of carbon phenolic. The effort should develop accurate measurement techniques for typical carbon phenolic materials at temperatures from room temperature through temperatures associated with reentry environment.

b. Physical Properties of Antenna Window Materials at Elevated Temperature: Investigate and measure the viscosity, specific heat, density, thermal conductivity and other physical properties of reentry vehicle antenna window materials at temperatures above 5000 deg Rankine. The physical properties of these materials are needed such as silica tend to react with crucible materials. This effort should develop a design of test equipment to measure these properties.

AF89-217 TITLE: Cost Reduction in LWIR Radiometry

OBJECTIVE: Develop methods to significantly reduce the cost of long-wave infrared (LWIR) radiometry.

DESCRIPTION: Radiometric measurements of relatively low temperature objects such as ballistic vehicles prior to atmospheric reentry typically entail very expensive hardware. Sensors capable of operating at wavelengths of 20 micrometers and longer are usually desired for such applications. Individual LWIR detector elements with adequate detectivity and radiometric accuracy require exotic materials and demanding fabrication techniques. Mosaics or arrays of such elements therefore tend to be very costly. Whenever the sensor is located within the atmosphere, it must be mounted behind a suitable window or in a windowless cavity. Both options are expensive. The former, because windows with high optical quality and LWIR tranmissivity, like detectors, require special materials and techniques. The latter, because a windowless cavity must not introduce excessive distortion due to air turbulence and structural integrity/airworthiness must be maintained. Another cost factor in LWIR radiometry involves the need to cryogenically cool the focal plane array and possibly the entire optical path in front of it. New materials, fabrication techniques and design approaches are sought which hold promise of significantly reducing the cost of fabricating and/or using LWIR sensors.

AF89-218 TITLE: Aerodynamics and Flow-field Effects

OBJECTIVE: Develop techniques to investigate and measure various Reentry Vehicle (RV) aerodynamic and fluid mechanics phenomena.

DESCRIPTION: The following programs are of interest:

a. Measurement of Chemistry in RV Boundary Layers: Develop methods for making measurements of chemical interactions in shock and boundary layers of sub-scale reentry vehicle models used in a ballistic range. These sub-scale models have thin boundary layers which typically are on the order of 0.1cm thick. The specific chemical interactions and the location in the boundary layer or shock layer on the model must be identified. The presence and effect of ablation products in the boundary layer on chemical interactions should be included.

b. Measurement of Transition of Ballistic Range Models: Develop new methods to measure the occurrence of transition to turbulent flow on sub-scale conical models used in ballistic ranges. Methods other than Schlieren photography are sought to determine when and where on the model transition occurs. The influence of both thrusted and unthrusted wakes should be considered in the effort.

c. Aerodynamic Coefficients for High Performance Lifting RV: Perform tests obtaining aerodynamic coefficients that are applicable for high performance lifting reentry vehicles. The proposed project would define/develop a class of optimum Maneuvering Reentry Vehicle (MaRV) configurations of fixed geometry for glider and evader missions and to develop classes of variable geometry configurations for highly maneuverable RVs which enhance efficiency of converting kinetic energy to maneuver impulse by providing high (L/D) 3.5 over a wide range of Mach number and angle-of-attack that is possible with any fixed configurations. It is likely that fairly sophisticated CFD techniques will be needed to guide the facility selection and test matrix development.

d. Low Mach Number Aerodynamics: Algorithms are sought to estimate reentry vehicle aerodynamics at high Reynolds number (turbulent) and low Mach number flows ($0.7 < M < 3.5$). Methods for predicting the advent of the transonic angle-to-attack divergence and designs to avoid this dynamic instability phenomena are particularly of interest. In addition to engineering correlation, three dimensional inviscid (Euler) flow and Navier-Stokes models may be required. These methodologies should address the maneuvering reentry vehicle yaw stability and base drag. The offeror should be familiar with the state-of-the-art technologies.

e. Hypersonic Three Dimensional Rarefied Flows Analysis: Techniques are sought to estimate the rarefied 3D flow fields around an ascending missile or RV. Emphasis is placed on the calculation of thermal and chemical non-equilibrium phenomena. Development of 3D Monte Carlo Direct Simulation (MCDS)

approach is one approach which is ideal for the transitional flow. New concepts and formulations are sought to make MCDS faster and practical in engineering applications. Body configuration of interest is the blunt multi-conic body and the major parameters of interest are the force/moments, local heat transfer and the detailed flow properties. Flow regimes range from 10-3<kn<10 (where Kn equals the Knudsen number). Additionally novel concepts on assessing the validity of Navier-Stokes model with modified boundary conditions (e.g., surface slip, etc.) in rarefied flow environments are sought.

f. Gasjet Nosetip Flow Instability: Methods are sought to identify the mechanism of producing the flow instability observed on the gasjet nosetip ground testings at AEDC and NSWC tunnels. The objective is to ascertain the causes of these undesirable features and to find a design to alleviate the oscillating shock and unsteady flow phenomena. Specifically, ground tests at AEDC are necessary to demonstrate the validity of concept/designs which would eliminate the flow instability. The offeror should be familiar with the Gasjet design and database. He/she should have experience in the ground test diagnostic/instrumentation. A review of flight data may be required to see if this flow stability would indeed have adverse affects upon reentry vehicle performances. The offeror should quantify these instability effects from flight data if possible.

AF89-219 TITLE: Constructing Radiation Hard Semiconductor Devices on Advanced Substrates

OBJECTIVE: Design, build, and validate a demonstration chip capable of operating in radiation environments.

DESCRIPTION: The following programs are of interest:

a. Constructing Transistors on Doped Diamond Film: As the complexity of advanced reentry systems increases, the necessity for higher levels of integration grows as well. Once integration reaches an optimum level, further payoff is extremely hard to come by due to the requirement for heat sinks. The high thermal conductivity of diamond like coatings (DLCs) makes building semiconductor devices on such substrates more attractive as the level of integration increases. Additionally, the low power consumption and radiation hardness of such devices is desired. This effort will focus on constructing transistors on doped DLCs.

b. Increasing Neutron Tolerance of Analog Devices Built on SIMOX Substrate: The high level of neutron fluence postulated for the reentry mission poses a severe problem for analog devices. One way of coping with the attendant radiation environment is through the use of insulated substrates such as SIMOX. However, the structural damage caused by neutron irradiation still persists and must be addressed even for advanced substrates. This effort will focus on radiation hardening analog devices constructed on advanced substrates with the primary objective of increasing tolerance to neutron irradiation.

AF89-220 TITLE: Plasma and Optical/RCS Effects

OBJECTIVE: Develop techniques to investigate model or measure plasma effects and body and wake signatures of reentry objects.

DESCRIPTION: The following programs are of interest:

a. Reentry Body Radar Cross Section: Techniques are sought to estimate reentry body radar cross section. The radar frequencies range from 0.15 GHz to 12.5 GHz and at all possible target aspect angles. Both monostatic and biostatic radar should be considered. The body geometry is blunt cone with rounded bases and with body lengths of 20 to 250 cm. The body surface can be conducting, with dielectric layer or surface impedance. Specifically computer codes are sought for estimating the effects of: (a) antenna window; (b) plasma sheathing; and (c) 3D configuration effects.

b. Body/Wake Optical Signature. Simple and accurate methods are sought to estimate the bode/wake/plume optical signature of a reentry vehicle (RV) particularly in the near IR, visible and ultraviolet regimes. Improvements and upgrades on the state-of-the-art technologies (e.g., the optical signature code, standard

infrared model, etc.) in the areas of robustness, versatility, computer speed, propellant variations and accuracy of data input are particularly encouraged. The offerors should be familiar with the industry-standard methodologies and review the limitation and weakness of those formulations. The missing information on the existing data bank for the emissivity and other optical properties of radiating gases and particulates should also be identified. Approaches to eliminate those deficiencies should be proposed.

c. RV Flight Test Plasma Measurement Instrumentation: Develop methods to measure plasma levels (electron densities, boundary layer thickness, and collision frequency) on a RV during reentry. Currently, indirect methods such as electromagnetic interactions are used to estimate plasma levels. However, techniques, such as Langmuir probes, are needed to provide some direct measure of these quantities. Regimes of validity (e.g., laminar flow vs turbulent) for the particular method or methods chosen must be clearly identified.

d. Fast Boresight Error Computer Code: In order to perform Monte Carlo six-degree-of-freedom digital simulations of homing RVs, a more general and efficient algorithm for calculation of on-line phase shift and attenuation due to plasma is needed. Current techniques involve either massive look-up tables or simple algorithms. These tables are generated at enormous computational expense and are good for only one particular antenna and limited frequencies. The simple algorithms are based on such concepts as thin layer theory which can easily handle variations in antenna geometries but are overly restrictive in terms of the allowable plasma layer thickness and densities. Codes developed for this purpose should be applicable to a wide range of antenna configurations, frequencies, plasma properties, transmitted polarization, etc.

e. Plasma Properties Database: The frequent use in the reentry community of plasma data suggests the need for the development of a semi-empirical plasma properties database. Such a database would be extremely useful in preliminary design, simulation, and research activities in the reentry vehicle community.

The objective of this SBIR effort would be to generate a comprehensive document on reentry vehicle plasma properties. This document should reflect all pertinent ground and flight test data and employ state-of-the-art computational techniques and incorporate this data into a semi-empirical methodology suitable for making rapid, approximate estimates of plasma properties. The semi-empirical methodology developed should be appropriate for both graphical (or tabular) and computer based implementations. This database should provide means for determination of all plasma properties of interest including profiles of electron density, collision frequency, temperature, and associated integral parameters.

AF89-221 TITLE: Site Characterization

OBJECTIVE: Develop remote or on-site methods to determine engineering site characteristics.

DESCRIPTION: The following programs are of specific interest:

a. Develop remote techniques for geotechnical site characterization. Create new or adapt existing remote methods of areal study for application to investigation of locations not available for on-site study. Current geotechnical site characterization methods are dependent upon on-site methods can be costly, yielding detailed information which may or may not indicate sufficient information; gathered early in analysis, for elimination of noncompatible sites, can reduce time and cost of location suitability studies. This effort shall focus on methods of interpretation and analysis of satellite and airborne imagery, photographic and geophysical methods, and on the utility of combining any or all methods into an integrated method for remote characterization. Phase I activity will include feasibility studies with each method assessed as to accuracy, availability, cost, and resulting data. Phase II will develop and test the most promising techniques identified in Phase I.

b. Develop on-site techniques for geotechnical site characterization. Create new or adapt existing methods of on-site study using surficial and intrusive techniques to fully characterize the subsurface environment of a site. Standard procedures often rely on the use of a single method of site evaluation, such as multiple boreholes spaced throughout a location, requiring a large budget to be expended for characterization of a

single location. Well-developed and state-of-the-art nonintrusive and intrusive geophysical and geological methods should be studied in an effort to properly combine their use in a cost effective program of on-site geotechnical investigation. Emphasis shall not be limited to currently available methods but shall include applications of techniques not in standard use. Phase I will evaluate existing methods and develop the formulation of new concepts. Evaluation criteria shall include availability, quality of resulting data, and cost. Phase II will develop and test the most promising techniques identified in Phase I.

c. Develop techniques for estimating subsurface conditions prior to on-site study. Published information is not always available, or of the detail necessary for site characterization use. Develop methods of parameter extrapolation. The parameters of interest shall include, but are not limited to, geohydrologic regime, subsurface rock temperature, rock mechanics, and dynamic structures. Phase I will include a survey and analysis of techniques currently in use or proposed for use and methods considered suitable for characterization use shall be identified. Phase II will develop and test the most promising techniques identified in Phase I.

d. Advanced basing options offer cost effective basing options involving very high hardness through the use of beneficial siting. Current siting data for evaluation of advanced basing is based on limited field test data. These evaluations require a rapid method of site survey of a given area to ensure constructability and hardness potential. Remote sensing technology is available to rapidly acquire certain type of site characteristics that could significantly augment the available data and simple intrusive site testing. An automated methodology could expedite the evaluation and maximize the synergistic relations and benefits of various siting data. Phase I of this effort is intended to provide an evaluation of remote sensor and platform capabilities, and identification of a plan to develop an automated methodology to interpret both remote sensor and on-site/intrusive data. Phase II will develop the methodology with a focus on evaluating specific site characterics such as dry soil properties and water/rock depth to water/rock for a given site. Validate the methodology through a simple test.

AF89-222 TITLE: Hardened High Voltage Power Supply for Ring Laser Gyros

OBJECTIVE: Design, build, and validate a high voltage power supply for a ring laser gyro.

DESCRIPTION: A ring laser gyroscope requires a voltage on the order of a few kV for start up excitation of the HeNe laser. The voltage level needed drops substantially after start up. During a reentry vehicle mission, the power supply may undergo on/off switching for circumvention of nuclear effects. In addition, the power supply must be able to withstand the radiation environment associated with the reentry mission. Requirements for this effort include designing, building, and validating a radiation hardened high voltage power supply for a ring laser gyroscope. Particular attention should be paid to keeping size, weight, and power consumption to a minimum.

AF89-223 TITLE: Packaging Techniques to Reduce Radiation Effects on Electronics

OBJECTIVE: Develop packaging techniques for circuit boards to alleviate radiation effects on reentry vehicle (RV) electronics.

DESCRIPTION: During RV flight, a high level of nuclear radiation will be incident on the vehicle and the onboard electronics. A potentially effective way of limiting nuclear induced circuit degradation is through the use of advanced packaging techniques to shield the radiation at the device and circuit board level. Not only are total dose and neutron irradiation a problem but one must also prepare for the inevitable EMP. This effort should focus on the reduction of radiation-induced degradation through shielded packaging of the devices and circuit boards.

AF89-224 TITLE: Improved Basing Security, Safety, and Reduced Manning

OBJECTIVE: Develop techniques to improve ICBM security, safety, and reduce manning.

DESCRIPTION: Current mobile systems and several advanced basing systems introduced added problems of nuclear security, safety, and increased manning as a result of mobility. From the stand point of security the basing systems can be classed (1) as area secured where the public interface is removed from the missiles by security fences and other security measures and (2) as point secured with close-in public interface in open public land areas. Passive security measures such as a variety of sensors and surveillance devices have the advantage of reducing manning requirements but suffer from the problem of high false alarm rates or low probability of detection. Active security measures involving security and strike teams can be effective, but require increased manning to achieve the required degree of security. Mobile options requiring launchers to be in alert mode increase the manning requirements because of the needed rotation of large numbers of personnel. Phase I will investigate concepts to provide significant improvements in security, safety, and manning of advanced basing systems. These concepts might involve improved sensor and/or protective measures, automation, and other techniques. Phase II will develop the most promising options for specific basing concepts in detail.

AF89-225 TITLE: Signature Countermeasures and Tag/Implant Sweep Techniques

OBJECTIVE: Develop signature mitigation countermeasures and methods of locating implants/tags.

DESCRIPTION: Potential advanced ICBM basing systems achieve high ICBM survivability through mobility and concealment of missile locations in a secured area or in open public areas. In a secured area a large class of threat sensors that could locate the missile locations are eliminated by stand off distance. Areas of concern for these systems are (a) leakage of location information through internal agents, (b) location of missile positions by long range threat sensors, and (c) through the use of tiny implants or tags that could be deployed in any phase of missile/basing deployment life. These problems can be more severe for systems utilizing unsecured areas with public interface. Concepts for countering the missile/launch/facility seismic vibration, acoustic, and thermal signatures and methods of detecting/locating implants tags are sought. Phase I will explore one or more of these issues with several alternating solutions. Phase II of the effort will develop specific solutions through laboratory or small-scale test experiments.

AF89-226 TITLE: High Temperature Insulator

OBJECTIVE: Develop an insulative layer that would reduce the space occupied by current carbon phenolic heatshields.

DESCRIPTION: An acceptable insulative layer would, as a minimum, meet the following requirements.

a. Hot side temperature – 5000 deg Fahrenheit.

b. Cold side temperature – 400 deg Fahrenheit after 20 sec.

c. Minimum thickness – less than ½ inch.

d. Formable into conic shells.

e. Capable of transferring mechanical loads without insulative loss.

The intended use of this insulator is, on reentry vehicles, to reduce the space occupied by current carbon phenolic heatshields in severe environment regions.

AF89-227 TITLE: Development of a Heatshield

OBJECTIVE: Develop a heatshield with adequate structural strength and integrity in the presence of a large antenna window.

DESCRIPTION: The tape-wrapped carbon phenolic heatshields used on ballistic reentry vehicles depend on circumferential continuity for strength. The same quality of heatshield is needed for maneuvering reentry vehicles (MaRVs). Some of the MaRVs require large antenna windows for accurate guidance. These windows require large cutouts (12 X 12 inch min.) in the heatshield, resulting in a disruption of the circumferential wrap over a significant distance. This program would evaluate the consequences of these large cutouts on structural survivability and developed corrective solutions.

AF89-228 TITLE: Non-Destructive Tests and Evaluation (NDT&E) Techniques for Rocket Motors

OBJECTIVE: Develop portable NDT techniques and analytical models for defect/effect evaluation.

DESCRIPTION: Non-destructive test techniques for investigating defects in solid rocket motors, nozzles, cones, and other propulsion components are useful during manufacturing, acceptance and static and dynamic testing. Several techniques are in use which require extensive handling of heavy articles at certain facilities. There is a need for development of new methods for portable NDT techniques that could be rapidly and more conveniently used to support on-site fabrication, field testing (particularly the dynamic measurements), aging and surveillance as well as investigations of internal surfaces of large rocket motors. Another issue of concern is the lack of suitable engineering methods for the evaluation of effects of critical defects such as liner debonds and propellant voids on the structural and ballistic performance rocket motors. Engineering evaluation methods are also needed to evaluate the effects of fabrication and material defects in the carbon-carbon nozzle performance. Current methods for such evaluations are based on somewhat subjective assessments, experience of specific people and limited tests. These evaluations and database are expected to become less useful with time because of rapid changes in materials designs and manufacturing techniques and retirement of experience evaluators. Current methods need to be augmented with suitable engineering analysis and test methods that can take advantage of computer and material modeling techniques. This effort is aimed at the development of automated engineering evaluation methodology. An evaluation of available performance codes and the definition of propulsion systems accounting for the effects of defects is required. This effort includes investigation of methods of characterizing material properties with degradation due to defects. Phase II effort will develop computer codes for modeling material properties.

AF89-229 TITLE: Rocket Motor Test and Display Techniques

OBJECTIVE: Develop methods for testing grain burn back, insulation, and nozzle erosion rates.

DESCRIPTION: In the rocket performance testing, critical information on certain parameters is difficult to obtain and display. Examples of some of the critical measurement issues include rocket motor grain burn back, insulation erosion, nozzle throat erosion and particle distribution in rocket exhausts. This effort is aimed at the definition and evaluation of concepts leading to the development of dynamic measurements and/or display techniques for rocket testing. This effort will investigate techniques to obtain 2 or 3 dimensional topological mapping of grain burn back patterns and slag formation, insulation erosion characteristics, nozzle throat erosion rates and patterns and dynamic characterization of particle size and velocity distribution of condensable species. For the rocket exhaust, the capability to survey complete transactional scanning from the nozzle exit radius to the motor centerline is required to evaluate particle velocity lags. Phase II effort will design and test the most promising techniques.

AF89-230 TITLE: Sounding Rocket Thrust Vector Control

OBJECTIVE: Design a thrust vector control system for previously fixed nozzle sounding rocket motor systems.

DESCRIPTION: The purpose of this effort is to design a low cost system to provide thrust vector control of previously fixed nozzle sounding rocket type motor systems. Requirements exist to reduce impact dispersion areas, increase altitude, and allow the use of high performance motor systems on enclosed missile ranges. Thrust vector control of the vehicle system during boost will greatly reduce impact dispersions by reducing wind effects on the vehicle during initial slow moving launch phase. A thrust vector control system will also correct nozzle offsets and misalignments and provide for trajectory control. This effort will include trade-offs of gimbaled nozzle approaches

jet vane techniques, air vane concepts, nozzle injection methods, and combinations thereof. Typical motor boosters include Talos, Sergeant, Hydac, Apache, Orion, Nike Terrier, Nihka, Honest John, Castor I, Castor II, Castor IV, Black Brandt 3, and Black Brandt 5. This will identify the type of control system best suited for those motors selected. Control system packaging shall also be considered, the optimum approach being to self-contain the system including power, actuators, vanes (if needed), housekeeping and position sensors, and thermal protection. Command signals will provide to the control system via the payload attitude control system. The system must also be capable of operating in conjunction with fixed fins which are required for those systems that burn out while still in the effective atmosphere or have long coast phases between stages. Phase I will include conceptual design studies for various boosters. Phase II will develop the thrust vector control system designs for chosen booster systems.

AF89-231 TITLE: Integrated Case Structure/External Protection

OBJECTIVE: Develop design concepts for case structure/external protection to increase strength/stiffness and Directed Energy Weapon (DEW) hardness.

DESCRIPTION: Future mission requirements for booster structures include increased measures for external protection against dust and pebbles as well as protection from DEWs in a layered defense threat environment. Structural requirements for strength and stiffness may also increase along with flight load environment for missions such as fast burn boost. This effort is aimed at the investigation of design concepts for motor cases and boosters that will offer significant improvements in the structural strength and stiffness to weight ratios and protection to weight ratio. These concepts could include improved filament wound material/fabrication technology, resin density reduction, conical cases, improved protection systems for nuclear and DEW environments, and integrated protection/structural systems. Phase II will analytically and experimentally evaluate the most promising concepts.

AF89-232 TITLE: Sounding Rocket Telemetry/Tracking System

OBJECTIVE: Design a single telemetry tracking system to provide S-band telemetry.

DESCRIPTION: The purpose of this topic is to design a transportable system to receive telemetry data, determine actual trajectory, provide uplink control of payloads, and provide flight termination capability. Two systems will be required to satisfy the range safety requirements for redundancy. Each system will consist of an antenna(s) mounted to a two-axis pedestal. The data will be passed to recording and data analysis equipment mounted in an equipment shelter. A suitable computer will provide slant range, rocket trajectory, and projected impact zones for range safety. System requirements and accuracies will be determined as a part of this effort. The trackers will be located at the launch point. Pedestal equipment will be operated without a radome in winds up to 50 mph and surviving winds up to 120 mph. Dynamic tracking accuracy will be better than 0.2 x RMS at 15 x/sec target accelerations. Static pedestal accuracies will be better than 0.075 x in each axis. Slant range accuracy will be better than 250 meters at maximum slant range. The operational environments include rain, snow, ice, deserts, mountains, and coastlines. Downlink telemetry will be upto 750 KBPS on an S-band carrier. The telemetry will provide sufficient signal-to-noise ratio to exceed a bit error rate of 10-5 for all standard IRIG telemetry links. The receiving system will be capable of demodulating all IRIG standard rf signals. The uplink data will be on a UHF carrier with capabilities for payload attitude remote control and actuation of flight termination hardware. Sufficient rf link margin must exist to a distance of 1200 km slant range. The Phase I effort will consist of several trade-off studies to determine the optimal telemetry and tracking systems configuration. Trade-off studies will include receive antenna size, ground uplink antenna, slant range measurement system (CW vs. pulsed vs. PCM), transmitter power, trajectory computer (micro vs. mini), equipment enclosure and included data analysis equipment, methods of minimize station activation and alignments, programmable antenna controllers, transmit and receive equipment, and other test equipment. Phase I should result in identification of conceptual systems. Phase II will result in the complete conceptual design of a chosen system.

AF89-233 TITLE: Sounding Rocket Airborne Instrumentation System

OBJECTIVE: Design an airborne instrumentation system to obtain aging and surveillance data for sounding rocket boosters.

DESCRIPTION: This effort will design an airborne instrumentation system to collect solid propellant rocket motor performance data with respect to aging and surveillance. Current sounding rocket booster systems rely heavily on relatively old, government surplus, solid rocket motors. These motors, poured in the 1960's and 1970's have aged beyond the recommended life of the propellant. However, due to their availability and cost, they are still being used. As these motors age, their performance and reliability have shown deterioration. In order to better predict the future performance of these systems, there is a need to evaluate the current performance of these motors.

This effort shall design a self-contained aging and surveillance system (sensors, cables, PCM encoder, transmitter, power, and antennas), that with minimal payload interface (internal/external control and on/off control) can be used to obtain diagnostic data on these motor systems. The effort shall identify parameters to be measured including ignition delay, ignitor pressure, chamber pressure, steady-state longitudinal acceleration, high rate triaxial shock and vibration data, head cap and nozzle temperature data, and strain gage data at various points on the motor. This data will be used to predict average thrust, burn time, total impulse, and tail off and to better determine environmental test levels for sounding rocket payload systems. The effort shall also determine instrumentation to be used with a standard IRIG PCM formats and the required scaling levels or ranges for such instrumentation. The PCM encoder system and transmitter shall be compatible with standard IRIG S-band receiving and decommutation equipment. Phase I will include conceptual design studies for a proposed system. Phase II will result in a complete conceptual design for an airborne instrumentation system.

AF89-234 TITLE: Fiber Optics Ordnance

OBJECTIVE: Investigate and develop improvements in the performance, testability, and hardness to nuclear weapons.

DESCRIPTION: The newly developed concept of fiber optics ordnance is currently being implemented in the SICBM development to provide improved reliability, testability, and hardness. Further developments are needed in terms of more efficient performance, ease of testing and improved ionization resistance to nuclear weapons effects. This effort is aimed at improving the design efficiency, exploring the potential for fiber laser using doped fiber, exploring electro-optic switching using high voltage non-linear crystals, and exploring a fiber optic beam reducer in a laser fiber optic ordnance system. Performance improvements may involve improved initiator, more efficient coupling between the initiator and optical fibers and improved beam in laser fiber optics system. Phase II will develop and test one or more of the promising solutions.

AF89-235 TITLE: Development of New Scientific Research Instrumentation

OBJECTIVE: To stimulate the development of new scientific instruments for laboratory and industrial applications.

DESCRIPTION: Progress in fundamental research often depends on use or invention of new diagnostic techniques which can provide better insight into the fundamental processes or phenomena under study. Development of improved and novel scientific instrumentation will enable researchers to make more useful measurements per unit of time, to make measurements to a greater degree of accuracy and to make measurements in places and under conditions not now possible. It may also permit quality instruments to cost less and be more reliable. This effort to improve the basic function of scientific instruments which would enhance the scientific productivity of this country. Areas of interest include, but are not limited to, laser combustion diagnostic testing, vision testing equipment, advanced biogenetic tests for toxicity, new mathematical algorithms allowing improved computer program performance, optical information processing, accelerator mass spectroscopy, aerodynamic flow measurement devices, and improved material and process diagnostic systems. The Phase I effort should provide a review of various concepts and design options for the proposed type of scientific instrumentation. The Phase II effort would then develop a prototype or prototypes of the best/concept design alternatives, leading to Phase II commercialization

of the instrument. Evaluation of proposals will include the following factors: (a) potential value to the Air Force Research Program; (b) potential for transition to Air Force Laboratories; and (c) potential to aid the scientific community.

AF89-236 TITLE: Development and Application of New Theories and Concepts Relating to Fluid Mechanics

OBJECTIVE: Improve understanding of flow to improve performance of Aerospace Systems.

DESCRIPTION: Areas of interest include computational fluid mechanics, viscous, and separated flows, and hypersonic aerothermodynamics. Research in computational fluid dynamics is needed to predict flow past complex, three-dimensional shapes more efficiently and accurately. Procedures for exploiting new super-computer architectures and solution adaptive grids are examples of current interest.

Research in viscous and separated flows includes such topics as interactions of strong shock waves with turbulent boundary layers; methods for analytically examining higher order, inviscid flow coupling; and the nature of large-scale organized separations that frequently occur on low-aspect-ratio aerodynamic shapes at high incidence. Research issues associated with fluid dynamics and controls coupling are included. Research in hypersonic aerothermodynamics should improve understanding of strong viscous interactions with and without real gas effects.

For Internal Flow Dynamics, the main focus is on the mechanism limiting the performance of axial flow compressor, axial flow turbine and diffusers. Better flow prediction methods for modeling the effects of viscosity, turbulence, compressibility, unsteadiness and temperature variations are sought. New concepts for active flow control in the turbo-machine environment are encouraged.

Unsteady flow research addresses the scientific basis for exploiting unsteady flow driven by time-dependent boundary conditions to improve aerodynamic performance, especially maneuverability. Current research centers on unsteady flow separation and dynamic stall with emphasis on the mechanism of vorticity production, accumulation and shedding. The effects of motion history, multiple degrees-of-freedom, and Reynolds and Mach numbers are of interest.

Collaborative, interdisciplinary approaches involving fluid dynamics and control theory are desired to provide new approaches for controlling turbulent and unsteady flows.

AF89-237 TITLE: Development and Application of New Theories and Concepts Relating to Structures

OBJECTIVE: Improve structural efficiency and durability.

DESCRIPTION: We are particularly interested in the role of nonlinearity in structural response and in the ability to control the behavior by active and passive means. The dynamic response to external stimuli such as aerodynamics, gust and impact loads and complex interactions with fluids and control subsystems are of major interest. We seek the capability for accurate modeling of thermal diffusion through multilayer actively cooled structures including consideration of aerothermodynamic heating and surface reactions in hypersonic flight.

We support development of advanced constitutive theories capable of modeling the behavior of advanced materials such as polymeric, ceramic, metal matrix, and carbon-carbon composites. Consistency between micro- and micro-structural viewpoints and accommodation of progressive damage are desirable attributes in this regard.

Special emphasis is placed on innovative interdisciplinary approaches combining materials science and solid mechanics and aimed at bridging the gap between the microstructure and the macro-mechanical material behavior.

Emphasis is also placed on damage growth predictions and physically identifiable and measurable damage metrics. Probability aspects of damage growth and failure are pursued by considering the development of damage states as a stochastic process.

A significant portion of this research addresses composite materials for propulsion and hypervelocity flight structures, including airframe composite laminates; solid rocket fuel particulate composites; and very high temperature ceramic and carbon-carbon composites.

Research areas include micromechanically based, constitutive modeling of soil concrete and rock; identification and in situ measurement of properties of soils; identification of the mechanics of soil stabilization; investigation of blast-induced soil liquefaction; study of the strength and fracture characteristics of geological materials; modeling of the response of jointed and monolithic rock formations; identification of damage mechanism in concrete materials; investigation of structural systems for expedient facilities; study of the nonlinear structural response to high frequency dynamic loading; and investigation of structure-media interaction.

AF89-238 TITLE: Development and Application of New Theories and Concepts Relating to Propulsion

OBJECTIVE: Improve efficiency and stability of propulsion systems.

DESCRIPTION: Fundamental understanding of the physics and chemistry of multiphase turbulent reacting flows is essential for improving the performance of airbreathing propulsion and chemical laser systems.

We are interested in original and innovative research proposals using simplified configurations for experimental and theoretical investigations. Proposals to develop near-term, empirical, comprehensive models are not desired. We shall assign highest priority to research relevant to studying supersonic combustion, boron fuels, atomization and spray behavior of slurries and liquids, and understanding the chemistry of fuel combustion. Other topics of interest include, but are not limited to: turbulent combustion, soot formation, and combustion instability.

Topics of interest in electro propulsion include pulsed and steady-state plasma; equilibrium and nonequilibrium flowing plasma; characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface, -electrode, -magnetic, and –electric fields; losses to inert parts; plasmas in high magnetic fields and pressures; and plasma diagnostics (new and unique noninterference measuring techniques).

Our objectives are to predict and to suppress combustion instability in solid and liquid rocket systems, to control the complex roles of advanced energetic ingredients in solid propellant burning, to use metal fuels and to improve the service life of solid motors.

We are interested in new diagnostic techniques for analyzing surface reactions and flames of propellants, and in controlling the state of combustion products in plumes. Emphasis is on synthesizing and using advanced propellant ingredients to increase propulsion efficiency and to satisfy specific burning rate requirements.

Research is directed at new techniques for sensing temperature, concentrations, and velocities in energy conversion systems without interfering with the operation of the systems. The emphasis is on diagnostics of laboratory systems that simulate the hostile environments of high performance combustion and plasma systems.

AF89-239 TITLE: Multifunctional Non-metallic Materials Processing and Characterization

OBJECTIVE: To develop new nonmetallic material concepts for unique combinations of optical, electromagnetic and structural properties.

DESCRIPTION: Advances in ceramics, glasses and polymers are expected to come from the control of features at the 10-50A to 1000-10,000 level (ultra-structure) via chemical synthesis and processing methods. These materials may take the form of ultrastructural level composites which will perform a combination of active and passive functions. Processing includes new and improved materials based on methods of organic, inorganic, and organo-metallic chemistry as well as sol-gel, graphite-template chemistry, micro-morphology processing, transformation processing, intercalation chemistry, emulsion chemistry and other innovative processes. Imaginative combinations of these processes are of interest for materials with nonlinear optical, magnetic, superconducting and/or

semiconducting properties and phenomena and structural integrity. Subpicosecond, nonresonant or near-resonant low power optical polymers, organics and inorganics or combinations thereof or unique materials concept for high critical temperature superconduction are specifically required. Molecular composites, which would include the analogs of macroscopic composites, biological and natural systems as well as new synthetic combinations, are of interest. Device applications should be considered, particularly where the ultrastructured material will serve as a self-contained functional entity. New organic and inorganic polymers as well as oxides and non-oxide nonmetallics are needed for these multifunctional ultrastructures. New mechanisms and reactions are considered important components of nonmetallic materials processing and synthesis.

AF89-240 TITLE: Atmospheric Science Modeling Technology

OBJECTIVE: To stimulate the development of new experimental and/or numerical methods for modeling atmospheric processes.

DESCRIPTION: Advances in capabilities for more accurate specification and prediction of the state of the atmosphere depend to a large extent on the fundamental understanding of underlying physical processes. There are so many variables in the real atmosphere that isolating various causes/effects of these physical processes often becomes difficult to nearly impossible in the natural environment. Development of physical laboratory models and/or computer models will enable controlled simulation of individual processes to uncover the mysteries of their basic evolution. An improved knowledge and larger-scale numerical modeling efforts, which could aid both the research and operational communities. This effort seeks to enhance scientific research activities in the area of simulating lesser understood atmospheric processes. Areas of interest include, but are not limited to, gravity waves, lee waves, turbulence, convection, latent heating/cooling, and boundary layer fluxes. The Phase I effort should provide a review of various concepts and design the options for the proposed model (s).

AF89-241 TITLE: Neuocomputers, New Architectures and Models of Computation

OBJECTIVE: To stimulate the development of new computer architectures that implement neural network/connectionist models of computation.

DESCRIPTION: Few neural network and connectionist models of computation can be implemented in real-time on any existing computers. New types of computers, neurocomputers, must be designed in order that real problems can be solved with neural networks. Our interest lies in two areas: general purpose and special purpose neurocomputer architectures. General purpose machines must be able to implement as many neural network models as possible, handling extremely large numbers of artificial neurons and interconnections in different configurations with various learning rules and knowledge encoding. Special purpose machines, neural network accelerators, are designed for a specific type of neural network model and, more likely, for a specific problem that is solved by a neural net. Such machines must easily solve a persistently difficult problem and readily interface with other non-neural net machines. For all types of neurocomputers, the use of integration of new technologies, such as optics and organic polymers, into both neurocomputer components and architecture is highly encouraged. For example, it is most likely that many different types of artificial neurons and interconnections will be necessary to implement many neural network models. This will promote the creation of neural network “building blocks” from which many of the above systems can be built. There is also some interest in integrating neural net machines with other more traditional types of computation such as artificial intelligence and database computers.

AF89-242 TITLE: Heterostructures: Materials and Devices

OBJECTIVE: To grow model, measure, understand, and exploit electronic and electrooptic heterostructures.

DESCRIPTION: Relatively modern film growth techniques such as molecular beam epitaxy (MBE) and metallo-organic vapor phase epitaxy (MOCVD) afford the ability to grow electronic films of high purity and crystalline perfection. Such films include metals, semiconductors, and insulators. Under appropriate conditions, one type of material can be grown epitaxially on another material; this is known as heteroepitaxy. More recently, heteroepitaxy

has been extended to cases involving materials of different crystal types and lattice constants. (GaAs on Si is an example of current interest). With these constraints lifted, within limits, many novel and potentially important electronic structures can be visualized.

Research is sought in the electronic applications of heteroepitaxy and heterostructures. This includes theoretical studies of the initial and subsequent phases of heteroepitaxy; materials growth studies involving electronic semiconductors, metals and insulators; the characterization of surfaces and heterointerfaces; and the design and fabrication of electronic devices incorporating heterostructures. Examples of materials of particular interest include compound semiconductors such as the III-V and II-VI families, (e.g., GaAs and ZnSe). Devices of interest include artificial superlattices, quantum well structures, and electrooptic structures such as solid-state lasers.

AF89-243 TITLE: Life Sciences Basic Research

OBJECTIVE: To provide fundamental data in toxicology, neurobiology, sensory information processing, and cognitive sciences.

DESCRIPTION: Basic research in five areas in supported:

Toxicology: Emphasis is on fundamental mechanisms that organisms use to respond to toxic chemical exposure, especially chemicals to which Air Force personnel are exposed. Primary objectives are to identify early indicators of toxic insult, to elucidate the mechanism of action of toxic chemicals, and to enhance natural detoxification of environmental chemicals through conversion of toxic agents into non-toxic metabolites.

Neuroscience: Fundamental studies of the neurobiology of learning and memory, biological rhythms, fatigue, stress, and arousal are one area of emphasis. Proposals for neurobiological research in which behavior is not studied explicitly but which would clearly further the understanding of behavior are accepted. Neurobiological research on visual and auditory information processing and higher cognitive functions and studies that bring together information about cellular and neural-circuit functions with information from studies of artificial intelligence are also supported. The relationship between neural architectures and formal computations that might underlie goal-directed behavior, learning, memory, and pattern recognition is emphasized.

Vision: Psychophysical research is supported leading to the discovery and quantitative modeling of featural processing mechanisms underlying visual recognition. Contrast detection and discrimination, motion, eye-movement, and color, and stereopsis are examples.

Audition: Psychophysical research is supported on the perception of complex sounds in normal human adults. The mechanisms underlying recognition, pitch, localization, and speech are examples.

Cognition: Research is supported on cognitive aspects of perception, memory, learning, representation of knowledge, problem-solving, reasoning, and judgment.

AF89-244 TITLE: Research in Mathematics and Computer Science

OBJECTIVE: To stimulate innovative approaches to mathematical modeling, computation, design, and control for complex systems.

DESCRIPTION: The Air Force needs improved analytical and computational approaches to modeling, design, and control of complex systems occurring in many fields of application, including aerospace structures, robotics, electro-magnetic propagation, and fluid flow. Enhanced computing methods and artificial intelligence will have a significant impact on our ability to design and control physical systems.

Basic research is required in several areas related to this topic. Mathematical models are required for many of the systems of interest, including those occurring in propulsion, robotics, and laser optics. Effective mathematical understanding, using both analytical and numerical tools, is needed for nonlinear equations such as those for

transonic flow, laser focusing, detonation, stability of shear flows, geometrically exact elastically, and nonstandard viscoelastic media.

Capabilities for solving the partial differential equations modeling physical systems need to be vastly increased. This calls for research in computational mathematics, especially related to solving such problems on parallel architectures. Improvements in parallel computing environments as well as methods for dynamically mapping algorithms on to parallel architectures are needed.

Research is needed in several areas of mathematical control theory, including adaptive control and distributed parameter control. Research should address novel methods for dealing with nonlinear dynamics as well as model uncertainty and robustness. Research should focus on the mathematics of dynamics and control in areas applicable to control of systems occurring in large space structures, robotics, or control of fluid flow and combustion processes. Artificial intelligence approaches may be combined with control theory in order to control complex decentralized systems. Research in intelligent control methods, which couples these approaches, is needed.

Advances in software engineering and knowledge-based systems will be needed to implement computational models and control algorithms. Research is needed in knowledge-based systems with improved mechanisms for temporal reasoning for application of real-time critical problems. Research in software engineering should address issues of reusability, better programming environments, and the need to monitor change dynamically.

Future Air Force operations will require more effective methods for the design of complex systems and the optimization of design with respect to performance and life-cycle costs of the systems. Research in optimization is needed to develop the mathematics necessary to support and implement design optimization and control. As part of this process, research in optimization of infinite-dimensional systems is needed; this has applications to such areas as structural design and integrated structural and control design. In order to ensure reliability of these systems, new approaches are needed for statistical reliability analysis of complex systems.

Research in any of the above topics should stress fundamental and innovative research in mathematics or computer science and should have as a goal advancing the state of knowledge in those fields.

AF89-245 TITLE: Novel Techniques in Seismic Detection

OBJECTIVE: To devise new techniques or instrumentation for improved seismic detection.

DESCRIPTION: Seisometry is based upon using seismometers, which represent mature and perhaps dated technology. The goal is to incorporate new high-technology techniques and instrumentation to devise innovative detection schemes, which improved accuracy, sensitivity, and/or frequency response to seismic signals.

AF89-246 TITLE: Novel Electron-Beam-Driven Devices for the Generation or Amplification of Millimeter-Wave Radiation

OBJECTIVE: To advance the state-of-the-art in compact, efficient, high power, mm-wave vacuum electronics.

DESCRIPTION: The Air Force is the single largest customer in this nation for vacuum electronic microwave devices. In spite of the popularity of solid-state devices, there are numerous applications in communication, radar, and electronic warfare whose power requirements exceed the capabilities of available semiconductors. The current Air Force and DoD investments in R&D in vacuum electronics has been miniscule for over two decades. This situation has impeded the rate of innovation in the microwave tube industry. At the same time, more demanding DoD requirements are putting increasing pressure on the industry to produce more compact, more lightweight, more efficient, and more reliable microwave tubes. In addition, future applications are expected to require tube output at higher and higher frequencies. The shorter the wavelength of radiation desired; the more intricate and expensive are the required fast wave tube structures. New tube concepts and geometries are needed to meet these future needs. In addition, the physics involved with beam-plasma interactions offer alternative mm-wave device concepts that beg exploration. Phase I efforts should provide a solid theoretical foundation for the new mm-wave amplifier or

oscillator concept. Preliminary device design should also be addressed. Phase II should result in the design and construction of an actual prototype device along with preliminary performance optimization studies. Phase III should see the commercialization of the device concept.

AF89-247 TITLE: Infrared Astronomy

OBJECTIVE: Improve dispersion optics for ten-micron mosaic detector arrays.

DESCRIPTION: The operation of mosaic detector arrays in the ten-micron spectral region on large, ground-based telescopes provides stellar images near one arc-second resolution, but such systems must cope with the large thermal backgrounds from the atmosphere and the telescope. During operation of available mosaic detector arrays in this spectral region with a 0.1 micron spectral bandpass and one arc-second pixel field of view, the pixel charge integration sites approach saturation at the highest permitted frame rates. Such a 0.1 micron spectral bandpass results naturally when the 8 to 13 micron region of atmospheric transmission is covered simultaneously across one axis of existing 64 pixel square mosaic arrays, which is desired to minimize corruption of the stellar spectrum by temporal changes in atmospheric transmission. A need therefore exists for an optical design for which the dispersive element (prism or grating) spreads the 8 to 10 micron spectrum across the 64 pixels, but at a spectral bandpass near 0.01 micron per pixel. Discrete tilts of one of the sub-sampled spectrum at 0.02 micron sampling interval. Required design attributes include operation near 4 degrees absolute temperature, rejection of radiation outside the f/27 telescope beam, overall transmission approaching 50%, and construction/alignment capability without recourse to exotic materials or techniques. As an optional requirement, the offeror is invited to consider simple fore-optics at the telescope focus which would minimize the effects of atmospheric turbulence on the spatial position of the star on the mosaic array.

AF89-248 TITLE: Emerging Technologies Resulting in Lighter Aircraft, Increased Engine Performance, and Improved Design Tools

OBJECTIVE: Improvements in Aircraft Structure, Scramjet, and Aerodynamic Design Technologies.

DESCRIPTION: The National Aero-Space Plane is providing a quantum jump in aerospace technologies by investigating new and innovative solutions. Its goal is a Mach 25 air breathing scramjet vehicle capable of single stage to orbit. Emerging technologies providing significant performance improvements for the aircraft will be considered. Phase I must show experience and understanding of the relative importance of the technologies. It must also provide detailed drawings, specifications, and test procedures for the proposed technologies. Phase II requires prototypes and associated test results demonstrating decreased weight, increased scramjet performance, or improved aerodynamic design tools without increased liabilities.

AF89-249 TITLE: Hypervelocity Space Vehicle Interactions and Signatures

OBJECTIVE: Prototype flight sensors to measure aircraft/engine radiance and emissivity.

DESCRIPTION: Sensors are needed to measure electromagnetic radiation and chemical emissions on hypersonic aircraft. Sensors should be capable of measuring fuselage, engine, exhaust, outgases, or plasma sheath electro-magnetic spectrums (in the infrared, visible, or ultraviolet ranges). Phase I must demonstrate understanding of the phenomenon, sensors, and applications. It must provide detailed designs of the proposed sensor and the test procedures planned for the proving the concept. Phase II produces the prototypes, test results, and then analyzes the data against prediction performance.

AF89-250 TITLE: High Temperature (2000+ C) Instrumentation

OBJECTIVE: Prototypes and associated test results of high temperature (2000+ C) dynamic pressure, strain, temperature gages and/or acoustic microphones.

DESCRIPTION: High temperature (2000-5000 C) instrumentation is required for testing the materials, structures, and aerodynamics of hypervelocity vehicles. Specifically dynamic pressure, strain, temperature gages and/or acoustic microphones need to be developed and tested. Such instruments could be used in ground-based facilities or eventually developed into flight weight systems for hypervelocity research aircraft. Phase I efforts need to demonstrate experience and knowledge in high temperature instrumentation as well as detailed designs for a prototype. Phase II must produce prototypes and test.

AF89-251 TITLE: High Temperature Fasteners and Attachment Techniques

OBJECTIVE: Prototype fasteners, specifications, attachment techniques and experimental test results.

DESCRIPTION: High temperature (2000-5000 C) structures are composed of components which need to remain attached together. In structural testing this includes attaching strain gages to test specimens. Carbon/carbon, Ceramic Matrix, and cooled Titaniums are examples of high temperature structural components requiring attachment to one another. The Phase I effort need to show knowledge/experience in fasteners and attachment techniques in addition to detailed designs for the fasteners. Phase II must proceed to develop the prototypes and test.

AF89-252 TITLE: Kinetics Turbulence Interaction in Reacting Flows

OBJECTIVE: Kinetics turbulence computer codes for reacting flows.

DESCRIPTION: Hypervelocity (Mach 6-25) aerodynamic simulation requires further refinement of the kinetics and turbulence models for the reacting flows of the air stream. Phase I must show an understanding of the state of the art simulation and kinetic turbulence interactions. Phase II must provide the computer code describing the turbulence.

AF89-253 TITLE: Finite Rate Chemistry Algorithms for Hypersonic Flows

OBJECTIVE: Improved computer algorithms for the finite rate chemistry in hypersonic flows.

DESCRIPTION: Hypervelocity (Mach 6-25) aerodynamic simulation requires improved algorithms to describe the chemistry in the airflow. Improvements in the finite chemistry calculations are of specific interest.

AF89-254 TITLE: Global Communication Strategies for Hypersonic Vehicles

OBJECTIVE: Improved test control strategies and centers for hypersonic flight tests.

DESCRIPTION: Testing hypervelocity (Mach 25) vehicles provide a new problem to traditional aircraft test ranges. The higher speed vehicles no longer remain within the confines of the range, or even the country, but still require continuous communications and telemetry. Phase I studies must describe available systems and those planned to be operational by May 1995. The studies should show how the appropriate systems could be integrated to form a single point test control center. Phase II should form a demonstration single point test control center and exercise the worldwide telemetry and communications.

AF89-255 TITLE: High Temperature Non-Intrusive Diagnostic Instruments For Field Measurements (with and without chemistry)

OBJECTIVE: Prototype instruments with test results demonstrating their sensitivity and accuracy.

DESCRIPTION: Non-Intrusive Diagnostic Instruments and Techniques are required for experiments with high temperature (2000-5000 C) aerodynamic flow fields. The instrumentation must be capable of working in flow fields

with chemistry as well as those without chemistry. Phase I should demonstrate knowledge of existing measurement techniques and provide detailed drawings of proposed new or improved instruments. Phase II must build and test prototype instruments.

AF89-256 TITLE: Visibility Requirements for Non-Instrumented Landings

OBJECTIVE: Minimum visibility requirements and the supporting statistical analysis of experimental studies.

DESCRIPTION: All aircraft limit the pilot's external field of view to some degree, but the minimum field of view required for non-instrumented landing an aircraft is undefined. Non-instrumented landings are manual landings using only aircraft performance indicators and visual cues of the approaching landing strip. They do not depend on any automated landing devices, communications, or external sensors such as radar. Research is required to identify the minimum field of view required. Experimental results and statistical analysis are expected. Phase I should demonstrate an understanding of the problem. It should then provide the experimental procedure and statistics to be used in defining the minimum requirements. Phase II will contain the experiments and analysis. The quantitative requirements for a minimum field of view and a final live flight demonstration of the minimum requirements is expected.

AF89-257 TITLE: Multiple Mode Optical Switches for Fiber Optic Networks

OBJECTIVE: Prototype optical switches, specifications, and test data.

DESCRIPTION: Optical analysis techniques are requiring multiple mode switches in fiber optic networks. Multiple mode switches allow multiple samples for a single analysis and several different techniques to be applied through the same network. Switches must demonstrate improvements in radiation fidelity, reliability, switching speed, and/or alternative paths beyond the current state of the art. Phase I will identify current switch designs and their specifications. It will also identify the proposed improvements or alternatives. Phase II will produce prototypes and test results to confirm expectations.