AIR FORCE

PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBR program is with the Air Force Command Deputy Chief of staff for Technology. The Air Force SBIR Program Manager is R Jill Dickman. Inquiries of a general nature or problems that require the attention of the Air Force SBIR Program Manager should be directed to her at this address:

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HQ AFSC/XTXC (SBIR Program Manager)
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No additional technical information (this includes specifications, recommended approaches, and the like) 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 section 7.1 in this solicitation for further information on DTIC.

All Air Force topics seek innovative solutions to the enumerated problems. Any level of R&D, whether Basic Research, Exploratory Development, Advanced Development or Engineering Development will be considered appropriate for any topic.

DEPARTMENT OF THE AIR FORCE

FY 1991 TOPIC DESCRIPTIONS

AF91-001 TITLE: Armament Research

OBJECTIVE: Develop innovative concepts in areas associated with air deliverable conventional munitions and 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, projectiles, fuzes that include 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, and lethality and vulnerability assessment techniques. Some examples of desired research are low drag/observable weapon airframes; conformal ejector racks; high-voltage storage-and-switching techniques; compact, short-term, cryogenic cooling for passive IR fuzing; millimeter wave-seeker's/sensors for mid-course and terminal guidance; heavy metal self-forging fragment warheads; heavy-metal shaped charges; long-rod penetrators; reactive fragment warheads; computational fluid dynamics including interactive grid-generation techniques, and warhead hydrocode-assessment techniques.

AF91-002 TITLE: Innovative, Electromagnetic-launcher concepts

OBJECTIVE: Explore and combine new technologies to enhance existing electromagnetic launcher (EML) capabilities.

DESCRIPTION: Innovative concepts to advance the technology of hypervelocity electromagnetic launchers should be directed toward the following: 1) lightweight technology (especially projectiles); 2) mega ampere switching (opening and closing switch technology); 3) directional control concepts for distribution of electrical and thermal currents (advanced concepts required for armatures and projectiles); 4) energy recovery; and 5) high strength-to-weight electromagnetic launchers. Continuous development of key technology areas are required to address critical issues (e.g., velocity limitations caused by inbore rail damage) which limit the performance and efficiency of electromagnetic launchers. The knowledge to be gained will be assessed with regard to the use of advanced materials and structural designs, especially the compatibility of the armature and/or the projectile with the rail conductors. The knowledge also will be evaluated by the capacity to obtain more reliable measurements to better establish the maturity and performance potential of EMLs, and by the feasibility of merging new technology with system requirements. Phase I should focus on expanding existing knowledge of EML s and should provide recommendations as to how this increased knowledge will advance the state of EMLs. Phase II should incorporate hardware or experimental demonstrations resulting from the concerns defined in Phase I. Phase III should produce prototype devices that will advance technology applicable to space based EMLs in areas such as platform mass, cooling requirements, and system efficiency.

AF91-003 TITLE: Microwave-Monolithic-Integrated-Circuit (MMIC) Technology for Air Target Fuzing

OBJECTIVE: Develop MMIC technology to integrate the components of a radio-frequency (RF) proximity sensor for missile fuzing.

DESCRIPTION: Radio-Frequency (RF) technology has historically been the technology of choice for all-weather air target missile fuzing. In order to achieve 360 degrees azimuthal coverage without access to the missile frontal area, RF fuze systems have employed complex, expensive duplexers, circulators, power dividers/combiners and RF plumbing between the single transmitter/receiver module and remote antennas. The Air Force Armament Test Laboratory (AFATL) is interested in innovative techniques of applying MMIC technology to the problem of air target fuzing. To support the guidance function, future air target missiles will include significant signal processing which can also be utilized by the fuzing system. Recent investigations into azimuthal-target location by air-target fuzing offer a potential solution to the "early bir/late bird" problem and the option to employ aimable/directional

warheads. However, these advances entail increased fuze design complexity and cost. The technical challenge is to apply MMIC technology to transmit/receive (T/R) modules and conformal patch antennas which would individually cover a segment (60 degrees to 90 degrees) around the missile. The individual modules should be centrally controlled, provide azimuthal-target resolution, and eliminate most, if not all RF, plumbing. Phase I will include the analysis and design of MMIC components for a missile proximity fuze. Component designs should then be integrated into an overall system concept. Phase II would include integration, fabrication and demonstration of the conceptual designs from Phase I to show proof-of-concept. Phase III would include extension of the demonstrated concept to advanced missile fuzing with possible commercial application in transportation and shipping sensors.

AF91-004 TITLE: Electronically Scanned, Reconfigurable, Millimeter-Wave (MMW) Antenna

OBJECTIVE: Develop a skin-embedded, low-radar-cross-section (RCS), reconfigurable, electronically scanned, antenna system.

DESCRIPTION: Work is currently being pursued in the area of Smart Skins technology. Smart Skins systems will reduce the weight and volume consumed by avionics systems and enable the airframe designer to maximize the airframe performance while providing an avionics system which is capable of monitoring its health and compensating for damaged or failed avionics systems. Advances being brought about by the Smart Skins technology for aircraft must be exploited by armament designers to produce weapon delivery systems which are low drag, lightweight, optimized for airframe size, capable of operating at speeds above Mach 1, and low-cost. The technical challenge is to develop a low RCS electronically scanned antenna embedded in the skin of a missile/weapon airframe. The antenna will be scannable in 2 dimensions and operate at 35/94 GHz. Additionally the antenna will be reconfigurable to optimize the available antenna aperture for low RCS and to offset element damage or component failure. Phase I is to analyze and design the antenna and associated electronics to satisfy the above requirements. An analysis of the electrical and structural properties of the materials will be conducted. This phase will culminate in a recommendation of antenna design, skin material, and associated electronics. Phase II includes the fabrication and embedding of the antenna and associated electronics into the proposed skin material. Tests will be conducted to characterize antenna performance, demonstrate the ability to scan in two dimensions and validate the structural integrity of the skin material. Antenna elements will be altered through manual or mechanical means to demonstrate RCS reduction potential and reconfigurability. Phase III will produce the software required to reconfigure the antenna for RCS reduction and to optimize performance in the event of damage or component failure. Such an antenna will also have direct application in the obstacle avoidance systems of automobiles and sensors for automatic doors.

AF91-005 TITLE: Pressure/Temperature Shock-Wave Sensor

OBJECTIVE: Develop a sensor to measure temperature and pressure in the reaction zone of an explosive.

DESCRIPTION: The reaction zone of a detonating explosive has not been well characterized. Some work has been done on the theory of how an explosive is initiated (hot spot theory). To date, very little experimental data to validate these models exist because of the extreme environment of the detonation front. A shock front sensor that can measure both the temperature and pressure of the detonation is needed. This sensor needs a response time of 1 nanosecond or better and must survive in the explosive environment for up to 2 microseconds. The sensor must measure pressure up to 500 kilobars with a resolution of $\pm$ 10 kilobars. The sensor must measure temperatures up to 3000°C with a resolution of $\pm$ 50°C. Finally, the sensor must be small, be able to be cast in an explosive chare or attached to an external charge surface, and must be relatively inexpensive. Phase I will include analysis and selection of possible design approaches to a detonation shock wave pressure/temperature sensor. Fabrication and small scale testing would be completed to make appropriate design changes and recommend a design concept for development in Phase II. Phase II includes final design and fabrication of the selected concept from Phase I. Full scale testing on explosive charges and validation using empirical or other available data would be conducted.

AF91-006 TITLE: Three-Dimensional, Aerodynamic, Flow-Field-Analysis Animation

OBJECTIVE: Design and develop an interactive data reduction and visual representation tool for aerodynamic databases.

DESCRIPTION: Wind-tunnel experiments over the past few decades have generated aerodynamic data for a multitude of configurations. These data bases, due to their magnitudes, have gone largely untapped. In addition, with the maturation of computational-fluid-dynamic (CFD) techniques, the size of this valuable database continues to grow. Current analysis techniques are based primarily on out-of-date engineering procedures. These methods do not fully utilize the capabilities of graphic workstations for interpreting and rendering a three-dimensional database. The goal of this task is to develop an interactive, graphical, analysis tool which will aid the researcher to investigate the results of these large databases. The technical challenge is to exploit graphical tools for rendering the steady and unsteady properties of the databases in three dimensions. Phase I will develop volume rendering techniques and demonstrate their applicability in volume rendering and develop novel applications of such techniques to allow the researcher to visualize a full, three-dimensional flow field. To define visually the major flow structures, the techniques will enhance specific flow properties in the flow field. Some examples of applications are a volume rendered image of a three-dimensional flow field with translucency tied to the density and the use of ray tracing techniques to simulate Schlieren photography. The graphics software must be designed to handle general (unstructured) flow-field data bases. Phase II will produce a user-friendly, graphically interactive analysis tool for an unsteady, time-dependent, three-dimensional, flow field. It will aid the researcher through levels of automated analysis in locating areas of interest in the flow field such as high gradient locations, shocks, asymmetry, etc., with less automation for the experienced researcher and more for the novice. The volume rendering techniques of Phase I will expand to exploit the capabilities of the chosen graphics hardware for the complete set of unsteady, three-dimensional, flow properties, still maintaining the completely general flow-field structure. Phase III efforts will develop the required hardware and/or software to port the resulting graphics analysis tool for aerodynamic flow fields to various popular graphics hardware stations. This effort will culminate in an off-the-shelf product which is easily installed and operated.

AF91-007 TITLE: Interpenetrating-Polymer-Network (IPN) Capacitors

OBJECTIVE: Examine combinations of polymers resulting in stable, lamellar, IPN, exhibiting capacitive behavior.

DESCRIPTION: In the past, development efforts have been undertaken to improve the state of the art in low-voltage, high-energy density capacitors. Compact, high-capacitance, double-layer capacitors have been developed to enhance our ability to store low-voltage electrical energy for fuzing. The charge storage mechanism for these devices stems from the small-scale morphology of the electrode coatings employed. Specifically, jagged surface anomalies on the order of twenty atomic diameters in size are responsible for the electrode's high surface area which, in turn, gives rise to large capacitance density (up to 1 F/cm^2). Mobile ions within the electrolyte concentrate along the electrode surface so that charge is stored in response to an applied voltage. In theory, an IPN interface has extremely high surface area and could be adapted to high-density charge storage; double-layer capacitors can be envisioned from this standpoint. However, to permit repeated charging and discharging, tow two polymers (the doped conductive polymer electrode and the ionically conducting polymer electrolyte) must be compatible over the applied voltage range. Phase I includes an evaluation of physical and chemical properties of available conductive polymers and polymer electrolytes which result in a set of candidate IPN combinations which appear most promising for high energy density capacitors. A subsequent Phase II would further refine the dopant chemistry and consider the interactive effects of polymer electrode and electrolyte through detailed experimentation. IPNs would be fabricated and demonstrated.

AF91-008 TITLE: Recrystallization of 1,3,5-Triamino-2,4,6-Trinitrobenzene (TATB) Using Supercritical Fluid Technology

OBJECTIVE: Develop a recrystallization process for TATB producing various particle sizes using supercritical fluid technology.

DESCRIPTION: 1,3,5-Triamino-2,4,6-Trinitrobenzene (TATB) is a desirable ingredient in explosive formulations because of its shock insensitivity, thermal stability and high energy. TATB is insoluble in solvents such as acetone, water, and ethanol. It is only slightly soluble in others such as aniline, dimethylsulfoxide (DMSO), and dimethylformamide (DMF). The most common solvent used to recrystallize TATB is concentrated sulfuric acid, ~20% (W/V). It is also difficult to produce TATB crystals larger than 50 microns which is why it is primarily used in pressed charges. TATB could be used in high-solids, melt, cast systems if the particle size distribution could be increased to 150-250 microns. It has been demonstrated that supercritical fluid (SCF) technology can be used to recrystallize explosives in various shapes and sizes. These fluids also possess the ability to dissolve the solvents whether on the surface of or occluded within the crystal. Recrystallized particles are then recovered dry. The goals of Phase I are to 1) demonstrate the feasibility of using super critical fluid technology or recrystallize TATB: 2) produce and deliver 200 grams of TATB in the particle size range of 150 to 250 microns; 3) prepare an economic assessment of the process. The Phase II program goals are to 1) scale up and optimize the recrystallization process of TATB; 2) produce and deliver 100 pounds of 150 to 200 micron TATB for small-scale tests; 3) prepare a process flow chart and an economic assessment.

AF91-009 TITLE: Portable, Miniaturized, Aerosol, Particle-Measuring System

OBJECTIVE: Develop a miniaturized, remote, particle-measuring system to better define real-time cloud physics.

DESCRIPTION: A great deal of effort has been expanded in developing particle measuring systems to better define the properties of aerosol clouds. These systems tend to be large in size, therefore intrusive in the actual flow field. The technical challenge is to develop a miniaturized remote sensor with a range of two microns to 5mm which could be easily placed in areas such as inside engine inlets. This would greatly enhance the evaluation of aircraft icing problems. This measuring system would also have application to cloud physics, leading toward more precise weather forecasting. Phase I is to conduct an analysis to determine the feasibility of such a system and to propose measuring techniques and hardware concepts best suited for this application. In Phase II the recommended prototype system design from Phase I will be fabricated and thoroughly tested with emphasis placed on ease of use, accuracy, reliability, miniaturization, and remote capability.

AF91-010 TITLE: Laser-Beam Steering Device (LBSD)

OBJECTIVE: Develop a nonmoving electronically controlled scanner for steering laser beams of active infrared (IR) seekers.

DESCRIPTION: Current active IR image seekers use moving optical devices to steer the laser beams and to generate recorded images. Rotating prisms and the Kennedy scammer are two examples. The push-broom, active, IR seekers use the airborne vehicle motion in conjunction with moving optics to generate scanning patterns. These steering methods require unwanted weight, slow scanning rates and costly precision mechanisms for pointing accuracy. The technical challenge is to investigate and develop a nonmoving, electronically controlled, beam-steering device that can steer the laser beam and the returned image signal in scanning pattern. The beam steering device shall scan a field of view (FOV) of + and – 45 degrees in both azimuth and elevation, and steer a 10-watt long wave infrared (LWIR) CO2 laser beam. In this project, all other components such as the laser, detectors and lenses shall be off-the-shelf items. Phase I will include the investigation, analysis, and design of a candidate laser beam steering device. Characteristics of typical, active, IR, image systems shall be used in determining the beam steering device surface area and the instantaneous FOV. The beam steering device characteristics such as reflectivity, transmitivity, power absorption, and surface linearity will be defined. The output from Phase I will be a complete, prototype, laser-beam, steering-device design. Phase II will include the fabrication and testing of the LBSD designed in Phase I. Performance characteristics such as scanning rates and pointing accuracy for various levels of laser power and modes will be determined through testing. The ability of the scanner to generate returned scanned images will also be demonstrated.

AF91-011 TITLE: Near-Field, Radio Frequency (RF), Hardware-In-Loop (HIL) Simulation

OBJECTIVE: Explore new techniques for testing RF seekers, and develop a prototype HIL simulator.

DESCRIPTION: Guide weapons are becoming more sophisticated and costly to develop. Hardware-in-Loop (HIL) simulation offers and efficient and cost effective method for emulating targets, backgrounds, and engagement scenarios and for developing, testing and evaluating seeker hardware and software. At microwave and millimeter wave frequency bands, large anechoic chambers are required to test seekers in the far field of the seeker's antenna. These chambers are expensive to build and maintain.

The goal of this program is to develop and implement techniques for testing microwave and millimeter wave seekers in an HIL simulator in the very near field of the seeker's antenna. Testing RF seekers in the near field means that much smaller chambers could be used. This would greatly reduce the overall cost of RF HIL simulator systems. The technical challenge is to develop a technique that would simulate a far-field condition to a seeker being tested in the near field. If successful, the target antenna array could be located as located as 50 to 100 wavelengths from the seeker. For a typical Z-band seeker, the anechoic chamber focal length would be 5 to 10 feet instead of the 40 to 50 feet required today. Phase I would define simulation test requirements for microwave and millimeter seekers, investigate techniques and concepts for HIL simulation testing on these seekers in the very near field, and recommend candidate techniques to be pursued in Phase II. Analytical evaluations will be performed on each candidate technique as part of Phase I. Phase II would demonstrate performance of candidate techniques by developing hardware and software models performing proof-of-principle testing in a controlled environment, and collecting and analyzing test data. The models will be used to develop specifications and a design for a prototype system. Phase III is expected to produce a prototype HIL simulator that will demonstrate the total system concept of performing HIL simulation tests on the seeker in the very near field.

AF91-012 TITLE: Infrared/Radio-Frequency (IR/RF) Sensor Data Fusion

OBJECTIVE: Develop sensor level data fusion for infrared (IR) and radio-frequency (RF) sensor.

DESCRIPTION: A promising trend for future, tactical, missile guidance is the employment of dissimilar sensors to complement the characteristics unique to each. An issue arising from this trend is how to combine or fuse information from various sensors so as to optimize acquisitions and tracking capabilities of the missile. Initial studies have indicated benefits occur when the fusion process occurs at the sensor level rather than later in the signal processing chain. Separately, microchip processor technology has developed sufficiently to support requirements for real-time data fusion. As sensor data fusion technology continues to progress, signal processing architectures adapted to data fusion with specific sensors will likely be developed for tactical missile guidance. The goal of this task is to develop technology for fusing data from two dissimilar sensors, preferably radar and infrared as used for acquisition and tracking in air-to-air missiles. The intent is to accomplish data fusion by operating on sensor signals that have been processed as little as possible or, preferably, not at all. The technical challenge is to demonstrate feasibility and then develop the techniques of establishing a single track file from data as near to the sensor level as possible. Two dissimilar sensors configured on a common platform are to be used. The thrust of Phase I is to demonstrate the sensor-level data-fusion concept and verify its advantages over multi-track file fusion. Algorithms employed in the demonstration should be as simple as possible and algorithm development kept to a minimum. Sensor-level data of simultaneous radar and infrared scenes may be simulated although real data with clutter is desired. In Phase II algorithms will be expanded and refined as appropriate. Extensive comparative analysis of sensor-level data fusion and processed data fusion will be accomplished to determine the relative performance of each. Tests and analysis will be performed on the best sensor data set available. Phase II tasks will also include designs of the processor architecture necessary to implement sensor level data fusion in tactical missiles. Phase III will involve completion of the fusion processor design started in Phase II and assembly of breadboard processor hardware. The breadboard processor with radar and infrared sensors will then be installed in either a tower or an aircraft for further demonstration and test.

AF91-013 TITLE: Surfactants for Plastic-Bonded Explosives (PBX) and TNT-Based Systems

OBJECTIVE: Identify and characterize candidate surfactants for use in explosives processing.

DESCRIPTION: Plastic-bonded explosives (PBX) consist of an explosive filler material combined with an inert polymer binder. For increased energetic performance, it is desirable to minimize the binder content. However, too little binder may result in a mix consistency that is unprocessable. A surfactant is needed, therefore, to act as a wetting/dispersing agent. This allows a reduction in binder content without a subsequent decrease in processability. The candidate surfactants must be compatible with typical PBX components, as well as with the hydroxyl-terminated polybutadiene (HTPB) binder itself. In addition, the surfactants should neither adversely affect the mechanical properties of the binder nor hinder the curing process. Melt cast systems, on the other hand, present problems not encountered in PBX mix casting. These formulations consist of an explosive granular filler suspended in molten TNT. The TNT then serves as the binder when solidified. The need for increased solids content result from performance and/or shock sensitivity requirements. Thus, the problem of maintaining homogeneity of the suspended solids needs to be addressed. Lecithin is currently used for this purpose. However, because lecithin is not readily soluble in TNT, a replacement surfactant is needed to act as a dispersing/suspending agent. The surfactants must be compatible with typical melt-cast components and they should not have a detrimental effect on the mechanical properties or the solidification process of the TNT binder. Phase I consists of a search for various surfactants to improve the processing mentioned. For each application (mix and melt cast), candidate surfactants will undergo compatibility tests with the individual components, and effects on the mechanical properties of the binders will be determined. Phase II will consist of a complete characterization of potential surfactants for mix processing studies will be conducted to determine the effectiveness of the candidates with respect to the relevant, explosive, formulation characteristics.

AF91-014 TITLE: Extremely-High-Frequency (EHF), Millimeter-Wave, Transmission Devices

OBJECTIVE: Develop efficient, active, 140GHz and 220GHZ, millimeter-wave components.

DESCRIPTION: Recent advances in solid-state-device technology, permitting the generation and amplification of signals at extremely high frequencies and at usable power levels, have prompted renewed interest in potential EHF applications. Of particular interest are those applications which can exploit the millimeter-wave transmission windows existing at 140 GHz and 200 GHz. The last significant Government-sponsored investigation and development of millimeter-wave components suitable for operation at the upper millimeter wave frequencies took place circa 1980-1983. That investigation addressed primarily the task of passive component development. In contrast, this development concerns solid state implementation of active components specifically designed for 140 GHz and 220 GHz transmitter/receiver applications. During Phase I, candidate, solid-state, heterojunction, bipolar transistor (HBT) and pseudomorphic-high, electron, mobility transistor (P-HEMT) devices will be assessed and designed. Millimeter wave components employing these devices will be proposed for detailed Phase II design and development at each of the two frequencies, 140 GHz and 220 GHz. During Phase II the most promising components for each of the two frequencies will be fabricated and completely characterized. It is expected that his solicitation will encourage further upper-millimeter, wave-frequency, component development leading to and extremely broad range of military and commercial applications. As typical examples, Phase III could address cellular telephone (commercial), imaging millimeter wave radar (commercial/military), or terminal guided weapons (military).

AF91-015 TITLE: Free-Flight Flow-Field Measurements

OBJECTIVE: Determine the density flow field around free-flight ballistic models using interferometry reduction procedures.

DESCRIPTION: Interferometry techniques are presently used in the Aeroballistic Research Facility, Eglin Air Force Base, Florida, to validate computational-fluid-dynamic (CFD) calculations of free-flight models. These interferograms provide a photographic image of the density fields around and in the wake of the models. The qualitative comparisons between the CFD calculations and experimentally obtained interferograms are accomplished

by integrating the density fields from the CFD calculations and comparing these with the interferograms. A technique is desired which will directly obtain the experimentally measured density fields from the interferograms and thereby provide a quantitative result for comparison with the CFD calculations. The basic interferograms will be provided to the contractor. Phase I task will demonstrate digitization procedures and develop/propose a topography algorithm that can be used with the digitized interferograms to determine the density field. The most promising technique will be selected for Phase II. Phase II will take the provided interferograms and develop and demonstrate the complete reduction routine culminating in experimentally measured density fields around free flight objects and will establish this process/technique as a permanent capability at the Aeroballistic Research Facility. Phase III will establish the technique and system for commercial applications associated with other ground test facilities.

AF91-016 TITLE: Zooming Infrared Optics (ZIRO)

OBJECTIVE: Develop zooming optics for infrared guided munitions.

DESCRIPTION: Recent developments in optical processing have yielded very robust optical filters that can correlate objects that change in aspect but not scale. The dependence of optical filters on the image size is well documented. The goal of this task is to investigate methods which minimize the range dependence of optical filters by changing the optical train or modifying an element in the optical train to maintain a constant image size as the range decreases. The technical challenge is to develop the optics capable of providing a continuous zoom capability. The optics must fit in a ten centimeter hemisphere and be capable of operating in the high “g” environment (30g’s axial, 60g’s lateral) of conventional missiles. Phase I will investigate and develop several, continuous, zooming, infrared, telescope concepts using non-traditional design methods and components. The Phase I study should include (but, not be limited to) a determination of the ability of a monolithic micro-mirror array to act as the zooming element in the optical path of a zooming infrared telescope. All of the concepts developed will allow for computer control of the zoom. The two most promising candidate designs will be chosen for further study, including a determination of the theoretical optical limits of each concept. Potential optical materials and fabrication techniques will be recommended. In Phase II the concept designs chosen in Phase I will be fabricated in breadboard and tested. Theoretical and practical image quality will be determined through simulation. The effects of the high “g” missile environment on the designs will be determined. A final design will be recommended based on the results of testing Phase III is expected to include the manufacture of the final design and application to missile seeker optical correlation.

AF91-017 TITLE: Two-Dimensional, Electronically Steerable, Monopulse, Millimeter-Wave (MMW) Antenna

OBJECTIVE: Develop a two-dimensional, electronically steerable, monopulse, millimeter-wave (MMW) antenna for air-to-air missile seekers.

DESCRIPTION: One-dimensional electronically steerable, MMW antenna have been developed, but they are not suitable for the dynamic environment of air-to-air missile engagements. MMW phase-shifter and gain-control component technology has improved sufficiently so that two-dimensional electronic-beam steering is now feasible. Two-dimensional, electronically steerable, monopulse antennas, capable of handling high scan rates without the use of gimbal systems, would greatly enhance the performance of air-to-air missiles. Moreover, the use of an MMW radar in air-to-air scenarios significantly reduces susceptibility to counter-measures and increases the probability of kill because of higher-guidance angle accuracies. The technical challenge of this project is to develop the low-cost components needed to construct a two-dimensional, electronically steerable, MMW monopulse antenna sized for an AMRAAM class missile. The challenge also includes the development of a monopulse feed network to output the sum, delta azimuth, and delta elevation channels. Recent developments in size reduction and increased power output of MMW solid-state transmitters provide the technology base. Phase I includes analysis and design of the antenna and monopulse feed network suitable to implement MMW antennas with beam-steering circuitry. Phase I will culminate with the recommendation of a candidate approach to incorporate the MMW components into the antenna and feed network design to be demonstrated in Phase II. Phase II includes the laboratory demonstration of the components of the two-dimensional, electronically steerable monopulse MMW radar antenna designed in Phase I. The demonstration should accomplish two-dimensional beam steering. Phase III is to produce a prototype antenna

sized to fit an AMRAAM-class missile. This antenna would have to be capable of electronically steering the beam in two dimensions and be capable of handling output power loads of 250 watts average.

AF91-018 TITLE: Location and Identification of Unexploded Ordnance

OBJECTIVE: Develop sensors for locating, identifying, displaying and determining arming status of unexploded ordnance.

DESCRIPTION: Airfield attack munitions continue to improve in terms of sophistication, intelligence, variety, and effectiveness for denying the generation of aircraft sorties. After an enemy attack, a key determinant of air-base recovery is the location and identification of unexploded ordnance, including time-delayed or influence-fuzed bombs, runway penetration munitions, and scatterable air-delivered mines/submunitions. This task must be accomplished before a minimum operating surface can be selected and Explosive-Ordnance-Disposal (EOD) personnel can conduct render-safe operations against the unexploded ordnance. Presently the location and identification is primarily a visual ground or helicopter operation which is time consuming and subjects personnel to great risk. The fundamental goal of this effort is to develop a system that can locate, identify, display and determine status of unexploded ordnance used against both paved and unpaved surfaces. These actions must be accomplished accurately and in a short period of time. The technical challenge is the development of a system that can discriminate a variety of munitions differing in size and shape that may be buried or partially buried and also operate under adverse weather conditions during both day and night operations. Phase I would include the analysis and design of the critical sensor concepts required for air-base recovery. Studies and analysis prior to design should include evaluation of the variety of munitions, technical risk, operational requirements complexity and cost. Phase I should culminate in a recommended design concept to be tested in Phase II. Phase II includes the development of critical components culminating in laboratory tests of sensing concepts and the bench testing of critical information processing and display techniques. Phase III would include the fabrication of a prototype demonstration/validation system for field trials. Data from the field trials would be utilized in preparing the system level specification for follow-on full-scale development.

AF91-019 TITLE: Process Development for Uniform-Response Lead-Sulfide Detectors

OBJECTIVE: Develop a manufacturing process leading to production of uniform-response PbS detectors.

DESCRIPTION: Historically PbS detectors have been manufactured by a web chemical deposition of PbS onto sapphire substrates having a delineated Ti/Au pattern. The final step sensitization involves heat-treating the PbS film in air. The existing processing leads to the production of PbS detectors lacking uniform detector performance not only from different PbS depositions, but also from within a deposition batch. Certain applications have a requirement for a large number of detectors exhibiting uniform response across each detector as well as from detector to detector within a quadrant. Many parameters affect the deposition process such as concentrations of oxidant, lead acetate, and thiourea/thioacetamide; substrate finish; reaction temperature; and impurities. The technical challenge is to investigate and analyze unknown effects of process parameters such as crystal orientation, crystal size, sensitization methods, film formation, etc. and then develop a process which will produce the desired detectors. Phase II will include selection of the most likely method to produce consistently uniform detectors of the preferred particle size and to demonstrate in a laboratory environment that uniform, high-yield detectors can bee achieved. Phase III will include the development of prototype equipment which can produce detectors at realistic production rates.

AF91-020 TITLE: Aerospace, Ground, Environmental, Simulation Testing

OBJECTIVE: Develop advanced test and evaluation techniques, instrumental, Simulation Testing

DESCRIPTION: New and innovative ideas and concepts are needed to develop facilities, methods and techniques to accomplish 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 temperature conditions for testing at hypersonic flight conditions. Some additional 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. Additional examples of areas of desired research are aerostructural, aerothermal, and propulsion testing in ground facilities. Generation of the test environment, measurement of the test conditions, analysis and interpretation of the test results are also within the scope 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 involve compromise of test conditions, high cost, poor productivity, or other major problems where innovative approaches might provide much needed benefits.

AF91-021 TITLE: Miniaturized, Non-contacting, Docking Device for Wind-Tunnel Models and Probing Devices

OBJECTIVE: Develop a non-contacting mechanism to be used to detect the distance between two bodies.

DESCRIPTION: In a continuous flow hypersonic wind tunnel, the most reliable method for tracking and positioning one test article relative to another or for locating a probe on a model surface usually involves a manual operation using an optical imaging system. Unfortunately, there are many circumstances where this optical technique will not work. A more useful automatic docking or positioning system would be one that was located on the traversing probe or model. Space on the model/probing mechanism is limited and, therefore, the mechanism must be less than 18 inches long with a diameter of nominally 0.1 inches. The detector should have a depth of field of at least 1 inch with an accuracy of +/- 0.002 inches. The device must be able to withstand surface recovery temperatures of 1300 degrees F and pressure from 0.05 to 50 psia. Any electronics or cables to the sensor must be able to survive temperatures up to 1000 degrees F and the vibrational and acoustic environment of a hypersonic wind tunnel. The support hardware to the model/probe is normally water cooled. Phase I should focus on demonstrating the feasibility of such a device and provide a conceptual design. In Phase II a prototype device should be fabricated and tested in a wind tunnel at AEDC.

AF91-022 TITLE: Highly Responsive, Gaseous Hydrogen, Sensor System

OBJECTIVE: Develop a gaseous hydrogen sensor system with a total response time not greater than 0.25 seconds.

DESCRIPTION: A highly responsive gaseous hydrogen sensor is required for operation in process air ducting at AEDC. The gaseous hydrogen detection systems currently available have unacceptable response times of 7 to 300 seconds. The total system response shall be no greater than 0.25% by volume and provide a signal. The sensor should work in a pressure range of 0.5 to 15.0 psia and a temperature range of 500 to 3000 degrees R. The sensor will meet all requirements for the National Electric Code Class 1, Division II, Group B Classification. In Phase I a preliminary design must be completed along with a practical demonstration of the device in a simulated ground test environment. Phase II should result in the fabrication and testing of a prototype sensor.

AF91-023 TITLE: Dynamic Stress Analysis for Projectiles

OBJECTIVE: Predict dynamic stresses for projectiles launched at hypervelocities in the ballistic ranges at AEDC.

DESCRIPTION: A computer code is required to perform dynamic stress analysis of projectiles launched at hypervelocities in the ballistic ranges at Arnold Engineering Development Center. The projectiles are constructed of metals, plastics, and composite materials and are subjected to acceleration loads of several hundred thousand times gravitational acceleration (g's). They are also subject to elastic and plastic deformations. The major loading is axial but the effects of side loads must also be included. If necessary the code may be designed for use on a supercomputer as AEDC has a CRAY X-MP-12. The source code will be provided along with documentation on its use. Phase I should focus on proving the feasibility of performing this analysis on simple geometric shapes and

should result in a prototype code which can be demonstrated at AEDC on Air Force computers. Phase II should result in a code that will provide all the required output for typical model configurations along with proper documentation.

AF91-024 TITLE: Dynamic Model Tester

OBJECTIVE: Develop a device to test model and sabot designs under equivalent dynamic conditions.

DESCRIPTION: A device is required to test model and sabot designs under representative dynamic conditions prior to launch from a hypervelocity, two-stage, light gas launcher. Model/sabot failure can cause serious damage to the launch tube. The device should apply a step stress wave to the test model equivalent to the peak step stress encountered by the model in an actual launch. The device should also simulate the presence of the launch tube. Magnitude and duration of the stress is to be controlled. Output should include condition of the model/sabot after test and the measured magnitude and duration of the stress pulse. Desirable outputs would be the strains of various portions of the model and sabot. Phase I should focus on a preliminary design and proving the feasibility of the concept. Phase II should result in a prototype device to be tested at AEDC.

AF91-025 TITLE: Command-Control-and-Communications (C3) Systems/Subsystems

OBJECTIVE: Develop innovative concepts for increasing warfighting capabilities of the Air Force (C3) System.

DESCRIPTION: Proposals may address all aspects of AF C3 systems/subsystems not specifically given in other SBIR topics. Proposals may cover any of the following AF C3 missions: Strategic C3; Tactical AF C3I; Theater interoperability for joint and combined operations; NATO Air Command and Control Systems; Air Space Management;C3 systems for AF mobility and Special Operations Forces missions; Air, Missile and Space Integrated Tactical Warning/Attack Assessment C3; World wide C2; All warfare. This topic offers great flexibility to bidders to propose solutions addressing AF problems. Past submission included 1) Advanced Communication Systems, 2) Air Space Management Capabilities, 3) Multilevel Communications Security Concepts, 4) Manufacturing Productivity Tools, 5) Air Surveillance Systems, and 6) Relocatable Target Detection System. AF managers evaluate proposals on their merits and applicability to ESD programs.

AF91-026 TITLE: Transportable Very-Low-Frequency (VLF) and Low-Frequency (LF) Transmit Antenna

OBJECTIVE: Develop and demonstrate transportable antennas capable of operation at very low frequencies or at low frequencies.

DESCRIPTION: Present Very Low Frequency (VLF) and/or Low Frequency (LF) transmit antennas are either very large ground installations, or very long trailing wires from airborne aircraft. There are no physically small transportable transmitting antennas that are compatible with a ground mobile command and control capability at these frequencies. A capability is necessary to allow transmission of VLF and/or LF message communication from ground mobile platforms either truck or rail-borne. This capability would need to be operable by a small crew and be operational within a few hours from start of set-up. Minimum special conditions for set-up are desirable. The antenna either needs to be recoverable in similar time or be expendable – with multiple units (reasonable quantity) carried with a command element – and allowing that element to move several times with a VLF and/or LF capability possible at each stop. The proposal must address what would be accomplished during Phase I which would allow the antenna implementation and demonstration to be accomplished in Phase II.

AF91-027 TITLE: Automated, Remote, Chemical and Biological, Sensor-Reporting System

OBJECTIVE: Develop and demonstrate a warning system capable of detecting known chemical and biological agents at remote locations and notifying base level warning systems.

DESCRIPTION: Development of an automatic reporting system for remote groups of sensors for chemical and biological agent detection in the air and air base drinking water supply is required. The system will form party of the air base facilities for recovery after attach and must survive any type threat which could be imposed against an air base in a theater environment. The sensor(s) should detect impingement of known liquid, vapor, aerosol, thickened, and solid (particulate) chemicals. Detection and alarm notification of the chemical/biological agents for an on-target attack should occur within two minutes. Once a sensor detection decision has been made, the automated notification to the air base alarm center should occur within 30 seconds. False alarm rates should not exceed 0.04 per hour. The reporting system must operate without the requirement for personnel to physically inspect the individual detection and warning sensors placed through out the base. The system connectivity between the sensors and the base alarm center must be survivable and capable of remote independent operation. A radio transmission capability between sensors and the alarm system is preferred, but alternatives may be proposed. The typical air base alarm system with which the reporting system must operate is built around microcomputers using a UNIX operating system, relational data base and X-Windows. The information relayed must provide detection notice, agent type, concentration of the agency, and sensor location. Key system parameters must have high reliability and be easily inspected/maintained/repaired, accurate in all weather conditions, easily decontaminated, and capable of expansion as new chemical/biological agents become known. The proposal must address what would be accomplished during Phase I which would allow demonstration of the reporting system during Phase II.

AF91-028 TITLE: Commercialization of New, Gaseous-Reactor Technology for Vapor Phase Deposition

OBJECTIVE: Implement deposition reactor for production of epilayers on single or multiple wafers using organometallic epitaxy or other vapor growth process.

DESCRIPTION: Vapor phase epitaxy is used to grow multilayer semiconductor structures, including quantum wells and superlattices, for a variety of electronic and optoelectronic applications. New reactor technology provides laterally uniform epilayers over large areas, and abrupt or graded compositional changes between successive layers in a controlled manner. This thin-film technology provides for precise control of layer thickness, composition, and doping for reactors operating in the viscous flow regime. A vertical, rotating-disk, single-wafer reactor that permits such control has been developed, and its utilization for organometallic vapor phase epitaxy has been demonstrated. Thickness uniformity of 1% and AlGaAs compositional uniformity of 0.1% have been obtained for epilayers grown on 5 cm diameter substrates. Heterostructures have been grown by molecular beam epitaxy. A detailed description of the demonstrated reactor, including machine drawings, will be available to the SBIR awardee. The technology to be provided under this topic is patented and subject to a royalty fee for commercial sales to other than United States government or its contractor. The patent owner will grant an option for the SBIR awardee to negotiate a royalty bearing, limited-term exclusive license to the patent rights. During the option period the SBIR awardee will have the right to use the patent rights for research purposes. Phase I Evaluation will be based on the business plan presented to transition vapor phase deposition reactor technology into a saleable product or wafer production capability and associated marketing plan. Phase II Evaluation will be based on accomplishments during Phase I period and updated business plan.

AF91-029 TITLE: Automated, Battlefield, Radio-Frequency Manger

OBJECTIVE: Provide an automated system to support the management of the radio frequency spectrum of a battlefield environment.

DESCRIPTION: Develop and demonstrate a capability to allowing a radio frequency manager to automatically assign operating frequencies to military units operating within the managers area of responsibility (AOR). The system must respond to changes in the number of operating units or personnel within the manager's AOR. Desired attributes include 1) Automatic processing (with manual input possible) of the communication equipment (receiver, transmitter, antenna) assigned to the military units, within a given area, that require frequency assignments; 2) Accepting changes in the number of military units or communication equipment assets within a given area; 3) Processing changing unit frequency requirements and operating priorities and proposing alternative redistributed frequency assignments based on current or planned operations; 4) Automatic processing (with manual input possible) of the data on hostile forces operating frequencies, electric warfare assets and current status; 5) Analyzing

hostile forces data and proposing frequency assignments for friendly forces and assess the probability of successful communication given the hostile forces capabilities; 6) Graphically depicting the frequency spectrum (by frequency band) showing assigned military units frequencies, hostile frequencies, jammed frequencies, etc. All military frequency bands from 3MHz to 44 GHz may be included, and terrain effects on line of sight frequencies may be included in the spectrum analysis process. The Phase I objective is to develop a functional description and an implementation concept for demonstration of the frequency manager during Phase II.

AF91-030 TITLE: Advanced Technology Application for Small/Manpack, UHF, Satellite Terminals

OBJECTIVE: Develop Concept for a new lightweight advanced-technology, UHF, Satellite, manpack terminal with DAM capabilities for DATA and voice.

DESCRIPTION: UHF Satellite Terminal Technology has progressed to a point where new state-of-the-art devices are/will be available for use in the next generation UHF manpack satellite terminal. Survey and assess those state-of-the-art advances in UHF device technologies. Determine device advancements in RF/IF and monolithic components, microprocessors. SAW and Charge Coupled Device (CCD) processors, digital signal processors, Power Generation Devices, VHSIC components and other technology applications for UHF Satellite Terminal design. During Phase I prepare a functional description/top-level design of a new Advanced UHF Satellite Terminal incorporating the results of the device survey. During Phase II the terminal design will be developed and demonstrated.

AF91-031 TITLE: Computer-aided, Software, Fault-Tolerant-System Development

OBJECTIVE: Develop a set of automated tools to assist in the production of systems which incorporate software fault-tolerance technology to achieve high reliability.

DESCRIPTION: To meet the stringent reliability requirements of many mission critical software systems, the development process for them should include the insertion of software fault-tolerance technology during the earliest possible phases of the software life cycle in order to reduce costs and risks. The opportunity exists to lend automated assistance to the development process through the Software Life-Cycle Support Environment (SLCSE), which is comprised of an extensible set of tools that share a common database. The integration of tools and data structures with the SLCSE will support software fault-tolerance technology and its insertion into the system software development process. In order to effectively accomplish this, it will be necessary to have a better understanding of software fault-tolerance models and techniques, their data inputs and outputs, and the tools that currently exist or need to be developed. It is also advantageous to adhere to standards that directly apply to system and software fault tolerance for enhanced usability, interoperability, and extensibility of the tool set. Phase I of this effort will consist of three areas of research and development and a technical report documenting the results of each. The first area involves the investigation, development, and enhancement of software fault-tolerance models/techniques, and the definition of their data inputs and outputs. The second area involves the investigation of the market place for automated tools that produce data for or use data from such models and techniques. The investigation should also determine the feasibility of (1) integrating existing tools with the SLCSE and (2) developing new SLCSE tools to fill the gaps in the market place. The third area involves the investigation of existing and emerging standards related to software fault tolerance and to the application of this knowledge to both Phase I and Phase II activities. Phase II of this effort will include the development of a prototype tool set that consists of at least one automated, software, fault-tolerant-system-development tool that demonstrates its utilization of SLCSE project database information to enable the insertion of software fault-tolerance technology into the earlier phases of the system software-development life-cycle, and the resulting payoff in terms of improved system reliability. The work expected to be performed during Phase III of this effort is the enhancement of the initial tool set development of the initial tool set developed during Phase II.

AF91-032 TITLE: Application of Natural Language Technology to Advanced Software Engineering Environments

OBJECTIVE: Investigate the potential application of state-of-art text-generation technology within advanced software engineering environments.

DESCRIPTION: Advanced software engineering environment consist of numerous software development tools and support a variety of software development methodologies and personnel. One area of significant concern within these varying environments is that of user interface, i.e., displaying information to the user in an easy to understand format. Current software test tools, for example, generate detailed tables that indicate, module by module, the outcome of each test. Many times a high level manager desires a more textual report that provides the overall status of testing activities. In addition, there are numerous applications possible in the area of support for project management. A natural-language text-generation system, in conjunction with project-management and database software, can significantly broaden the usability and applicability of project management reports. Complex tables, figures, and charts can be reduced to meaningful text and keyed to the appropriate level of management. The technical challenges of this effort are to develop the technology to provide this text in a meaningful way: 1) the text is automatically derived from the project development activities; 2) it does not repetitive or awkward; and 3) the manager can immediately obtain the reasons why certain conclusions were made about the status of the project. Phase I will investigate the feasibility of the application of state-of-the-art text-generation technology within an advanced software engineering environment, addressing high payoff areas of application and highlighting the area of project management. An initial application of this technology to the problem of project-management reporting will investigate the following: a) automatically generating text, tables, figures, and graphs, which provide an analysis of project spending, percent completion, expenditure rate, milestones met available resources; b) providing an analysis in terms of the current project status as well as the status over a period of time; and c) entity-relationship and object-base data models. The results of Phase I will be documented in a Final Technical Report. Phase II will develop and deliver a prototype natural-language-test generation system for one of the application areas identified during Phase I.

AF91-033 TITLE: High-Modulation-Rate Optical Detectors

OBJECTIVE: Develop an integrated optical detector for microwave-modulated optical signals

DESCRIPTION: Transmission of microwave signals via optical carriers has been demonstrated. Replacement of microwave/millimetric waveguide with photonic waveguide (e.g. fiber optics, SiN, AlGaAs/GaAs) will have a profound impact on military systems heavily dependent upon microwave hardware: antenna manifolds, interconnections, phased array antennas. Replacement with photonic waveguide demands transparent operation; that is what was a passive microwave waveguide has been replaced by an active photonic system. High modulation rate laser sources and external modulators have been demonstrated at microwave/millimetric wave frequencies. High-speed detectors have also been demonstrated, but they are low dynamic range and efficiency. What is needed is an integrated optical detector that provides microwave/millimetric gain. Optical wavelength of choice is 1.3 um to minimize photonic waveguide loss. Radio frequencies of interest are at 2-4 GHz, 8-10 GHz, 20 GHz (nominal +/- ten percent), and 44 GHz (nominal +/- ten percent). Traveling wave versus area detectors may offer the greatest advantage in linearity and dynamic range. In Phase I, study and limited experimentation will be accomplished. In Phase II, demonstration breadboard will be fabricated.

AF91-034 TITLE: Efficient Network Models

OBJECTIVE: Develop efficient, user-oriented, network-level, communications performance models suitable for DoD.

DESCRIPTION: Data communications and networking are technology bottlenecks in military weapons systems. The problem is assured/secure communications for users. Military communications must be user friendly yet responsive to command requirements Simulation and modeling is the critical defense technology used for performance analysis of communication network alternatives. The technical challenge is to construct a tool that gives insight into the difficulties of resource allocation in communications network design to satisfy user

requirements for data communications service. Importance sampling, knowledge engineering etc. have not yet yielded a suitable tool. In communications, the cost of providing service exceeding requirements must be traded off against the time value function to the end user. Phase I of this effort would develop methods for modeling efficient experiments to evaluate network performance. Experiments have become huge with embarrassingly large amounts of data with little useful information content. Phase II will propose development of an accurate and complete model for DoD communications networks that is capable of quick simulation while providing coarse but accurate results.

AF91-035 TITLE: Active, Programmable, Microwave, Directional Coupler

OBJECTIVE: Design, build and test a programmable active microwave directional coupler which would be suitable for inclusion into the transmit/receive module of an airborne, phased-array, antenna system used as surveillance radar.

DESCRIPTION: Current beamforming techniques for active aperture powered radar systems require the production of directional couplers with coupling coefficients that are a function of the element position. The challenge of this effort is the development of a programmable directional coupler that will be affordable due to the capabilities of Gallium Arsenide technology. The coupling ratio will be programmed as a function of scan angle by the use of microprocessors residing at the element level. Moving the coupler into the R/R module which powers each element would then result in mechanically simpler microwave systems with increased reliability. The directional coupler should pass, with unity gain, no loss, and phase dispersion correctable to 2.5 degrees root mean square (RMS) phase error, and exciter signal that provides the transmit pulse for the radar. The coupler should be capable of splitting the received signal along two paths. One path would correspond to the transmit path previously mentioned, and the other path would be operated over a 30 dB range with the same phase requirements as on transmit. Switching speed is to be consistent with a radar antenna operating in a wide-angle surveillance mode. Frequency response of the device should support 10% - 20% instantaneous bandwidth in any microwave band. In Phase I of this effort a detailed design to the component level of such a device is requested. In Phase II of this effort the device is to be fabricated and tested. The ability of this device to support ultra-low, sidelobe, phased-array (1) antennas is to be demonstrated.

AF91-036 TITLE: Remote-Antenna Fiber-Optic Link

OBJECTIVE: Develop Remote-Powered, Fiber-Optic, Cable System for Operation at Millimeter Wave Frequencies.

DESCRIPTION: Fiber-optic cables are an attractive replacement for coaxial cables where electromagnetic isolation of the antenna from the receiver is desired. Coaxial cable constitutes unacceptable bulk and weight to the application at millimeter wave frequencies. Presently, most applications require a power source at the antenna termination as well as the receiver. Limited research and development has resulted in small probe-like antennas which use light through a fiber-optic cable to supply biasing current for a semiconductor laser. Systems have been developed with excellent bandwidth and dynamic range properties to about 10GHz using a few meters of fiber. Phase I will investigate techniques to overcome frequency limitations of the laser diode modulator. Phase I will also investigate techniques to increase the minimum distance through a fiber-optic cable that a laser may be remotely powered. Phase II will implement the most feasible approach that was investigated during Phase I. A design goal minimum will be a device capable of operation from 1-100 GHz. The fiber-optic cable length will be a minimum of 40 meters. The Phase II effort will also include fabrication and demonstrations of the prototype device.

AF91-037 TITLE: Novel, Perovskite, Crystal Substrate for Thin-Film Superconductors

OBJECTIVE: Determine a compound suitable for thin-film growth of superconducting YbaCuO (1,2,3) which is thermodynamically stable from 77K to 1000K, and develop a method for synthesis and growth.

DESCRIPTION: High-temperature, superconducting thin films can be grown on some perovskite compounds because they are nearly lattice matched to the YbaCuO (1,2,3) crystal structure. Research on thin-film superconductors has advanced to the point where small areas can be produced with acceptable properties and high

critical temperatures. However, one obstacle to production of large areas of uniform quality is the substrate material itself. The available substrate materials either have high dielectric constants or exhibit crystal transformations during processing which cause surface roughening of the thin film. A compound must be found which will be twin or transform between 77K and 1000K, and its crystal structure must have a low dielectric constant (near10). The Phase I objective is to synthesize a compound which can meet the requirements and determine its thermodynamic stability by x-ray analysis. Phase II will demonstrate growth of single crystals which will be tested for use as substrates for high temperature superconducting films.

AF91-038 TITLE: Ternary, spatial-Light Modulators

OBJECTIVE: Develop three- and four-state, electrically addressed, phase-dominant, spatial-light modulators.

DESCRIPTION: Electrically addressed spatial light modulators (SLMs) are key components in optical correlation systems for applications in automatic target recognition and robotic vision. Phase-only and phase dominant SLMs have been identified as optimal approaches to smart filtering. Recent experimental work with binary phase-only filters, although promising, has revealed the need for another to smart filtering. Recent experimental work with binary phase-only filters, although promising, has revealed the need for another generation of SLMs that are more sophisticated. Specifically, three-state (ternary) and four-state (quaternary) phase dominant SLMs are required for improved correlation performance. In such devices, the phase state of a pixel is denoted by F1 and the corresponding amplitude output by A1. The ternary SLM in this project is required to have the states F1, F2, F3 = x, 0.5 pi with A1, A2, and A3 = 0, 1, 1, respectively; where x is arbitrary and the unity output amplitudes have the same optical polarization. For the quaternary SLM, the goals are F1, F2, F3, F4 = x, 0.5 pi, pi, 1.5 pi with A1, A2, A3, A4 = 1v, 1h, 2v, 1h, respectively; where v and h represent vertically or horizontally polarized output light. The use of ferroelectric liquid crystals or other electro-optic materials is an acceptable approach. The reconfiguration time of each pixel should be less than 100 microseconds. It is acceptable to fabricate each pixel as a composite of two optical elements in series. The contractor will provide resolution of the SLM, taking depths and area into consideration. Phase I will consist of the fabrication of a small array in order to prove the principle. Phase II will consist of implementation in a large working array.

AF91-039 TITLE: Development and Construction of a New Vapor Phase Epitaxy (VPE) Reactor for the Production of Multiple Quantum Well Structures

OBJECTIVE: Develop a new reactor to produce the next generation of photonics devices.

DESCRIPTION: The next generation of commercial photonic devices will be primarily based on multiple quantum-well structures. The structures will be either thin films of superlattices or strained layer superlattices of the III-V semiconductors. Current methods for production of layered structures are molecular beam epitaxy (MBE), metal organic chemical vapor epitaxy (MOCVD), and has problems with carbon incorporation; MBE is expensive and production yields are low. VPE has been consistently capable of producing high quality III-V semiconductors. The study requires an understanding of the controlled fabrication of semiconductor thin films with high crystal perfection using the various epitaxy techniques. The VPE technology may be based on either the chloride or hydride system. The new reactor should incorporate the advantages exhibited by MOCVD and technology will be valuable for the production of high frequency electronic devices. Phase I of this program will deal with reactor design and address solutions to current limitations in VPE technology. Phase II will construct the reactor and demonstrate its improved capabilities.

AF91-040 TITLE: Scanning Tunneling Microscope for Advanced Device Processing

OBJECTIVE: Develop scanning tunneling microscopy (STM) for ultra fine structure device processing.

DESCRIPTION: The scanning tunneling microscope recently has been shown to be an excellent tool for lithography to 0.1 micron dimensions. This region is currently inaccessible to optical and E-beam lithographic techniques. The STM, on the other hand, is capable of atomic level resolution and is surprisingly easy to operate in the nanometer

resolution region. This reduced scale opens up a new area of device physics. Entirely new families of quantum devices can potentially be processed onto existing chips with this technique. The phase I objective is to define the operational criteria that will allow the STM to become an effective add on attachment to current device processing equipment. The Phase II objective is to fabricate the STM attachment that will be retrofitted into existing process equipment. The device will be qualified by the production of quantum lines on the surface of a silicon based device.

AF91-041 TITLE: Microwave-Processed Sol-Gel Glasses and Ceramics

OBJECTIVE: Develop techniques and apparatus for processing glasses and ceramics prepared by sol gel and other technique necessary for nonlinear optics and high temperature superconductor applications, using new microwave technique.

DESCRIPTION: A wide variety of techniques have been employed for drying, sintering and annealing of sol-gel prepared films and monolith. Among the serious problems that face the progress of sol gel technology are: incorporation of crucial active elements in the solution and maintenance of stoichiometry during drying, and fracture of films and monolith. For example, in the nonlinear optics (NLO) it is necessary to use sol gel technique to prepare very high silica glass films and bulk pieces containing active elements (e.g. Pb, Ga, Bi, Nd, etc). Incorporating such elements and maintaining the stoichiometry during the process is very difficult. Similar problems are faced in high-temperature superconductor (HTS) films prepared by the advantageous sol-gel technique. Regardless of the applications, heat treatment is necessary to achieve dry, dense, and completely sintered films and bulk pieces that have the correct stoichiometry, microstructure homogeneity, the correct density, high strength and most of all improved NLO and HTS parameters. To date, conventional furnaces, the heating rates are generally slow. Because the material is heated from its exterior, temperature gradients exist within the material during processing. Microwave processing of materials is an emerging and exciting technique. In this novel processing approach, heat is generated within the material by the dissipation of microwave energy. This internal heating mechanism enhances the processing rates, resulting in more homogeneous materials with finer and more uniform structure, thus improving the properties. In Phase I, feasibility of the microwave technique and improvement of properties over conventional processing techniques should be demonstrated. A microwave processing apparatus suitable for laboratory research in ceramics and glasses is to be designed. In Phase II the apparatus must be constructed and tested. CuO-based superconductors will be optimized. Other ceramic compositions, e.g., Bi203-based will also be tried. Deliverables will include the apparatus.

AF91-042 TITLE: Volume Holographic Recording Glasses

OBJECTIVE: Develop improved Bragg filters using disordered solids.

DESCRIPTION: It has recently been shown that amorphous solids can be utilized as volume holographic recording media using selected write-beam wavelengths. An approach to accomplish this is to locally induce shifts in the color-centers of the material through an optically sensitive structural modification and/or an electronic transfer mechanism which effects a change in the refracting properties of the medium through the Kramers-Kronig relationship. Some examples of this development can be found in rare earth-doped phosphate and silicate glasses, and in GeO(2)-doped silicate glass which has an ultraviolet absorption band that can be bleached using excimer laser beams. Since glass can be molded into various geometries, drawn into fiber, and manufactured cheaply, photorefractive glass systems could be quite useful to the design and fabrication of Bragg filters, couplers, optical frequency demultiplexers, and read/write/erase optical memories. Furthermore, research to date has shown that amorphous materials have the ability to record gratings which are in phase with the interfering write beams. This provides a substantial improvement over single crystal photorefractive materials by eliminating phase noise in optical signal processing systems. Widespread application of the rare earth-doped glass systems is currently limited by the low scattering efficiencies of the induced refractive index gratings to optical wavelengths of practical interests in the near-infrared; the GeO2-doped glasses cannot have their photosensitivity tuned to accommodate holographic encryption using other laser systems. This program should address an approach to advance the current state of the art by developing stable glass systems in which transient and permanent/erasable refractive iex gratings can be recorded using visible or diode laser optical sources and have enhanced scattering efficiencies to signals in the near-infrared optical spectrum, i.e., approaching or exceeding 0.1. In Phase I glasses should be prepared which

demonstrate feasibility of the approach. Phase II should focus on optimizing scattering efficiencies in these materials and their complete characterization, as well as the preparation and demonstration of specific filter geometries and component fabrication.

AF91-043 TITLE: High-Speed Optical Image Processors in Rare Doped Glasses

OBJECTIVE: Develop an optical processor to modulate 0.8 and 1.315 micron pulsed images at nanosecond or picosecond gate intervals.

DESCRIPTION: Stimulated photon echoes from optically active ions in glasses have been used to study effects related to the molecular dynamics of the host medium in the immediate vicinity of the active site. Recently, photon echoes have been suggested for use in high-speed optical circuitry and in memory-storage-device applications. Since active ions can generally be incorporated into the matrix of a glass in higher concentrations than they can be doped into the lattice of a crystal, amorphous solids have the potential to be a more suitable host material for these applications. Phase I of this program should determine the more suitable host glass compositions on the basis of the system, potential, dynamic range and its resistance to thermal distortion under various optical fluences. It should also identify candidate rare earth ions and compensate for the effect of cross-relaxation mechanisms on echo signal intensity as it relates to rare earth-doping levels. Phase II of the program should focus on the practical testing and refinement of photon-each-optical-image processing circuits, such as pattern recognition, correlator, spatial masking and logic circuits, operating at 0.8 and 1.315 micron wavelengths from the preferred materials.

AF91-044 TITLE: Memory Media for Three-Dimensional, Photonic, Memory Architectures

OBJECTIVE: Investigate and develop media for us in 3-D optical memory architectures.

DESCRIPTION: Soon electronic computers will be handling computational rates exceeding one trillion FLOPs. Perhaps the greatest deficiency in the development of these machines is in the area of memory. At this time, electronic memory devices are not capable of delivering the data rates necessary for the computers of the future. Three-dimensional optical-memory technology has been theoretically identified as one area where the strengths of photonics can overcome this bottleneck. Materials research is badly needed to find and develop materials useful for three-dimensional memory devices. Phase I will develop potential memory media that could offer orders-of-magnitude improvement over existing memory media. Phase II will implement chosen storage material into a demonstrable system.

AF91-045 TITLE: Free-Space Optical Interconnects

OBJECTIVE: Study the problem of design and fabrication of free space optical interconnects for future computer interconnect applications.

DESCRIPTION: Possible optical memory architectures of the future necessitate the development of high-bandwidth, optical interconnect devices. Due to the necessity for high data rates, and memory requirements for computers in the future, optical 3-D memory technology has been identified as one possible solution to this problem. Some architectures for 3-D memory show great promise for on-line memory needs of the future. One problem with the implementation of such devices is in the area of device interconnections. At this time, no electronic or fiber-optic bus meets the needs of these devices. Free-space interconnects have great potential to correct this deficiency. The relative ease of maintenance and extremely high data rates make these interconnects attractive. The greatest difficulty is in the implementation of these devices at this time due to their vibrational sensitivity. For this reason, amplitude-independent digital-encoding techniques should be studied. During Phase I contractor will demonstrate, via Engineering Development Model, a one-channel, free-space, optical interconnect to maximize efficiency, amplitude modulation tolerance, environmental isolation and digital throughput. Phase II will demonstrate, as a minimum, a 16 or 32 bit standard input/output optical interconnect system for a microcomputer.

AF91-046 TITLE: Semiconductor Optical Amplifier Interconnects

OBJECTIVE: Develop improved approaches for amplified optical interconnects utilizing semiconductor direct optical amplifiers.

DESCRIPTION: Future designs of Air Force digital signal processors will employ optical interconnects utilizing photonics technology, a DoD Critical Technology. Current interconnect components have large inherent attenuation. The successful implementation of digital signal-processing architectures depends on overcoming this limitation. While many semiconductor optical amplifiers have an internal gain of 30dB, the gain available after interfacing is typically only 7dB. This represents a serious loss in performance. In Phase I develop innovative methods for interfacing semiconductor optical amplifiers into OEIC or fiber-optical circuits. Procure or fabricate amplifiers as part of this effort and process and test the concept in a collaborative effort working in the RADC Photonics Laboratory and the Cornell National Nanofabrication Facility. In Phase II, working in the Photonics Laboratory, develop the Phase I concepts to optimize performance and provide a working, subsystem, interconnect demonstration.

AF91-047 TITLE: 3D Micromovement Analysis Facility

OBJECTIVE: Demonstrate a facility capable of experimentally verifying the thermal and vibrational finite element analysis (FEA) of microcircuit packaging.

DESCRIPTION: While significant effort has been consumed in developing FEA tools for modeling and predicting the reliability of new microcircuit package designs, interconnection methods, and technologies there has bee no demonstration of a capability for experimentally verifying and validity of the models, methods, and assumptions used. This requirement is for the demonstration, verification and utilization of a facility capable of measuring the actual thermal expansion and/or vibrational micromovements of microcircuits and their assemblies in a manner that will allow the correlation and verification of FEA models. Phase I will require the development and demonstration of a suitable experimental method to verify the validity of the models, methods, and assumptions used. Phase II will require the verification of a group of FEA models.

AF91-048 TITLE: Hypertext-Based Reliability and Maintainability Advisor for Computer-Aided Design

OBJECTIVE: Develop a hypertext system to advise electronic system designers on reliability and maintainability design aspects.

DESCRIPTION: There is currently a lack of efficient means for providing electronic circuit and systems designers information relevant to the reliability and maintainability aspects of their design in a manner that is both user-driven and minimally interruptive to the design process. A software tool is needed to interface a reliability and maintainability (R&M) knowledge base to a computer-aided design (CAD) workstation environment. This should be accomplished in such a way that the user can transition aback and forth between the contexts of R&M and design with minimal difficulty. The user would have total control of the sequence in which they accessed the R&M knowledge base, entering and leaving it at times, locations and contexts of their own choosing without losing their place in the CAD design process. The interface between the CAD software and the R&M knowledge base should be based on an emerging class of man-machine interfaces and database management techniques collectively known as hypertext. Phase I would involve the development of a representative R&M knowledge base and its hypertext. Phase I would involve the development of a representative R&M knowledge base and its hypertext interface along with an approach for integrating this software into existing CAD hardware/software environments. Phase II would expand the knowledge base and develop a prototype implementation of the integrated hypertext and CAD environments.

AF91-049 TITLE: Automated Thermal and Vibration Assessment of Electronic Devices Using Closed Form Procedures

OBJECTIVE: Provide an automated, computer-based, thermal, shock, and vibration-assessment capability for electronic devices.

DESCRIPTION: The finite element analysis approach to predict the response of devices and structures to thermal and dynamic environments is technically sound and valid; however, the approach is also time-consuming, computer-intensive, and requires skilled engineering resources. A reliability assessment capability is needed that would allow a rapid assessment of electronic devices subjected to a defined thermal, shock, or vibration environment in order to isolate problem areas which may require detailed, finite, element analyses. Closed-form procedures using strength of materials' relationships, empirical data, or other simplified analytical techniques would be used, with input data provided in a question/answer format to automatically determine device response. Phase I of this effort will determine the approach needed to accomplish the objective and will also develop a proof-of-concept code to demonstrate feasibility and to verify results. Both thermal and dynamic loads will be considered. Phase II will develop the complete code and contain a data base for a wide variety of electronic devices, interconnects, and subsystems.

AF91-050 TITLE: Photonics Transducers

OBJECTIVE: Develop low-insertion-loss, high-frequency, photonic transducers.

DESCRIPTION: Most forward-looking avionic-system designs include high levels of integration among the various avionic subsystems resident on the projected platform. These levels of integration imply extremely high bandwidths for both analog and digital signal types. Fiber-optic (or photonic) interfaces are expected to play a crucial role in the required digital interfaces, but the extremely high insertion loss of available photonic transducers to high-frequency signals (>1 GHz) greatly limits their applicability to many high frequency functions. Specifically, a variety of radio frequency (RF) and high-frequency IF menifolding and beamsteering functions could be greatly simplified using photonic transmission or combination of signals if sufficiently low-loss photonic transducers were available. The co-integration of GaAs transducers with primary RF MMIC chips is also possible and would represent a significant reduction in size and a substantial increase in reliability. Thus the proposed Phase I investigates techniques fro low-loss fiber-optic transduction. During Phase II a detailed design, fabrication, and t4est of the most promising concepts will be accomplished. Following proof-of-concept demonstration by the small business investigator, a joint effort may be possible between that investigator and a major MMIC design house/foundry where an investigation of possible monolithic implementations would integrate the low-loss transducer and primary RF circuitry within the same MMIC chip so that RF amplifier/manifold/true-time-delay hybrids could be implemented comprising two or three IC's associated power distribution and photonic interconnections. These in turn, could form the building blocks for next-generation shared-aperture systems.

AF91-051 TITLE: Update Method for Inertial Navigation System

OBJECTIVE: Develop a method for updating the on-board inertial navigation system in order to provide position accuracy to within +/- foot of absolute position relative to earth's surface.

DESCRIPTION: In order for a mobile rapid runway repair (RRR) robot to be able to navigate to the edge of a bomb crater on a damaged airfield, the absolute position of the robot will have to be known to within +/- foot. Current update systems such as the Global Positioning System (GPS) and Loran are accurate to within =/-3 feet, under the best of conditions. Reliable updates to inertial navigation system and/or correlation with digitized maps of air base features are seen as critical for air base response to damaged runways. These updates would be necessary for reliable, consistent repair of damage without exposure of human resources to hazardous environments. Phase I will determine feasibility of objective stated above. Phase II will develop the capability of a one-foot absolute position error.

AF91-052 TITLE: Sensor Technology for Rolling Deflection Measurement to Assess the Repair quality of Bomb-Damaged Runways

OBJECTIVE: Develop sensors, sensor mounting equipment, prototype loading system, and data acquisition system for a rolling deflectometer (load-deflection) test to assess the repair quality of bomb-damaged runways

DESCRIPTION: Currently, Air Force pavements are evaluated with a Falling Weight Deflectometer. This device tests a relatively small discrete area, which is not adequate for the assessment of repair quality criteria. A continuous (rolling) device is needed which will apply a prototype load to the repaired runway section. Several types of rolling deflectometers (such as the Cox Deflection Device) have been researched, but none of these included sensor systems which would continuously measure a reference elevation (datum) to allow measurement of the changes in the actual deflection basin under the moving load (these devices actually measured curvature, rather than magnitude of deflection). A sensor system is required which will combine with a prototype loading system (similar loading to a heavily loaded aircraft wheel load) to allow measurement of 1) continuous elevations along a line on the repaired runway prior to the load rolling over; 2) continuous deflections at a series of radial points beginning at the load center; and 3) continuous final elevations to measure permanent deflection of the repaired runway surface. The system would include sensors, mounting hardware, prototype loading system, and data acquisition equipment needed to complete the required repair quality testing. Phase I will determine feasibility of a rolling (continuous) deflection and measuring device. Phase II will develop and evaluate chosen concepts for field use.

AF91-053 TITLE: Quantity-distance Criteria for Earth-Bermed Aircraft Shelters

OBJECTIVE: Develop explosive safety (quantity-distance) criteria for an earth-bermed aircraft shelter.

DESCRIPTION: When munitions are stored in a structure, a large strictly zoned area around that structure exists as dictated by safety. The driving criteria for the size of this area is the quantity/distance (Q/D) ration. Q/D criteria provide a relationship between an explosive weight and a distance to a relative degree of safety should a detonation of the explosive occur. It has been proposed that earth berms placed around concrete aircraft shelters would reduce the Q/D ratio; however, level of improvement has not been quantified for an internal explosion in an aircraft shelter. This program seeks to develop guidance for determining the change in Q/D distances for earth berming of aircraft shelters, and possibly other explosive storage structures. Phase I will could be determine these effects by engineering analysis, computer modeling, model testing, or any other appropriate technical approach. Phase II will provide conceptual designs and be validated by field testing to determine the effects to existing aircraft shelters, Q/D criteria due to berming and recommended Q/D criteria for earth-bermed aircraft shelters.

AF91-054 TITLE: Iron Control for Air-Stripping Groundwater

OBJECTIVE: Develop a method to control the iron in groundwater so that it doe not precipitate out and plug up a packed air-stripping tower during remediation operations.

DESCRIPTION: The Air Force has a need for a technique to control the iron that is present in groundwater pumped through air-stripping columns. Currently iron concentrations of 1-10 milligrams per liter (mg/L) are being oxidized in air-stripping operations. The resulting ferric oxide precipitate grows on the packing material until it restricts the flow of air and water. Similar problems are anticipated in aboveground bioreactors. The technique developed in Phase I can be some type of pretreatment to remove the iron or it can be an additive to alter the iron so that it flows through the column and does not form the precipitate Phase II, if approved, will be the testing of the technique at flow rates of 30-50 gallons per minute at an Air Force approved site.

AF91-055 TITLE: Advanced, Landfill, Cover Materials

OBJECTIVE: Develop a technologically advanced, waterproof, durable, elastic, cost-effective, self-sealing system for eliminating surface infiltration into landfills and resultant leachate generation.

DESCRIPTION: Older landfill caps consist of local soil and permit precipitation to percolate and contaminate groundwater. Newer caps, especially on hazardous waste sites, consist of various layers of soil, gravel, sand, clay, and stones. Often polyethylene sheets, geotextiles, and bentonite are sandwiched between these. It is generally accepted that all and fill caps leak due to settling, failure of seals in plastic sheets, biointrusion, pressure of rising methane, or unforeseen traffic. Existing cap designs are also very expensive to install. A technologically advanced, self-sealing blanket is needed to prevent leaks and to pinpoint cap failures for spot repairs. Phase I effort should demonstrate properties of the advanced material in the laboratory, especially leak resistance after being strained. The ability to locate mechanical failures, to wick precipitations sideways or into the atmosphere, and to cope with gas evolution, biointrusion and unwanted traffic are other important properties. Phase II, if approved, would pilot test blanketing materials under simulated field conditions.

AF91-056 TITLE: Methods for Separating and Concentrating Organic Solvents from Groundwater

OBJECTIVE: Develop an innovative technology to separate and concentrate organic solvents such as trichloroethylene contaminated groundwater.

DESCRIPTION: Trichloroethylene (TCE) is the second most common groundwater contaminant organic chemical found at Air Force bases. It is found in a wide range of concentrations, from a minimum of 0.004 g/L up to its solubility limit in water. Treatment of groundwater containing very low levels of TCE is inefficient. Bioreactor and chemical oxidation technologies, under development at AFESC for destroying organic solvent contaminated in groundwater, operate more efficiently at higher concentrations (>10ppm) than are typically found at contaminated sites (<100ppb). Therefore, the Air Force has a need for a technology that will concentrate organic solvents from groundwater. This technology should remove 99+ percent of the contaminants from the groundwater stream and concentrate them in a separate water phase. This system must be capable of treating a wide range of TCE concentrations in groundwater (10ppb-100ppb). The system also must resist the effects of inorganic constituents such as iron and calcium that may foul the system. During Phase II, the contractor will develop a system to remove and concentrate TCE from contaminated groundwater. The fouling effects of inorganic constituents in the groundwater will also be examined. During Phase II, if approved, the contractor will scale up the concept and fully characterize its performance capabilities by field testing at a groundwater contamination site.

AF91-057 TITLE: Disposal of Chlorofluorocarbons and Halons

OBJECTIVE: Develop nonpolluting technology to convert CFCs and halons into environmentally benign materials.

DESCRIPTION: CFCs and halons are cited as stratospheric ozone depleters, and, therefore, will be removed from service as refrigerants, firefighting agents, solvents, propellants, and constituents of blown foams. Incineration of these materials is expected to be an unsatisfactory method of disposal, as unburned feeds, products of incomplete combustion, and hydrogen halides produced by complete combustion would require stack treatment prior to release. A technology is needed to convert these materials into an environmentally benign form that can be disposed of as a nonhazardous waste (terminating Resource Conservation and Recovery Act custody) or that can be used for another purpose. Phase I should include experimental demonstration of feasibility of the proposed technology. Phase II should include experimental demonstration of the proposed technology on a kilogram or larger scale, including emission control methods and final disposal of all unusable residues.

AF91-058 TITLE: Liquid Phase Reduction of Chlorinated and Nonchlorinated Organics

OBJECTIVE: Develop a liquid phase treatment system to mineralize dilute concentrations of chlorinated and nonchlorinated organics in groundwater pumped from contaminated aquifers.

DESCRIPTION: Currently, the most common technologies for removing organics from groundwater are activated carbon adsorption and countercurrent air stripping. However, they merely transfer the contaminant to another phase which has to be subsequently treated.

AF91-059 TITLE: Human Systems/Subsystems Research

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

DESCRIPTION: Proposers may submit ideas to enhance man's capability to function effectively and safely as an integral part of Air Force systems and military operations while increasing mission success. This includes: 1) human factors engineering, such as methods improving man/machine interfaces or enhancing human physical or cognitive performance; 2) personnel protection/life support, such as crew escape from a transtmospheric vehicle; 3) chemical warfare defense, such as advanced personal and collective protection equipment; 4) occupational/environmental hazards, such as identification of and protection from toxic materials and electromagnetic or ionizing radiations; 5) personnel training and simulation, such as new technologies that improve the effectiveness or efficiency of training programs and methods. Ideas are solicited that effect any or all of the operations, maintenance, and support roles of Air Force personnel.

AF91-060 TITLE: Optimal Handling of Medical, Incinerator, Paint Operations and Other Wastes

OBJECTIVE: Minimize medical waste disposal costs; develop technology for reducing incinerator toxics and treating paint waterfalls.

DESCRIPTION: Specific areas include: (Specify subtopic by letter)

a. Minimize medical waste disposal costs. PHASE I: Determine whether factors contributing to medical waste disposal costs can be readily incorporated into an optimization process. PHASE II: Produce an optimization algorithm using factors like number of patient beds, waste volume, type of medical support provided, e.g., nuclear medicine, contractor costs versus on-site treatment costs, fees for air pollution, life-cycle equipment costs, etc.

b. Develop a control technology to reduce toxic hydrocarbon emissions including dioxins, furans, polyaromatic hydrocarbons, etc., frequently associated with medical and municipal waste incinerators. PHASE I: Determine whether technology exists and could be applied to field medical and municipal waste incinerators for the reduction of toxic hydrocarbons. PHASE II: Produce a prototype capable of reducing volatile organic compound's emissions by 75%. These products include chlorinated plastics, pathological waste, and other products of incomplete combustion and polymerization commonly found in emissions from medical and municipal waste incinerators. Describe its design and operation specifications in a supporting technical document.

c. Develop a control technology to reduce soluble and nonsoluble hazardous products from water used in waterfall stripping of airborne compounds in painting operations. PHASE I: Examine the feasibility of developing a small-scale, on-site treatment process for eliminating the hazardous waste component(s) of water used in paint operations. PHASE II: Produce a prototype which will reduce both the soluble and non-soluble components from water used in paint operations. It will be capable of removing solvents, metals, particulates, and other compounds or elements whose presence in the water causes it to be classified as hazardous waste. The resulting water should be dischargeable into the sanitary sewer system. Describe the design and operation specifications of the prototype(s) in a supporting technical document.

AF91-061 TITLE: Application of Artificial Intelligence Technologies to Training Systems

OBJECTIVE: Apply Artificial Intelligence Technologies to Training Systems.

DESCRIPTION: Artificial intelligence technologies hold significant promise for developing automated Intelligent Tutoring Systems (ITS) that achieve a student-to-teacher ratio of one-to-one by customizing presentation of instruction to an individual student. All proposed software systems should run on IBM/XT compatible microcomputer under MS/DOS. Within this topic we invite proposals which address one of the following areas: (Proposals should include the specific subtopic letter as shown below.)

a. Knowledge representation can run the gamut from formal logic grammars (most rigorous) to freedom text (least rigorous). Much research suggests that an optimal approach to knowledge representation in an ITS may be "semiformal" in nature.

b. In order for ITSs to adapt to the instructional needs of individual students, they must be able to diagnose skills and knowledge a student possesses at various stages of training. On-line diagnosis of problem solving abilities is a viable near-term goal. Research on student models and Psychometric Theory feed the design and development of a prototype computer based diagnostic testing system. A successful project in this area must 1) design specifications for student modeling; 2) identify psychometric issues and solutions in computer Based Diagnostic Testing (CBDT); and 3) design, develop, and document a prototype CBDT Software Shell.

c. Artificial Neural Networks (ANNs) may provide significant capabilities for ITSs in areas such as student modeling, recognition of patterns of "paths" students take through instruction, intelligent interfaces, rule generators for expert systems, and others. Proposals in this area should emphasize a novel application of ANN technology to ITSs.

AF91-062 TITLE: Technology for Manpower, Personnel, Training, and Safety (MPTS) Tradeoff Decisions

OBJECTIVE: Develop a computer-assisted workstation for simulating the impact of MPTS tradeoff decisions.

DESCRIPTION: Weapons development contractors are now required to analyze the logistics, human factor, and MPTS implications of alternative approaches as part of the weapon systems design process. Unfortunately, the available knowledge about MPTS tradeoffs is not well organized or readily accessible; most weapons systems designers do not have all the expertise needed; and most of the needed information on variable relationships is not available in a form that makes it readily available for design purposes. Although computer assisted design (CAD) techniques already permit the study of interactions among large numbers of complex variables the CAD systems, data bases, and expert systems needed to simulate and interrelate Logistics Systems Analysis Records (LSAR), human factors (HF), and MPTS variable do not yet exist. Computer-based technology is needed to: 1) develop data models to facilitate HF and MPTS analysis; 2) enhance the capabilities of current human/machine interface models (man modeling); 3) expand the range of human factors criteria that can be estimated and evaluated in a CAD/man-modeling environment (with emphasis on the impact of human/machine interfaces); 4) integrate these advanced task analytic methods data systems, and analysis tools into a user-oriented, CAD-based, LSAR/HF/MPTS analysis workstation (capable of simulating man machine interfaces and the implications of job design alternatives; and 5) develop design relevant evaluation criteria for us in assessing the merit of proposed human/machine interfaces (for use in contract evaluations). Such a system would enhance and expand the utility of computer-assisted design for the evaluation of human/machine interactions. Ideally, it would link up Logistics Systems Analysis Records (LSARs)—the major source of manpower, personnel training and safety MPTs data—with computer-assisted design (CAD)—the major tool in equipment design. It would also make extensive use of human factors (HF) simulations and data bases. Expert systems to facilitate human factors decisions would be an important part of the total system; and the CAD-based LSAR/HF/MPTS analysis workstation would be used to graphically simulate alternatives. Demonstrations of component systems that could be used in the design of MPTS-tradeoff-oriented workstations (e.g., MPTS requirement analysis systems, CAD systems, data bases, and expert systems for MPTS tradeoff decisions) are appropriate responses to this announcement. Phase I will demonstrate the feasibility of a comprehensive computer-based system for simulating MPTS tradeoffs in the weapon system design process. Phase II will produce a "demonstration system" of the above MPTS-Tradeoff Workstation.

AF91-063 TITLE: Life Support Systems Development

OBJECTIVE: Develop advanced systems to provide life support for aircrew of high altitude/performance aircraft.

DESCRIPTION: Specific area include: (Specify subtopic by letter)

a. Aircrew of high performance fighter aircraft capable of sustained 9-G and high altitude aircraft capable of altitudes >60K, have unique requirements providing for their basic physiologic functions to allow them to perform at an adequate level. Frequently this performance required man-machine interface at a highly technical level; i.e., a compromise in performance results in a less than satisfactory equipment function. These environments include high-thermal stress, high-sustained $+G_z$ exposures of 9-G for 30 seconds, long-term continuous operations, hypobarism, rapid decompression, laser eye hazards, and chemicals of warfare, Although protective methods and systems are available for these extreme environmental changes, they frequently do not provide adequate protection to allow aircrew optimal performance. These operational systems frequently need to be refined or new solutions provided. Examples of solutions are protective garments, equipment or methods, systems models, and exposure tables. Phase II will result in prototype hardware that will be transitioned to the HSD Acquisition Group for further operational development.
b. Develop advanced decompression/denitrogenation computer systems for real time and predictive decompression sickness risk assessment. High altitude exposure in aircraft, hypobaric chambers and extravehicular activity (EVA) in space result in an inherent risk of decompression sickness (DCS). In the past, general guidelines for safer altitude exposures have been developed through costly time-consuming studies, each specific to unique altitude exposure scenarios. The results of these studies are often difficult to apply to new altitude requirements. Therefore, new, time consuming studies must be undertaken. Rapidly changing technology in aircraft design dictates improved decompression risk assessment capability. Databases exist at USAFSAM that contain information necessary for the development of a standardized altitude decompression/denitrogenation model. Such a standardized decompression software package will permit hardware development for altitude decompression computers. These computers are needed for both real-time DCS risk information as well as DCS risk predictive capabilities. Phase II will result in prototype hardware that will transition to the Acquisition Division for further operational development. Utilization of such hardware is anticipated in aircraft cockpits, or hypobaric chamber control stations, in EVA suits, and as high altitude mission planning computers.

AF91-064 TITLE: Dosimetry Technology for Radio-Frequency (RF) Radiation-Induced Currents and Temperature Increases

OBJECTIVE: Develop systems to measure induced currents and temperature increases in humans exposed to radio frequency fields.

DESCRIPTION: Specific areas include: (Specify subtopic by letter)

a. Develop systems to measure currents induced by RF fields in humans. It has been sh own recently that vertically polarized radiofrequency fields in the VLF-VHF band are capable of inducing fairly significant body currents in a freestanding human being. A second problem in the VLF-VHF band of frequencies is that commonly encountered ungrounded metallic objects such as a car, van, bus, etc. will develop open circuit voltages on the order of 30-100 Volts when objects are exposed to incident electric fields of 100 V/m. Voltages are proportionately higher for larger incident fields. Upon touching objects, large currents on the order of hundreds of milliamperes may instantaneously flow through the hand, the arm, and the body. To reduce such problems, limits on these currents have been proposed by International Radiation Protection Agency (IRPA) of the World Health p4@o Organization and the Ministry of Health and Welfare of Canada. Limits on currents promulgated by ANSI C95.4. Instrumentation for determination of induced electrical current in humans is needed so that probes should be self-contained, compact, and wearable.
b. Although a probe and system for temperature measurement in radio frequency radiation (RFR) fields are commercially available, there is not an interface to standard laboratory computers. The computer interface will provide an easily implemented method for accurate temperature measurements which are used for two purposes in RFR experiments. The temperature of the preparation is, of course, needed to document experimental conditions; Initial temperature increase at the onset of RFR is used to determine specific absorption rate. The interface will be constructed using standard hardware components and have associated software written for its use. It is anticipated that the connection to the probe will be an appropriate analog-to-digital converter. However, a search must be performed to identify devices which facilitate communication with IMB PC compatible computers. The Phase I feasibility study will be a search for appropriate technology to allow computer interface between commercially available temperature measurement systems and standard computer systems. Initial designs will consider direction connection of

a converter to the computer, such as the Intersil ICL7I09. The search will also identify the most appropriate sensor board for a PC expansion slot. Phase II will produce an interface between temperature probe and computer.

AF91-065 TITLE: Noninvasive Physiological Monitors

OBJECTIVE: Develop a rapid, lightweight, mobile and easily monitored assay(s) to record and quantify physiological activity.

DESCRIPTION: Specific areas to be addressed include: (Specify subtopic by letter)

a. Many stressful events encountered by military personnel are manifested in the body by physiological events. For example, cortisol is released to generalized stress. Similarly melatonin may indicate level of fatigue, and glucose measures suggest energy and oxygen utilization. A noninvasive assay system for these and other physiological indicators is needed to quantify stress in a variety of situations. Since time is usually limited during stress, these assays would have to rapidly provide a reasonably close approximation of more sophisticated measures. The ideal system would use saliva or perhaps urine to register more than one physiological parameter in an easy-to-use-and-interpret monitoring device. For example, 1 cc of saliva in such a system might provide multiple assays. The numbers might be stored on microchip for later processing. Such a device would allow personnel to document their level of stress (fatigue or otherwise).
b. The Air Force needs a data acquisition and information control system to monitor patients during aero medical evacuation. Patients transported in this environment require frequent monitoring to determine their physiological condition as a result of their injury and their reaction to the transportation environment. We would like one system which can organize both conventional physiological data and patient records with the possibility of including unconventional physiological data such as skin color, pupil size and reaction, and nail bed blanching. The idealized system would be able to monitor both patients and the aero medical evacuation environment. Once patient data has been entered; the system should be able to organize it to monitor the patient's progress and cross-reference the information with a database to predict probably current and future conditions. Current research has identified what type of patient records and physiological data needs to be acquired. Future research emphasis is to develop the hardware and software capabilities necessary to: perform voice or handwritten data entry; recognize and process unconventional information; and cross reference the acquired information with a database to predict probable conditions. This research may be performed in segments or as a part of one complete system.
c. Research efforts are being sought to produce instrumentation capable of executing sophisticated signal processing software and interacting with test subjects in research projects to provide the noise exposure and human response data. Air Force planners require human response data to predict the effects of changes in flight operations along Military Training Routes (MTRs) and around firing and test ranges. Accurate prediction of the effects of sporadic aircraft over flight noise exposure on sparse populations living in these areas is constrained, however, by an incomplete understanding of the effects of aircraft noise on rural populations. Currently, data exists in a database maintained at the Armstrong Aerospace Medical Research Laboratory to allow fairly accurate predictions of human annoyance at the community level around airbases. However, application of these data and the resulting Schultz curve, based on these data, to predict human responses to aircraft over flight noise is, in many situations, a debatable scientific procedure. Use of the Schultz curve data is questionable for the present application because of significant differences in the type and amount of noise generated and because of expected differences in human attitudes between people who live in an airport environment versus the MTR range environment. The most persuasive and useful data would link noise exposure and sufficiently lightweight to allow it to be conveniently and relatively unobtrusively carried or worn for periods of days or weeks; it must contain all of the electronics necessary to allow sensors and software to be effectively used for continuous monitoring, processing and analyzing of acoustic signals; it must be capable of both passively accepting spontaneous human responses and administering a questionnaire at specified times or upon detection of an aircraft flyover; the power source must provide sufficient resources to make the device self sustaining during transport to remote areas, to make the required measurements and to retain the data for long periods of time; and the per unit cost must be a primary consideration in the design strategy because a low cost device will allow the large number of individuals to participate in the study that are required for the results to be valid and reliable. Phase I

should produce the "plan" for a personal noise dosimeter that meets the requirements outlined here. Phase II will produce a prototype personal noise dosimeter.

d. Develop methods to remove or correct artifacts of physiological origin from psycho physiological data. The collection of ambulatory data from operators performing their daily tasks makes possible the monitoring of the effects of workload, time on task, fatigue and other factors. The main source of data artifacts is not electrical or magnetic interfaces from the environment, but is rather physiological in origin and is produced by movement and muscle artifacts. These "physiological" artifacts are, unfortunately, difficult to deal with since they are in the same frequency range as the signals of interest which are heart rate, eye blink, EEG and respiration. In order to make the best use of "on the job" physiological data, these artifacts must be reduced at data collection and must be removed from the data of interest. Phase I product is evaluation of the problem and proposed solutions. Phase II product will be hardware and software implementation of the proposed solution.

AF91-066 TITLE: Medical and Neurophysical Aspects of Aircrew Performance Capabilities

OBJECTIVE: Develop medical/neuropsychological models to predict human performance.

DESCRIPTION: Practitioners of Aerospace Medicine and Neuropsychology use a variety of clinical tests and procedures developed within the specialties of neuropsychology and the neurosciences to assess the basic human performance behaviors of aircrew. On the other hand, human factors scientists and engineers generally employ stimulus response techniques to measure relevant task performance in objective terms. Resulting data are often used to derive performance models based on biomechanical, psychomotor, perceptual or manual control theoretical constructs. The Cognitive Scientist has the opportunity to integrate a rich "clinically derived" performance database with the voluminous "human factors derived" performance database to develop robust models of such higher order behaviors as memory, pattern recognition, reasoning, decision-making and executive control functions. Continued progress in this domain requires a theoretical framework supported by reliable experimental and functionally based mechanisms. The product of Phase I shall be a first generation theoretical structure and conceptual design for appropriate experimental and analytical tools to bridge the gap between "behaviors" and "mechanisms." The product of Phase II shall be a refined theoretical structure with prototype experimental and analytical tools, demonstrated in a research environment. A potential Phase III could result in marketable test devices and analytic procedure software tools derived from Phase II. These products could have wide ranging applications in both civilian and military enterprises for screening applicants for specific jobs, evaluating training systems and outcomes, detecting/predicting performance aberrations and specifying man-machine interface designs.

AF91-067 TITLE: Helmet/Head-Mounted Systems Technology

OBJECTIVE: Develop virtual world or helmet/head mounted display applications for aircrew operations and/or training.

DESCRIPTION: Proposals in this area should include the specific subtopic (by letter) as indicated below:

a. Investigate and establish the suitability of night vision goggles (NVGs) to provide nuclear flash blindness protection. Phase I is an initial paper study to estimate both eye protection capability and NVG resistance to damage. IF result is encouraging perform additional studies and design/integrate/brass board NVGs will Lead Lanthium Zirconium Titanate (PLZT).
b. Enhance pilot daytime passive visual search with the integration of Low Powered Binoculars with the standard USAF lightweight helmet. Design, test and evaluate these devices as installed on USAF 55-P helmets and as worn by human subjects or pilots with 20./20 corrected vision.
c. Integrate an instrument to nonintrusively measure visual accommodation and ocular vergence with a helmet mounted display (HMD). Phase I objective is to breadboard a helmet mounted optometer for a laboratory proof of concept demonstration. The optometer must be lightweight, compact and capable of being incorporated into an HMD with little or no modification. The required resolution and accuracy of the optometer is 0.125 diopter. The resolution and accuracy requirement for vergence measurement is 0.1

degree. Both requirements shall be maintained thorough a 60 degree meeting the above requirements, plus potentially destructive flight qualification tests.

d. Design, evaluate and prototype a passive optical sensor system for aircraft altitude determination based on optical flow fields. Phase I consists of overall system architecture; sensor requirements; signal processing and computation requirements; and expected performance under nominal and degraded conditions. If feasibility is demonstrated, Phase II would develop and evaluate a working prototype.
e. Prototype a helmet mounted virtual image display (VID) without see thorough for supporting man machine interface research. Phase I shall concentrate on design and proof of concept demonstration of a helmet mounted virtual image display using two color image sources to provide a true three dimensional world. Initially, resolution requirements will be only Color Graphics Adaptor (CGA) compatible, but eventually the virtual environment will include high resolution graphics, so there should be a plug in capability for future color image sources. The optics should be free of geometric distortions, so predistortion of image input is obviated. Field of view goal is 120 degrees horizontal and 90 degrees vertical, with a minimum requirement of 80 H by 60 V. Phase II will assemble three fully functional lab breadboards for display/optical performance verification.

AF91-068 TITLE: Ergonomics/Perception

OBJECTIVE: Improve crew systems via techniques for acquiring, interpreting, visualizing and applying ergonomic and perceptual data.

DESCRIPTION: Within this topic we encourage proposals in the following areas: (Specify subtopic by letter)

a. Develop prototype automated 3D full body, anthropometric measuring system. Technological advancements in design and manufacturing systems allow for automated production of clothing and protective equipment. These systems operate in a three dimensional environment and need three dimensional data as input. Therefore, to use them effectively, three dimensional human body surface data is required. A system is needed to obtain high density, 3D data on the entire surface of the human body, including areas which might be masked, such as under the arms. It must acquire and display data rapidly and be readily transportable as it will be used for anthropometric surveys at widespread locations. A number of technologies are available to produce such a system, so Phase I would entail assessing the various techniques for this particular application. During Phase II a prototype system will be built and evaluated.
b. Analyze the visual mechanisms underlying the discrimination of small structured targets at supra-threshold contrasts. The human visual system's capability to detect and discriminate objects is based in part on the luminance and chrominance differences between the object and its surround. The relative contributions of the luminance and chrominance mechanisms in mediating detection, and discrimination varies as a function of the spatial and temporal properties of both target and background. To the developer, of camouflage, concealment and description (CCD) techniques, such observations are critical. Presently, the luminance and chrominance contributions to the discrimination of small structured targets in spatially complex backgrounds is poorly understood at supra threshold levels. This topic seeks development and implementation of innovative approaches to determining these relative contributions in a manner which will facilitate the development of optimal camouflage techniques.

AF91-069 TITLE: Manikin for Injury Assessment

OBJECTIVE: Develop manikin instrumentation and complementary criteria for relating measured responses to human injury likelihood.

DESCRIPTION: The Air Force has develop an Advanced Dynamic Anthropomorphic Manikin (ADAM) for use in testing and evaluating the performance of ejection and protection systems. The final design report is available from DTIC. While this manikin has been designed to have humanlike properties, its application emphasis has been on determining the effects that a human body would have on an aircraft system rather than the effect that the system would have on man. This effort would seek to develop manikin-integrated sensing and instrumentation methods to measure responses relevant for assessing hazards associated with aircrew force exposure environments.

Additionally, it would develop appropriate criteria for injury likelihood prediction as a function of the manikin measured responses. Injury of the long bones and joints during limb flail, and of the neck and spine during vertical acceleration and windblast exposure are among the areas of most concern. While it is desirable that this methodology be compatible with the designs of the ADAM, the current ADAM design should not constrain the proposal of different approaches that can better satisfy the overall objectives. Phase II would involve incorporating the methodology developed in Phase I into prototype manikins and demonstrating by tests the validity of the approaches.

AF91-070 TITLE: Human Sensory Feedback in Air Force Telerobotic Systems

OBJECTIVE: Develop sensory feedback modes and subsystems for intuitive operation of robotic systems by human operators.

DESCRIPTION: Concepts for human control of robots in unstructured Air Force environments combine the cognitive abilities of the human with the hardiness and heavy manipulation capabilities of robots. By capitalizing on the human judgment and the robot's ability to operate in conditions lethal to humans, the advantages of each "system" can be exploited. Human operator awareness of the robot's work environment adds significant flexibility to mission capability. The challenge is to develop quality feedback from the robot to the operator. Two specific current challenges are: Feedback Control: Control instability may be encountered when the operator feedback control mode switches from position control to force control. Techniques must be developed to minimize the impact of this nonlinear transition on the human feedback mechanisms and mechanical system response; Force Feedback to Small Exoskeletons: Fine manipulation using human sized robotic hands requires human sized exoskeletons for intuitive control. Force feedback to these small exoskeletons using human sized volume, high efficiency semi linear actuator mechanisms. Actuators are needed to provide human range forces to exoskeletal feedback control to operator and force feedback to small robots. Phase II will result in brass board hardware employing these techniques, capable of integration with current and planned exoskeletal systems.

AF91-071 TITLE: ATLAS to Ada Software Compilation System

OBJECTIVE: Develop an Abbreviated Test Language for All Systems (ATLAS) software compilation system which can translate validated ATLAS test specification statements into Ada test program code.

DESCRIPTION: ATLAS has been the DoD standard test programming language since the mid 1970's. ATLAS has also been adopted by the airline industry as the standard test programming language. There is a current DoD initiative to adopt Ada as the standard test programming language. The government and industry have invested large amounts of money and time into the development of ATLAS test development and documentation tools that do not currently exist for Ada. To effect a smooth transition to Ada, an ATLAS software compilation system is needed that produces Ada test program code to maximize the use and benefit of existing ATLAS tools and expertise while gaining the additional benefits of Ada as a test language. Since there are numerous versions of ATLAS in the DoD and commercial marketplace, offerors should outline how each version can be accommodated in the proposed system to facilitate current vertical integration initiatives in the DoD. Consideration should be given to the modular modification of existing ATLAS compiler products versus new development. By modifying an existing modular ATLAS compiler must of the validated computer design can be retained, thus reducing the risk of development and the time required to field a mature product. An important consideration for selection will be the completeness of the solution, probability of success, and the ratio of investment to product value. Phase I will analyze existing ATLAS computer products, assess the feasibility of an ATLAS to Ada compilation system, and develop the Ada architectural design for implementation. Phase II will involve the modification of an existing ATLAS software compilation system to produce the Ada test program code, development of the Ada test program architecture, validation of the compilation system and the integration and demonstration of a simple test program set on a selected Air Force Automatic Test Equipment System. Phase III would involve the expansion of this compiler product into a total Ada environment for tests.

AF91-072 TITLE: Halon Replacement

OBJECTIVE: Develop a replacement for Halon 1211 and Halon 1301.

DESCRIPTION: The Montreal Protocol eliminates the production of chlorofluorocarbons (CFCs) in the United States by the year 2000. Halon 1211 and HALON 1301 are CFCs used by the Air Force for fire suppression. Halon 1301 is dispersed as a substitute needs to be developed for both agents. Phase I will identify potential replacement agents which can extinguish fire but are not hazardous to the environment. Phase II will test each potential agent to identify a substitute.

AF91-073 TITLE: New Canopy/Windshield Design to Extend Life of Cockpit Displays

OBJECTIVE: Develop a technology to enable effective control of cockpit ambient light environment.

DESCRIPTION: Cathode Ray Tubes (CRTs) have, until recently, held the monopoly in providing electronic portrayals of aircraft status and tactical functions to the pilots of military aircraft. Now, a new generation of color CRTs and flat panel/dot-matrix displays are arriving on the scene. Today, new Air Force aircraft systems are designing their respective cockpits to embody these electronic display instruments. Retrofits of existing inventory aircraft are being planned that will incorporate this new generation of electronic display instruments. Regardless of the display instrument technology being employed, the problem remains the same. Namely, to be readable the instruments have to be driven at or near their peak light output performance in order to at least marginally compete with the sunlight that, directly or indirectly, enters the cockpit. This mode of operation causes significantly higher operating temperatures of these subsystems and results in a direct, adverse impact on their reliability and frequency of maintenance.

A means of controlling these high ambient light conditions in military aircraft cockpits would eliminate the preceding, abusive, operating mode. This is believed to be attainable via canopies and windshields whose light transmission characteristics can be varied to suit the ambient light conditions. Such variability would significantly reduce ambient light levels in the cockpit; and could be achieved either automatically or under a manual control that is adjusted by the pilot. The latter is preferred; however, either method, or a combination of the two is acceptable. As an objective , in ambient light environments up to one hundred foot candles, the transmittance of the canopy and windshield should be 75% to 85%; a figure that is similar to present day canopy and windshield light transmittance characteristics. Above an ambient light level of two should exist for ambient light levels that are between the two aforementioned limits. Also, under any of the ambient light conditions, smooth gradations in light transmission uniformity across the entire canopy and windshield area, of up to 15%, will be acceptable. The light transmission characteristics of such canopies and windshields would, ideally, not alter the color spectral distributions of the light emitted and reflected by real world objects; nor, would they spatially distort or scatter light passing through them. A non-fluid method for achieving the objective is preferred. The proposed method should include a fail safe mode that would assure maximum transmittance of light in the event of component degradation or failure. Phase I should validate the concept, preferably through lab demos. Phase II would embody Phase I principles in actual canopy/windshield configurations.

AF91-074 TITLE: Aircraft Power – More Electric Concepts

OBJECTIVE: Develop electric power by wire concepts to replace conventional aircraft power system components.

DESCRIPTION: The goal of the More Electric Aircraft initiative is a doubling of aircraft power reliability by the minimization or elimination of troublesome systems such as: centralized hydraulics, gearboxes, and pneumatic bleed systems. Additional benefits possible are weight reduction, increased survivability, and reduced heat rejection to the fuel. In the near term, power can originate from gearbox mounted generators, be distributed through a “smart” fault tolerant electrical system and supplied to the various loads. The system will have the capability to sense faults or damage and reroute power to the highest priority loads,. Extensive built in test capability can be utilized to ease maintenance actions, and crud parts items such as electrical connectors and wiring will be addressed. In the far term, the generators can be buried in the main engines to eliminate the engine and airframe mounted gearboxes. A

switched reluctance type generator can be used because of its solid core, fault tolerance, and higher temperature capabilities. It is planned to have the power controls mounted outside the rotating engine core, so that the generator core and windings inside the engine will have a mean time existing components and to define new components which will be needed by More Electric Aircraft. Development and demonstration of many new component technologies is needed for the More Electric Aircraft concept including a wide variety of electrical equipment for power generation, distribution and utilization functions. Advanced high temperature electric wire insulation, high power connectors, solid state power controllers, inductive switching, built in test architectures and components, large electrical starter/generators, fault tolerant electric power distribution components and high temperature magnetic materials are needed. A wide variety of electric driven actuator technologies for a large spectrum of aircraft functions/subsystems is also required. Phase I goals include study results, analytical derivations and proof of concept experiments. Phase II goals include high temperature prototypical hardware demonstrations. Work to be accomplished in Phase III includes component integration, test, assessment and comparison to analytical models.

AF91-075 TITLE: Development of Aluminum Rivet for Use in 900 F Aluminum Structure

OBJECTIVE: Demonstrate a highly sustainable aluminum faster technology for use at temperatures of 900 F or above.

DESCRIPTION: Future high performance aircraft systems will demand structure that is lightweight and durable at high temperatures. For lightweight metallic structures, this demand is driving the use of aluminum to higher and higher temperatures. Naturally, with the high demand for increased readiness, sustainability, reliability, and decreased workload maintenance, unreliable aircraft structures resulting from fabrication of component assemblies using incompatible materials and fastener systems cannot be tolerated. Incompatibilities result from a difference in thermal expansion coefficient, galvanic corrosion characteristics and the like. This enhances the likelihood of unreliable, leaky structures as well as reduced durability and fatigue induced failures. The results of a Phase I and II small business innovative research (SBIR) effort, “Development of an Aluminum Fastener System for Use at Moderate Elevated Temperatures,” indicated that it was feasibly to make a 600 F aluminum fastener which compared structures at higher temperatures due to improved compatibility and high temperature fatigue resistance. The aluminum material temperatures are achievable for aluminum. A number of mechanically alloyed systems using inter-metallic dispersions of A14C3, Al203, Al3Ti are presently being developed to move the service temperature for aluminum up to 900 F. Accordingly, the objective of this effort is to assess the feasibility of forming 900 F aluminum materials into fasteners for use in 900 F aluminum concerned with alloy screening, quality assessment, feasibility and alloy(s) screening and selection. Phase II shall involve optimization of processing and material systems coupled with fabrication of coupons and generation of design allowable. In addition, Phase II emphasis should be placed on achieving small or subscale technology demonstration of equivalent or better performance (e.g., in terms of sustainability and reliability) than state of the art materials systems as well as payoffs in cost and weight.

AF91-076 TITLE: Hook-loop Attachment Concepts for Structural Doors and Access Panels

OBJECTIVE: Identify and evaluate concepts for fastener-less hook-loop attachment of structural doors and access panels.

DESCRIPTION: The skin of virtually ever Air Force weapon system is covered with numerous doors and access panels. These doors and panels are frequently removed to service subsystems and the airframe. The majority of these doors and panels are attached using traditional mechanical fasteners including bolts, screws, and rivets. In addition heavy doublers, nut-plates, and collars are required to build up the structure to lower stress concentrations in the fastener holes. The problems with traditional fasteners are well documented. Door and panel removal requires removal of all the fasteners and the reinstallation of the fasteners when the door or panel is put back in place. Removal and installation of the fasteners is time consuming, and often time leads to maintenance induced damage (MID) from tool slippage, over-torquing, use of the wrong fasteners, use of the wrong tool, etc. In harsh environments the removal and installation problems are compounded. The entire process is costly and reduces system readiness and sortie generation capability. For stealthy vehicles fasteners increase signature. This program will develop a hook-loop (analogous to the trade name Velcro material) fastening concept which uses no traditional

mechanical fasteners. No holes, doublers, nut-plates, and collars are required in the airframe and panel. Doors and panels held with hook-loop attachments can be removed and installed in one simple step. The hooks and loops are permanently attached to the faying surface of the airframe and panel, and cannot be dropped or lost, leading to foreign object damage (FOD). Problems of fastener over-torquing and using the wrong fastener will also be eliminated. The products of Phase I should include evaluation of hook-loop fastening material properties, identification of door and panel applications, design concepts, operational concepts, quantification of payoffs, and proof of concept through small scale testing. In Phase II full scale doors and panel should be fabricated and tested.

AF91-077 TITLE: New Aerospace Wire Insulation Materials

DESCRIPTION: Develop new wire insulation materials for aerospace applications.

OBJECTIVE: Wire insulations currently available cannot meet all identified performance requirements for aircraft and space applications. New insulations based on organic or inorganic materials are required. Current aircraft have experienced wiring failures which can degrade system performance. Future aircraft will most likely operate at higher voltage and temperature levels. Problem areas include resistance to are propagation, abrasion resistance, limited loss of mechanical and electrical characteristics at high temperatures, fluid resistance, and handling constructions. It is expected that new materials will be developed as candidate round and flat wire constructions. Phase I should examine existing materials, modification of materials and the potential design of new materials. Preliminary research suggests that the following polymeric materials may be of interest: fluorinated polymides, phenylated polyquinolines, polysiloxaneimides, fluorocarbon-hydrocarbon copolymers, organo-ceramic polymers and polybenzoxazoles. This effect should examine the feasibility of obtaining identified materials and provide a discussion on their potential advantages over existing materials. A Phase II effort would characterize selected materials and evaluate finished wire constructions for use as an aerospace power distribution system.

AF91-078 TITLE: Advanced Cold plates for Line Replaceable Modules

OBJECTIVE: Design and develop a light-weight, low-cost, highly thermally conductive composite cold plate.

DESCRIPTION: Avionics functions are contained in line replaceable modules (LRM), which are housed in integrated racks. These LRMs consist of electronic components, printed wiring boards (PWB), cold plates, connectors, and thermal clamps. The connector, which is the electrical interface to the rack, attaches to the cold plate. The PWB's containing the components attach to this plate. The connector, which is the electrical interface to the rack, attaches to the cold plate. This plate is also the thermal interface to the rack. The cold plates in today's systems are typically 1/8 thick aluminum. This is a heavy material and has a high thermal resistance. More importantly, the coefficient of thermal expansion (CTE) for aluminum is substantially different from that of PWB material used in the construction of circuitry. This CTE mismatch is a significant cause of avionic failures due to interconnect separation and PWB delamination and cracking. Also, aluminum adds avionic weight to the aircraft system and allows the electrical components to run at a high junction Temperature (TJ). For example, the junction temperature for a 50 watt, dual sided PWB will increase by about 120 C due to the aluminum plate alone. This increased temperature reduces the life of many circuits by almost a factor of 2. The reliability of these components as well as the LRM would be increased dramatically if the thermal conductivity of the cold plate can be increased. Cold plates of light weight materials will reduce the total avionics weight which in turn reduces life cycle costs. Phase I activity will include characterizing different materials for cold plates, performing trade studies (thermal, weight) of various materials, and recommending several candidate materials. Phase II activities will be the detailed design, prototype development, and testing of a lightweight, low cost, highly thermally conductive LRM cold plate.

AF91-079 TITLE: New Concepts and Innovations for Aeronautical Systems/Subsystems

OBJECTIVE: 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 (i.e., tactical, airlift, mobility, strategic, training, 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. Innovations in technologies that are currently available only from foreign sources or from limited sources in the United States are specifically encouraged. Additionally, innovative proposals which address Logistic technology Needs are encouraged. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF91-080 TITLE: Methodology for Premilestone I Planning

OBJECTIVE: Devise/develop effective methodologies for use in Premilestone I planning.

DESCRIPTION: This category of Pre-milestone I planning methodology is intended to cover three specific areas of interest in FY91. They are outlined as follows:

a. Pre-milestone I cost estimating from emerging technology to the fielding of weapon systems/subsystems employing these technologies is required. This will provide the wherewithal to cover specific technologies and then accumulate the cost of these technologies into a total systems/subsystems cost model. Examples of technologies of interest are: High temperature materials, ultra light airframes, smart skins, high performance turbine engines, advances avionics, technology and advance systems/subsystems should be addressed individually and in combination for a specific system application.
b. Develop software based systems to facilitate information structure analysis, function analysis, and dynamic performance analysis for the planning and requirements studies needed for the design and development of systems. Data collection and storage performed for problem definition and analysis, enterprise, system description, and requirements analysis for design and development is a critical phase of the planning process.
c. In the area of design and mission analysis methodology tools specific requirements exists to develop an effective methodology to determine the susceptibility of USAF intra-theater air-lifters to conventional threats (i.e., artillery, multiple launch rocket system, small arms, etc.) during ground operations such as loading, offloading or ground refueling. Determination of susceptibility as a function of time on the ground is vital. The impact of environmental factors such as terrain, weather, day/night operations must also be taken into account.

AF91-081 TITLE: Innovative Applications of Artificial Intelligence to Emerging Systems

OBJECTIVE: Support the development of system/subsystem concepts to locate, identify, and attack Strategic Relocatable Targets and Large Area Displays for cockpits for future strategic, tactical, and airlift systems.

DESCRIPTION: This category of innovative concepts is intended to cover application of all facets of artificial intelligence. It is meant to provide the innovator with latitude to focus on areas of application not addressed by other specific aeronautical topics. All aspects of artificial intelligence as applied to all aspects of the Air Force mission are to be considered. Special emphasis is placed on AI application to large Area Displays, which give total situational awareness information to the aircraft cockpit as well as location/identification/attack of SRTs.

AF91-082 TITLE: Future System Concepts and Related, Innovative, Analysis Tools

OBJECTIVE: Develop new concepts in the application of emerging technology and develop analytical tools for evaluating these emerging systems.

DESCRIPTION: This category of innovative concepts is intended to cover all facets of system application concepts and analysis techniques for future emerging aircraft systems. These emerging systems include: The Advanced Theater Transport (ATT), Special Operations Aircraft (SOA) for long range infiltration/exfiltration/resupply airlift; training system for T37 and T38 replacement; Advanced Multi-Role Combat Aircraft (AMRCA); Aerial Refueling

Systems for future tanker replacement; and Single Stage to Orbit (SSTO) system concepts. Of special interest are concepts and analytical tools related to the detection, location and attack of Strategic Relocateable Targets (SRTs). Analytical tools are to include areas of design analysis, design synthesis, mission analysis, mission effectiveness, and supportability analysis for subsonic to hypersonic system development. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF91-083 TITLE: ARIA Cruise Missile Trajectory Planner/Plotter

OBJECTIVE: Develop innovative, timely methods to plot cruise missile trajectories and generate/plot ARIA aircraft profiles.

DESCRIPTION: The Advanced Range Instrumentation Aircraft (ARIA) currently supports several cruise missile test programs by receiving, recording, and relaying telemetry data, as well as providing Remote Command and Control/Flight Termination System coverage. Each program has peculiar requirements and uses different test ranges to accomplish its respective mission. It takes approximately five man-hours per hour of cruise missile chase to plan an appropriate ARIA support profile. This equated to one person working full time for about 18 weeks to plan the cruise missile mission supports for 1989, and the number of mission per year is increasing. A planning/plotting program would allow more efficient use of manpower and reduce response time to new missions and mission changes. This concept requires a system to plot segments of the cruise missile trajectory on different scales of aeronautical charts. The system must be able to accept input in the various formats (tape, disk, etc.) provided by each program. The system must also be able to input the data manually. Each waypoint and time must be identified on the support profile. The profile must be within the ARIA aircraft performance limits and mission support requirements. Both these factors will be different on the aircraft. Support requirements will include distance form the missile, relative position of the missile to the ARIA, relationship of relative position to the altitude of the ARIA, and specific airspace restrictions for different operating areas. The missile track and the ARIA track must be able to work with information up to and including Secret-SAR. Phase I will consist of the feasibility demonstration and delivery of a preliminary modeling program mapping a cruise missile trajectory and the associated ARIA aircraft tracking profile. Phase II will be additional work to perform the full scale demonstration of the program so that the operating parameters and system capabilities are verified against known system limitations.

AF91-084 TITLE: Tactical Modem for Stealth Communication (TMSC)

OBJECTIVE: Develop a modular, expandable, parallel-processing modulator/demodulator for Stealth/Anti-Jam (AJ), adaptive, tactical communications.

DESCRIPTION: The trend towards intelligent jamming mandates demands that future tactical communications systems possess Electronic Counter-countermeasures (ACCM) responsive formats. The ECCM response to interference must be real time and adaptive to maximize the probability of successfully receiving a message. In addition, the adapted transmission must be transmitted in a burst to enhance the Low Probability of Intercept (LPI). A modem processing modular architecture is needed that supports up to 50 MHz input sampling rate while providing the needed adaptive processing. The module must be bale to adapt is demodulation processing to received signals which may be corrupted to real world interference and distortion. It must be able to adaptively select the best available modulation scheme to optimize the PLI/AJ performance in real time. Under Phase I of the proposed research, the basic system architecture would be identified and a top level system design developed; analyses would be conducted to establish system performance capabilities; the technologies necessary to accomplish implementation would be identified; the estimated weight, power consumption, and volume of such as system would be estimated; critical technologies would be identified; and a final report, including a develop specification, would be provided. Under Phase II of the proposed research, the contractor will fully develop a breadboard real time TMSC. The system shall be thoroughly evaluated through computer simulation. The effort will culminate in a laboratory demonstration which clearly demonstrates real time adaptation. The contractor will deliver a final report which documents the system as well as future enhancements. The contractor will also deliver the software developed during Phase II.

AF91-085 TITLE: A Complexity Measure for Avionics Software (CMAS)

OBJECTIVE: Develop the capability of measuring the complexity of avionics software.

DESCRIPTION: As avionics systems become more sophisticated and their capability increases, the software designed for these systems has become more complicated. Therefore, the need arises for minimizing software complexity so that the design and support personnel can comprehend how the system works. In order to minimize complexity, it first needs to be measured. The use of complexity matrices will aid in deciding what software implementations will be used in the system. A decrease in future software support costs will be realized by less complex software implementations. This work will provide the Air Force with the capability of measuring the complexity of the avionics software by examining the size, features, and structure of the avionics source code. Work performed under this effort can be divided into two phases. The first phase will identify concepts that currently exist in measuring complexity that can be applied to avionics software. New techniques will be defined in this phase. The second phase will emphasize the development of a system for automating the process of measuring complexity of avionics software.

AF91-086 TITLE: Low Probability of Intercept/Jam-Resistant (LPI/JR) Burst Communications (BURSTCOMM)

OBJECTIVE: Develop and evaluate new and unique concepts for an LPI/JR, burst, radio-frequency, communication system.

DESCRIPTION: Present aircraft communications are detectable at long distances, and when stealth is required, the solution has been to go with communications out. This practice greatly reduces coordination and flexibility and increases the chances for confusion, ineffective missions, and accidents. NewLPI/JR communication systems that are both affordable and broadly applicable to a wide range of aircraft and scenarios are needed to support modern Air Force operations. Envisioned applications include air lift, refueling, reconnaissance, and tactical and strategic defense/offense. Spread spectrum methods such as frequency hopping and direct sequence have been widely known and researched for a long time, but the primary emphasis with these techniques has been JR. Recognizing the growing importance of LPI communications, the Wright Research and Development Center has been investigating new adaptive and alternative spread spectrum communication approaches. One attractive method is burst communications. Transmitting with random short bursts, or burst time hopping, reduces the interceptor's ability to integrate the received energy which increases the detectability threshold. However, burst communications alone will probably not provide a worthwhile increase the detectability threshold. However, burst communications alone will probably not provide a hopping, frequency-hopping, direct-sequence, and/or other techniques will likely be required. Under Phase I of the proposed research, the contractor will study, design and develop quantitative performance measures for an LPI/JR burst communication system capable of reliably transmitting low data rate/voice information between multiple aircraft. The system will be capable of operating over line of sight communication distances commensurate with the above applications. At the conclusion of Phase I, the contractor will deliver a final report documenting the selected design, performance analysis, and recommendations and a Phase II. Under Phase II of the proposed research, the contractor will design, fabricate, test, and deliver a transmitter and a receiver breadboard which demonstrate the selected LPI/JR burst communication concept. At the conclusion of Phase two, the contractor will deliver a final report documenting the design, all results, and recommendations for future enhancements.

AF91-087 TITLE: X-Band, Air-to-Air Radar, Side lobe Clutter Mitigation Through Adaptive Processing

OBJECTIVE: To formulate and evaluate adaptive processing techniques capable of canceling side lobe clutter from tactical fighter pulse Doppler radars.

DESCRIPTION: Attainment of militarily useful all-aspect angel target detection and tracking ranges in difficult ground clutter and electronic countermeasures (ECM) environments against low observable (LO) threats will be technically challenging for several reasons. First, utilization of the classical all-aspect angle, medium pulse repetition frequency (PRF) look-down waveform results in the requirement for target detection in the presence of

directly competing, diffuse side lobe clutter, which can mask or obscure low radar cross-section (RCS) targets. Secondly, the number of side lobe clutter discrete, that are capable of producing false alarms in conjunction with either the regular antenna side lobe structure or a radome reflection lobe, will increase in direct proportion to the reduction in threats RCS. Finally, orders-of-magnitude reduction in target RCS will result in corresponding orders-of-magnitude reduction in threat signal-to-side lobe jammer ratios unless adaptive side lobe cancellation (ASLC) is employed. However, the presence of side lobe clutter can greatly degrade the performance of conventional ASLCs and, conversely, ASLC operation will reduce directly competing side lobe clutter in a medium PRF or alternative transmit waveforms, and significantly more sophisticated guard antenna false alarm reduction concepts. These will be effective to a degree. However, radar antenna installation under a radome can negate much of the potential performance gain. More exotic approaches, such as design or calibration of the antenna/radome assembly to result in lower installed rms side lobe levels have yet to be developed, and are likely to be costly. With the tremendous increases occurring in digital signal processing technology, airborne radar adaptive processing is rapidly becoming practical and affords the potential of mitigating the side lobe clutter. The Phase I activity will investigate exploiting adaptive processing to solve the all-aspect angle look-down radar mode diffuse and discrete side lobe clutter problems and the ASLC/side lobe clutter signal processing compatibility dilemma. The scope of the effort includes formulating and evaluating relatively simple (Doppler filtering followed by spatial nulling of competing side lobe clutter patches) and highly complex Phase I output will consist of an adaptive processing algorithm design, radar architecture definition, and digital computer simulation performance predictions include “on aircraft” effects. These activities will lead to the Phase II effort demonstrating adaptive processing side lobe clutter mitigation (goal of two orders-of-magnitude over conventional techniques) in near real-time using breadboard digital array signal processors and appropriate radar receiver/antenna hardware/emulations and tactical environment simulations.

AF91-088 TITLE: Target Recognition Using Spectral/Spatial Techniques

OBJECTIVE: Develop target recognition techniques based upon multi-spectral and space-time filtering techniques.

DESCRIPTION: Automatic Target Recognition (ATR) systems are required to minimize aircrew workload and maximize overall platform/target exchange ratio. Systems with low probability of intercept sensing concepts are most attractive for airborne platform applications. At present Electro-Optical (EO) sensing is the most covert approach available. Existing ATR approaches employing EO sensors have emphasized high spatial resolution, two dimensional wideband sensors with some consideration of low spatial resolution, multi-spectral sensors. The most promising ATR approaches employ target models to predict potential features to be matched against observed features. The recent advent of EO sensors providing a degree of both spatial and spectral resolution has created an opportunity for the development of model-based ATR techniques employing these sensors. This effort will explore the utility of combined spatial and spectral signature information for use in model-based ATR development. Sources are sought to explore the following specific technical areas:

a. Application of multi-spectral/spatial sensing for target recognition: This effort will conduct analysis of existing spatial and spectral EO sensing capabilities to establish potential EO multi-spectral/spatial discrimination features and predictive models of such features. Phase I will concentrate upon identification of promising features with a comparative trade-off between feature potential for recognition and required sensor complexity. Phase II will develop and implement a model-based recognition algorithm, based upon the most promising recognition features from Phase I, in the government supplied Sensor Algorithm Research Expert System (SAREXPERT) model-based algorithm development test bed.
b. Application of space/time filtering approaches to EO sensors to target recognition: Phase I will explore the utility of space/time filter decomposition techniques in EO sensors imagery for estimating target pose and extracting features for use in model based target recognition. Phase II will develop and implement a model based recognition algorithm, based upon the most promising filtering techniques from Phase I, in the government supplied SAREXPERT model based algorithm development test bed. Proposals which address the application of the above areas to non EO sensor data and integration of EO with non EO sensing will also be considered.

AF91-089 TITLE: Towed Decoy Counter-Countermeasure

OBJECTIVE: Investigate, develop, and evaluate unique and innovative techniques and tactics to protect airborne radars from a Towed Decoy environment.

DESCRIPTION: Towed Decoy is a promising electronic countermeasure (ECM) threat in which an active repeater radiates a signal as strong as the target and therefore guides the weapon away from the actual target. A secondary aspect of Towed Decoy threat is to present the radar with multiplicity of targets. The premise is that if the defending radars are unable to distinguish between aircraft and decoys, then we must address both threats. New Electronic Counter-countermeasure (ECCM) techniques need to be developed to negate these ECM threats. For our aircraft to survive in a toed decoy environment, advanced technology must be used to reduce the chances of detecting and attacking a false target or decoy. The technique to be developed shall be of such a nature that they are a basic part of the fundamental radar design. Also, these techniques must consider the total electronic warfare environment that the radar will encounter, and not just an isolated Towed Decoy threat. This effort will require access to classified foreign intelligence information; and a facility and personnel clearance level of Secret/NORFORN is required. Under Phase I of the proposed research, the contractor will investigate and define new ECCM techniques that will counter the Towed Decoy ECM threat. At the end of Phase I, the contractor will be required to produce a final report which documents the investigation and definition of these new ECCM techniques, along with a proposal for Phase II. Under Phase II of the proposed research, the contractor will fully develop and evaluate the techniques that showed the greatest potential for success in Phase I. At the conclusion of Phase II, the contractor will produce a final report which documents these techniques as well as possible future enhancements. Also, a recommended test demonstration approach for the techniques will be presented.

AF91-090 TITLE: Air-to-Air Anti-Radiation Missile (ARM) Electronic Counter-Countermeasure (ECCM)

OBJECTIVE: Investigate, develop, and evaluate unique and innovative techniques and tactics to protect airborne radars from air-to-air ARM attack.

DESCRIPTION: ARM is an air-to-air electronic countermeasure (ECM) threat that causes a missile to home-in on a radiation radar or aircraft and may increase the vulnerability of the aircraft. This will allow the enemy to possibly reduce the effectiveness of the Air Force aircraft in accomplishing their assigned mission. New ECCM techniques need to be developed to negate these techniques to be developed shall be of such a nature that they are a basic part of the fundamental radar design. Also, these techniques must consider the total electronic warfare environment that the radar will encounter, and not just an isolated ARM threat. These techniques, also, must be generic to all aircraft which need to counter this threat. The ARM ECCM techniques should be effective against any type of ARM guidance. This effort will require access to classified foreign intelligence information and a facility and personnel clearance level of Secret/NORFORN is required. Under Phase I of the proposed research, the contractor will investigate, and define new ECCM techniques that will counter the ARM ECCM threat. At the end of Phase I, the contractor will be required to produce a final report which documents the investigation and definition of these new ECCM techniques along with a proposal for Phase II. Under Phase II of the proposed research, the contractor will fully develop and evaluate the techniques that showed the greatest potential for success in Phase I of the project. At the conclusion of Phase II, the contractor will produce a final report which documents these techniques, as well as possible future enhancements. Also, a recommended test demonstration approach for the techniques shall be presented.

AF91-091 TITLE: Reconfigurable, Real-Time, Coherent Radar Simulator

OBJECTIVE: Develop a cost effective, modular, high-fidelity, reconfigurable, real time simulation of coherent, mono-pulse threat radars.

DESCRIPTION: A cost effective method of providing high-fidelity, real-time simulation of the full range of modern coherent and mono-pulse threat radar systems is essential to the efficient development of effective countermeasure techniques and systems. Past hybrid simulators have been designed as clones as individual threat radars to ensure simulation fidelity. This approach limited their availability since it required extensive hardware

development for each system and a separate simulator for each threat system of interest. It also gave rise to inaccuracies in the simulation fidelity due to the significant development time needed to update the design to match frequently changing intelligence assessments. The alternative to the hardware implementation was normally non real-time digital simulation. This approach, while more responsive to change than the hardware implementations could not normally provide the level of fidelity desired without computation times much slower than real time. This topic area seeks to exploit the technology opportunities presented by recent developments in high-speed digital processors, parallel processing architectures, fast digitizers and programmable analog devices to develop a truly reconfigurable, real time, threat radar simulator to perform simulation testing and evaluation. A successful design needs to address all aspects of radar processing functionality: waveform data extraction, angle data extraction and tracking function. Additionally, the design needs to address the real-time performance issues associated with the design. Finally, and perhaps most importantly, the design needs to have a traceability of design parameters to simulation fidelity. Under Phase I of the proposed research, the contractor will develop a preliminary design with an analysis of feasibility and cost/fidelity trade-offs for the various simulation functions. Performance demonstrations of critical aspects of the design are desired to evaluate risk in proceeding with Phase II. At the completion of Phase I, the contractor will produce a final report which documents the Phase I effort and provides a proposal for the design implementation in Phase II. Under Phase II, the contractor will fabricate, test and document the proposed design. Together with the delivery of the system, the contractor will provide recommendations for further development.

AF91-092 TITLE: High-Temperature Superconducting (HTSC) Switched Delay Line(s) Switched Delay Line(s) for Active Electronic Warfare (EW)

OBJECTIVE: Develop a low-loss, small-size, wide-bandwidth, HTSC, phase shifter capable of handling high power (2-3 watts) for use in EW active array transmitters.

DESCRIPTION: HTSC will enable lighter, smaller, more reliable, systems to be developed with higher operating frequency, wider bandwidth and improved performance. Much work is already being performed towards producing low loss passive microwave components such as delay lines for signals with power levels well under 30 dBm. Higher power levels, bandwidths, low microwave loss contacts and switches for delay lines are just now beginning to be considered. Initial results are extremely promising, showing there is no intrinsic property in the HTSC materials preventing power levels and bandwidths to be increased with development, especially in short delay lines needed for high power, wide band phase shifters for EW active array transmitters. Polarization control networks for EW applications currently use 8-bit ferrite phase shifters because of their wide bandwidth and low loss. But ferrites are large, requiring they be placed before the corporate feed network of the antenna array. It would be desirable to implement the polarimeters in GaAs Monolithic Microwave Integrated Circuit (MMIC) technology and place them directly behind each antenna element of the active array to reduce system size, increase reliability and improve performance. Unfortunately, high resolution GaAs device losses can be as much as 15-16 dB, making them impractical for this application. With development, HTSC will enable practical, high resolution, low dispersion phase shifters which exhibit the low loss of ferrites while maintaining the small size of GaAs MMIC technology. Under Phase I of the proposed effort, the contractor will fabricate a small HTSC delay line designed to optimize its use at liquid nitrogen temperature or above in a compact, high power, low loss, 6-18 GHZ phase shifter. The contractor will then measure the delay line loss versus frequency from 2-20 GHZ at input microwave power levels from 0.01-3 watts. At the conclusion of Phase I, the contractor will produce a final report documenting results and conclusions. Under Phase II, the contractor will continue fabricating, optimizing and measuring additional delay lines while introducing low loss, low power switching. An 8-bit, 360 degree, phase shifter will be a goal for Phase II. Maintaining MMIC size, low loss, power and bandwidth will continue to be emphasized as the program progresses. At the conclusion of Phase II the contractor will produce and deliver a final report documenting results and conclusions along with a multi-bit phase shifter hermetically packaged with input and output connectors.

AF91-093 TITLE: Multi-Threat Engagement Simulator

OBJECTIVE: Develop and implement a real-time, multi-threat electronic combat engagement simulator.

DESCRIPTION: Modern integrated electronic combat systems must handle multiple threats operating in the infrared and visible regions of the spectrum in addition to the traditional radio frequency environments. Furthermore, the growing density and complexity of this multi-spectral environment places increasing demands on the management of electronic combat resources and necessitates the design and testing of new electronic combat resource management systems. Assessment of the operational effectiveness of new systems/concepts requires closed-loop evaluation of how the system under test will perform in a combat scenario at the mission and campaign levels. The objective of this assessment is to determine the electronic countermeasure's effects on the threats. To create an accurate closed loop simulation that responds to electronic combat techniques will require a detailed weapon system representation. The multi-threat engagement simulator function will close the loop between the electronic warfare system and other simulators to make the scenario responsive to electronic countermeasures. The multi-threat engagement simulator will be aware of the geometries and modes of all threat systems, will evaluate the effects of generated electronic countermeasures on the threats, will determine responses of the threats to the electronic countermeasures, and will cause other simulators to implement these threat responses when necessary. Under Phase I of the proposed research, the contractor will develop a preliminary design of a real-time, multi-threat engagement simulator which can be operated stand-alone or incorporated into an integrated electronic combat effectiveness evaluation system. At the conclusion of Phase I, the contractor will produce a final report which documents the design of real-time, multi-threat engagement simulator, and demonstrates the critical aspects of the system. Under Phase II of the proposed research, the contractor will fully develop the real-time, multi-threat engagement simulator. This effort will culminate in a laboratory demonstration which illustrates all salient features of the multi-threat engagement simulation. At the conclusion of Phase II, the contractor will produce a final report which documents the system, as well as possible future enhancements. The contractor will also provide the documented software code that was developed under this effort.

AF91-094 TITLE: Advanced Packaging Concepts and Their Impact on System Design

OBJECTIVE: Investigate the impact on electronic system design considerations related to the concept of failure free life (FFL) in an all silicon approach and the use of mixed technology assemblies for ultra-high-speed performance.

DESCRIPTION: With the advances in device technology and integration techniques, namely monolithic, advanced multichip and 3D packaging, system designers are faced with a new set of design tradeoffs and considerations. Digital processing is moving closer to the analog sensor to meet system level communication bandwidth requirements. In addition, systems are being implemented using multichip assemblies, "reliability-without-hermeticity" coatings and enclosures, optical versus wired interconnects, area array interconnect techniques, and liquid/immersion cooling techniques. These approaches will have an enormous impact on design, manufacturability, performance and maintenance and should be considered in the investigation. By using an all silicon approach, the concept of failure-free-life can become a reality. However, when system requirements dictate ultimate performance, mixed technologies will be interconnected on a common substrate to realize the functional requirements. To successfully accomplish both of these approaches, a consistent set of design tradeoffs need to be investigated. During Phase I, trade-off analyses will be performed to assess the impact these two advanced system packaging concepts will have on the overall design. During Phase II demonstration vehicles will be fabricated to analyze and verify the Phase I results.

AF91-095 TITLE: Computer-Aided Electronic System Design

OBJECTIVE: Develop electronic design and synthesis tools.

DESCRIPTION: As clock rates have increased in electronic systems, old methods of system design and packaging are no longer appropriate if maximum performance is to be achieved. Current design and synthesis tools are targeted at single components and largely work at register transfer or logic level descriptions. Thus, designs essentially have to be done before use of the tools. In order to achieve the design of complex electronic functions that cannot be incorporated into a single component, next generation design and synthesis tools must be created that incorporate board and system considerations. Component, board, and system partitioning as well as packaging and test must be considered. The tools should have as an input abstract behavioral and functional descriptions that include timing and other constraints, based on the ANSI/IEEE standard 1076 hardware description language, and

should produce a design that includes packaging and test considerations. Test approaches should include IEEE 1149 and 1029.1 standards. Packaging considerations should include modern approaches such as multi-component carriers, integrated backplanes, and direct die on board. Phase I will consist of a six (6) month feasibility study for new and innovative synthesis methods. Concepts and ideas for design partitioning, packaging, and test will be generated. A report documenting these ideas and concepts should be prepared together with designs for a demonstration. Phase II will consist of twenty-four (24) months of additional work to perform the full-scale demonstration of the technique, such that proof-of-concept can be demonstrated. Phase III will demonstrate full synthesis capability across component boundaries and incorporate packaging considerations as well as test.

AF91-096 TITLE: Sensors for Specific Gases and Gas Concentrations Used in Semiconductor Processing

OBJECTIVE: Develop new and innovative devices and/or techniques for in-situ monitoring of specific gases and gas concentrations in semiconductor processing.

DESCRIPTION: Low-cost, semiconductor device fabrication facilities for Air Force, Army and Navy applications are increasingly dependent on real-time process controls for first pass success to the fabrication of very complex devices in small quantities. The trend in advanced-fabrication facilities for application specific integrated circuits and special purpose devices in silicon and other semiconductor materials is moving toward single-wafer processing using all dry plasma processes for deposition, etching, development of resists, etc. As more complex devices and processes are developed, cost effective, real time, in-situ sensors become even more critical for process control. In many cases, special sensors are needed to control critical plasma parameters, the rate of the process, or to detect end points accurately. Thin-film-detector technology may be used to monitor critical detector sensors. New semiconductor processes should be addressed to determine critical process steps limited by sensor availability. Proposed new sensor ideas should be theoretically analyzed to determine applicability to these critical process steps and feasibility of the approach. One sensor will be selected for experimental measurement and potential subsequent demonstration. A report of the Phase I ideas and activities should be prepared, as well as experiments and designs for a full scale demonstration. Phase II of this effort will consist of twenty-four (24) months of additional work to perform the full scale demonstration, depicting limits of performance, operating parameters and benefits of the technique. Phase III will demonstrate equipment implementing this in-situ sensor and process control technique for use in a semiconductor manufacturing facility.

AF91-097 TITLE: In-Situ Sensors for Molecular Beam Epitaxy

OBJECTIVE: Develop reliable, repeatable and accurate in-situ sensors to monitor and control the growth of a variety of semiconductor materials via Molecular Beam Epitaxy (MBE).

DESCRIPTION: The need for semiconductor heterostructures for advanced device applications make ever-increasing demands upon growth technologies. In order to meet the demands for prices control of material composition, thickness, and doping levels, new sensors must be developed which permit reliable, repeatable and accurate control information. This information can be applied to automatic monitoring techniques and subsequently to larger-scale production systems. This program is restricted solely to Molecular Beam Epitaxy as a growth technique and will result in hardware demonstrations of innovative techniques. To the maximum extent possible, all proposed techniques must not interfere with normal physical and operational demands of an MBE system. Emphasis will be placed upon those techniques which require only a minimal modification to existing machines. Application of prototype sensors to commercial equipment is desired. Phase I of this program will consist of a six month feasibility study for in-situ sensors for application to commercial MBE systems. New innovative ideas for non-invasive sensors for monitoring composition, thickness and doping densities will be analyzed to determine the feasibility of the approach. Critical experimental results should be obtained to validate the approach. A report incorporating the ideas and experimental verification will be prepared with design concepts for a full scale demonstration. Phase II of this program will consist of a twenty four month feasibility demonstration for the sensor technology. This feasibility demonstration shall include design, assembly, validation, installation, and demonstration of the prototype sensor system in an operational Air Force MBE system. This prototype system is considered a deliverable item under Phase II.

AF91-098 TITLE: Realization of Devices and/or Functions using Optical Illumination of Thin-Film Superconductors

OBJECTIVE: Assess the feasibility of using optical illumination to produce a spatially selective phase transition or impedance variation in superconducting thin films.

DESCRIPTION: Advanced investigation is required to explore the use of spatially selective optical illumination to define superconducting device architectures. The phase transition or impedance variation induced by optically illuminating superconductors should be used in the definition of specific device/function architectures. The focus of the effort is to provide an optically definable and reconfigurable device for insertion into USAF radar, communications, and electronic countermeasures systems. The investigation should highlight the benefits derived using this device in place of existing devices or device networks. Emphasis will be placed on the use of the optical interaction phenomena to realize passive devices, device networks, and possibly some basic signal processing functions. Material application studies include bulk and patterned, thin-film, high-temperature, superconducting material studies, but low temperature and possibly hybrid architectures are encouraged. Typical high temperature superconducting materials may include compounds based on thallium. Low temperatures materials may include niobium based compounds. Investigation should include experimentation of the devices at the following temperature regimes; well below the materials critical temperature, near Tc, at/above Tc. Figures of merit that should be addressed are noise effects, time delay, insertion losses, band width, delay distortion, coupling effects, impulse response, step responses, and phase velocities. Phase I activity should provide proof of concept by assessing material parameters and integrating them with microwave design techniques, and fabrication process and design database development. A study effort alone would not be acceptable. Phase II activities should be a refining of design and fabrication techniques, device fabrication, device testing, characterization, and database validation.

AF91-099 TITLE: Multiplexing for Fiber-Optic Sensors

OBJECTIVE: Develop optical and electronic multiplexing and demultiplexing techniques for combining multiple fiber-optic interferometric sensors and sensor functions for aircraft instrumentation.

DESCRIPTION: Fiber-optic sensors possess many advantages over their electronic counterparts, which are currently being explored. Many sensors and sensor functions can be multiplexed to maintain situational awareness and redundancy while minimizing the number of components. Fiber-optic interferometric and other types of fiber-optic sensors have been used to measure temperature, pressure, strain, acoustic pressure, rotation, acceleration, E/M fields and other phenomena. This program would develop techniques which show promise for the implementation of a fiber-optic sensor “nervous system” which may be used in advanced aircraft, smart structures/skins applications. The sensors would be arranged in passive element arrays and selectively perform different sensing functions. Phase II would enable the deconvolving of each of these data inputs from a single sensor and sensor array.

AF91-100 TITLE: Low-Insertion-Loss Millimeter Wave Probes for On-Wafer, Noise-Parameter, Measurement Accuracy

OBJECTIVE: Develop low-insertion loss, high-frequency, wafer probes with improved noise parameter accuracy in transistor and integrated circuit characterization.

DESCRIPTION: The development emphasis in frequency extension of wafer probes for on-wafer noise/scattering-parameter measurements of MMICs has overshadowed the critical need for low-insertion loss, millimeter-wave wafer probes for accurate noise characterization of extremely low-noise devices, such as high electron mobility transistors. Noise-parameter measurement accuracy is a function of instrument uncertainty, the number and location of source reflection coefficient states, and the parameters of the device under test. Probe losses increase the possibility of the device’s optimum source impedance falling outside the matching area of the tuner, as well as increase the second stage noise figure of the measurement system. These factors can result in large measurement errors when characterizing low noise devices. Low loss probes will improve the measurement accuracy of on wafer noise parameter measurements and result in more accurate device/MMIC characterizations and designs. The

developed probes must have the capability of easy integration with commercially available probe stations for on wafer noise/scattering parameter measurements. Phase I of this program will consist of a six month feasibility study for the low insertion low, millimeter wave probes. A report documenting ideas, design, analysis, and experimental measurements should be provided. Phase II of this program will consist of an additional twenty four months of work to complete development of the wafer probe and integration into commercially available, on wafer, scattering noise parameter test systems, such that performance can be analyzed.

AF91-101 TITLE: Optical Sensor Development for Fluid Flow Measurement

OBJECTIVE: Develop new, non-intrusive methods for critical measurements in areas of complex flow interactions.

DESCRIPTION: Optical, non-intrusive diagnostic techniques such as laser velocimetry, interferometry, holographic cameras and laser light sheet systems are used extensively in fluid dynamic test facilities to provide non perturbing parameters. Advancement in electro-optics technology in recent years may significantly expand the capability of such instrumentation. For example, fiber optics and/or holographic optical elements, when integrated with existing measurement technology, may provide the required optical access into boundary layers at structure junction points, and even into internal flow channels. Another example can be found in the recently developed TV holography that may allow for much broader application of holography in wind tunnel diagnostics, for the study of model parameters. Phase I activity will include concept development and a feasibility study through a consideration of optical interference, facility and/or model vibration, temperature fluctuation, etc. Phase II activities will lead to the development and fabrication of a system including validation using a calibrated measurement. Consideration must also be given to application to full scale flight vehicles.

AF91-102 TITLE: In-Place Data Recorder for Aircraft Transparency Systems

OBJECTIVE: Develop a device that is attached to an aircraft transparency system which will record fabrication history and operational experience.

DESCRIPTION: One of the largest challenges confronting designers of windshield, canopy, and window systems of Air Force aircraft is obtaining realistic, actual, and complete data on the fabrication history and operational experience of existing transparency systems. Available data is scattered among many sources and, when acquired and interpreted, has proven to be incomplete for use in failure analysis methods, reliability prediction methods, and durability specification development. Phase I activity will involve analysis and application of results from review of related technologies which include smart skins; programmable, erasable, read only, memory devices, data sensors; miniaturized electronics aircraft data recorders; and field operated computers. Possibilities for tie in with the aircraft main data base and/or power source, and for data load and data dump by the crew chief will also be examined. Phase Ii activity will involve the design, fabrication, and demonstration of an in-place, data acquisition, recording, and retrieval system for full-scale, aircraft, transparent structures.

AF91-103 TITLE: High-Gain, Acoustic, Sensor System for Aircraft Noise Signature Detection

OBJECTIVE: Develop a high-gain, acoustic, sensor system which will result in an order of magnitude increase in the signed to noise ratio of aircraft noise signatures.

DESCRIPTION: One method to detect low flying aircraft is by their radiated acoustic signature. The suppression of the radiated acoustic signature requires that a higher signal to noise ratio be realized at the point of reception if the same detection distance is desired. This requirement illustrates the need for a high gain acoustic sensor which will result in at least an order of magnitude increase in the signal to noise ratio of aircraft noise signatures. Unique and novel sensors and sensor configuration need to be designed to achieve this objective. Phase I activity will include a feasibility study to determine the technical feasibility of the proposed effort. If it is shown to be feasible, the end product of Phase I will be the recommendation of a specific design of a high gain acoustic sensor system. Phase II will include a laboratory or field test to verify the performance of the sensor system recommended in Phase I.

AF91-104 TITLE: Application of Unique Motion Devices for Control of Primary Flight Actuators

OBJECTIVE: Investigate the use of novel controlled-motion devices capable of main control valve operation for primary flight control actuator.

DESCRIPTION: As military aircraft become more agile and powerful, the flight control actuation devices become more complex and heavier. Electro hydraulic valves (EHVs) are currently used to control the main control valve, which in turn controls the flight control actuator. The EHV and corresponding hardware are the key drivers to system complexity and weight. Unique motion devices are sought that will perform in the same manner as an EHV but with less complexity and weight. Unique motion devices are sought that will performing the same manner as an EHV but with les complexity and weight. For example, field dependent fluids and piezoelectric crystals have been investigated for EHV control capabilities. This effort will entail the design, development, and test of a prototype device capable of operating the main control valve for a primary flight control actuator. Phase I activity will entail design studies to determine concept feasibility in association with predetermined power requirements, control limitations, and operation parameters. It will also identify a final design for development and test. Phase II will proceed with hardware development of proof-of-concept tests. A Phase III follow on effort may examine optimization of the motion device as a primary surface actuator and eliminate the main control valve.

AF91-105 TITLE: Projectile-Target Impact History Sensor

OBJECTIVE: Development of a 3 axis force sensing and recording or transmitting device for installation in a 23 mm diameter projectile to impact composites at 1500 feet per second.

DESCRIPTION: Ballistically ignited fuel fires represent most frequent cause of aircraft losses. Current incendiary projectiles are designed to operate against metallic targets although composite structures are replacing these in military aircraft. Vulnerability assessment must address the interaction force history during penetration of composite panels to understand, explain, and predict the penetration mechanics and projectile incendiary functioning. A recording and transmitting interaction force sensor would prove invaluable in experimental investigations designed to understand, develop, and verify theoretical predictions for threat phenomena. Progress in microelectronics and integrated sensors has made such a device possible. Phase I will be to develop a prototype sensor capable of being mounted in an inert 23 mm projectile which will either transmit or record acceleration during impact. Phase II would be a calibrated and verified sensor capable of being used in any projectile, 23 mm or larger.

AF91-106 TITLE: Numerical Analysis on Massively Parallel Processing Computers

OBJECTIVE: Establish procedures for running Navier-Stokes or Euler formulated fluid dynamics codes on single instruction multiple data (SIMD) or multiple instruction, multiple data (MIMD) parallel computers.

DESCRIPTION: Numerical analysis of fluid flows about arbitrary shapes requires the volume surrounding the shape to be decomposed into a discrete grid or mesh. For moderately complex geometric shapes, these grids may contain millions of points. On each of these discrete points, the computational fluid dynamic code solves for primitive fluid variables, such as density, velocity, and temperature. During this process, the CFD code stores and uses from 25-85 words per grid point. Execution of the codes, therefore, requires many millions of words of storage and consumes many hours of computer time. Phase I of the effort will determine if a massively parallel computer architecture can be used to significantly speed up the numerical solution of the Reynolds-averaged Navier-Stokes and Euler equations. The contractor will discuss the relative merits of SIMD and MIMD architectures and, if appropriate, other architectures that would be advantageous for CFD solutions. The contractor will also discuss the optimum number and/or arrangement of processors and compare maximum theoretical computer speeds with realistic speeds for practical problems. A possible Phase II effort would be to develop or modify a Reynolds-averaged Navier-Stokes or Euler code that would be optimized to run on an existing machine that utilizes the computer architecture determined in Phase I to show the greatest payoff.

AF91-107 TITLE: Determination of the Mechanical Response of Micro scale Structures

OBJECTIVE: Develop methods and associated equipment to measure the mechanical behavior of the micro scale structures that make up today's electronic equipment.

DESCRIPTION: As the size of electronic assemblies shrinks, it becomes more difficult to measure the responses of the micro scale structural elements to stress inducing effects. Electronic assemblies are highly loaded, are non-linear in response, and exhibit time-dependent deformations. Knowledge of these responses is necessary to allow durability assessments of modern avionics to be accomplished during the early stages of design. Advanced methods, including innovative instrumentation and experimental apparatuses, are needed to enable the mechanical behavior of these micro scale structures to be determined. These techniques should also be applicable to larger scale systems. Phase I must demonstrate understanding of the scope and complexity of the problem. It must provide detailed engineering analysis and design specifications for the proposed methods. It must also include a test procedures plan for validating the performance of the method. Phase II requires construction and validation of a prototype as described in the plans of Phase I. Correlation of results with other established techniques will be required.

AF91-108 TITLE: Turbulence Modeling

OBJECTIVE: Develop a generalized turbulence model method for use in computational fluid dynamics (CFD).

DESCRIPTION: Identify deficiencies in current turbulence models, develop improved turbulence models and incorporate improvements in one module to handle a variety of flow effects. Many studies have been done to modify turbulence models for various effects: low Reynolds number, surface roughness, strong pressure gradients, and merging of shear layers. The inclusion of these effects in a single module for utilization in state of the art multizone Navier-Stokes codes would be helpful. Such an effort would assess the success of the above modifications and would point out other deficiencies in current turbulence models as well as provide logic so that the proper coefficients and scales are used in each case. Simple "prior history" effects may also be included as long as code efficiency does not suffer significantly. Phase I of this research effort will be the identification of all turbulence modeling schemes available for fluid mechanic flows with a complete description of the physics embodied in each approach. Phase II will be experimental validations of CFD solutions incorporating the recommended turbulence models. These satisfactory validated turbulence modeling methods will then be programmed into a single module that could be retrieved for CFD solutions.

AF91-109 TITLE: Cockpit Design for Super Maneuverable Fighter

OBJECTIVE: Identify cockpit design criteria for super maneuverable fighters that permit full exploitation of system capabilities.

DESCRIPTION: The capability now exists for significantly enhancing the maneuver capability of fighter aircraft. By operating in the low speed, low G arena, Air Force fighters will possess an advantage over adversary aircraft with the potential for greatly improving the Close in combat kill ratio. Full exploitation of this capability, however, requires that the pilot be fully aware of the combat situation and be able to intuitively employ the total maneuvering envelope. The problem is such that information display requirements and pilot control techniques for fully exploiting the potential tactical advantage of super maneuverable fighters are undefined. Phase I work will identify specific applications of super maneuverability through mission analysis and identify unique control and display criteria and pilot constraints associated with its implementation. Based on these requirements, cockpit design concepts will be identified. Particular areas to be emphasized in the designs include use of automation, situation awareness, pilot decision aiding, and two ship coordinated attack. Upon completion of the Phase I effort, the various options that have been considered will be rated in terms of scientific or technical merit and feasibility, and best ideas for design will be chosen for further pursuit in Phase II. The Phase II approach will be to investigate the most promising Phase I concepts under full combat simulation. The goal of the Phase II effort will be to produce a

well defined cockpit design. Products of the Phase II effort include software and cockpit graphic displays as well as a final report defining areas for application.

AF91-110 TITLE: Rapid Flight Line Detection of Degraded Electronic Cockpit Instruments

OBJECTIVE: Develop a rapid, "go no go" test method/equipment providing flight line assessment of legibility performance of CRT and matrix type cockpit displays.

DESCRIPTION: There is a new generation of cockpit instruments which are totally electronic and embody none of the gears, levers, motors and painted read-outs of the old generation instruments. From a military viewpoint these new instruments bring with them several significant advantages. However, they also bring with them a radically new, high technology identity that must be dealt with logistically, especially on the flight line. Transitioning these instruments from the laboratory to field use requires a unique/testing method for checking against degradation. The new generation instruments will be capable of electronically displaying high resolution sensor video information and alphanumeric/symbolic images to the pilot that heretofore have not been possible. Pictorial rather than word descriptors will enable the pilot to more accurately and rapidly assimilate the status of conditions relating to the control of this flight vehicle and associated tactical activities. Producing electronic instruments with such capabilities is within our grasp today. Day-to-day checks for degradation of this imaging capability, in a practical manner under tactical operational conditions is not within our grasp today. The science of electro optics is the knowledge base for this new display instrument. The image quality produced by these new instruments is dependent upon the interactive behavior of optics related parameters such as: luminance, spot size, gray scale, color, contrast, uniformities, and resolution. Subjective assessments by the pilots and field maintenance personnel will not be sufficient. The original specification performance values will have to be periodically measured in the aircraft for meaningful signs of degradation. The measurement of these parameters is presently accomplished by the use of precision laboratory type instruments. To merely repackage and ruggedize such instruments for flight line use is not the answer. The time consuming and highly skilled procedures involved in these tests would be prohibitive in an operational environment. In Phase I a flight line image quality assessment test will be developed that replaces the specialized skills and impractical, cumbersome laboratory equipment approach; and basic demonstrations will be provided that validate the developed test. During Phase II a model of the related equipment will be developed and fabricated; and a database accumulated and verified to support its transition to a potential Phase III prototype, operational evaluation. Special test patterns can be provided on the electronic display instruments, if required, to accommodate the new test.

AF91-111 TITLE: Real Time, High Density, Spatial Light Modulator

OBJECTIVE: Develop a Spatial Light Modulator capable of real-time, high-density modulation of transmissive or reflective illumination for information display in cockpits.

DESCRIPTION: Future cockpits require high definition, real time displays which are light weight and space efficient. A promising method of meeting these requirements is to spatially modulate a light source with a 2D array of viable transmissive or reflective pixels. In addition, the spatial modulation of light is becoming a required characteristic of many other applications, including projection displays, coherent optical processing, spatial filtering, optical computing and computer generated holography. The performance of any of these applications is generally related to the speed and resolution of the modulating device. A useful step in the evolution of such modulators will be the development of a device with a maximum 10 millisecond response, 100:1 minimum contrast ratio and pixel density of at least 40,000 pixels per square centimeter. As these devices are generally intended as components for integrated system, space requirements and cost should be minimized. Phase I will involve the demonstration of a multipixel device and the presentation of scalability, fabrication and cost issues associated with the device. Phase II will involve the characterization, optimization, fabrication and demonstration of a 1,000 x 1,000 pixel device.

AF91-112 TITLE: New High Performance Polymers

OBJECTIVE: Investigate the synthesis, processing, and properties of new high performance polymer systems.

DESCRIPTION: Investigations are sought to discover new polymeric materials with potential for the development of improved structural materials. Polymer systems with exceptionally high use temperatures and reasonably low processing requirements are of primary interest. Areas of emphasis include investigations of the following: synthesis routes and methods to improve processing of rigid rod polymer molecular composites which give rise to very thermally stable structural materials under reasonable processing conditions and without the evaluation of impractical quantities of volatiles; the development of a new generation of high strength rigid rod polymer molecular composite liquid shim materials for low cost high structural integrity air frame assembly; theoretical and synthetic chemistry to provide fundamental understanding of the molecular requirements for achieving nonlinear optical or intrinsically conductive properties in organic and semi organic polymer systems; processing, morphology and mechanics of rigid rod polymers to discover approaches for achieving superior compressive strengths; and polymer structure property correlations to elucidate processing options for achieving desired morphologies as well as electro optical and mechanical properties. 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 further develop the new high performance polymers.

AF91-113 TITLE: Smart Processing of Carbon-Carbon Structures

OBJECTIVE: Develop reliable and reproducible structures through smart processing, process control, and defining microstructure/property relationships.

DESCRIPTION: Advanced innovative approaches are needed for the development and implementation of reliable and reproducible carbon-carbon composites for turbine engine, hot structure and space applications. In order to accomplish this, structure/microstructure/property relationships for substrates and coatings must be defined, advanced high temperature sensors and in process control methodologies must be developed and life prediction must be addressed. Smart processing approaches for the development of microstructure/structure vs. property relationships through the use of advanced sensors and process control methodology will be investigated. Phase I will address the processing schemes, sensors and/or control methodology necessary for substrates and coatings which provide improved intrinsic materials structure and microstructure which can be used in future Air Force Systems. Phase II will perform the enhancements of the developed materials, sensors or control methodology in order to promote rapid development of smart processing of carbon-carbon structures.

AF91-114 TITLE: Controlled Emissivity Materials and Techniques

OBJECTIVE: Develop new and improved materials and techniques for controlling the emissivity of surfaces.

DESCRIPTION: The Air Force is interested in conducting research into the science of understanding and controlling the emissive/reflective nature of materials. Specifically, research shall involve controlling emissivity/reflectivity in the ultraviolet, visible, and infrared regions of the electro-magnetic spectrum. Investigations may include bulk materials, properties and/or novel concepts based on combinations of constituents materials in some unique construction. Phase I of this effort will address application requirements and goals as well as initial formulation, fabrication and evaluation of specific subjects for proof of concept. Phase II will further develop and optimize the material(s) techniques, and produce larger samples for a full spectrum of evaluations.

AF91-115 TITLE: High-Temperature Structural Materials for Advanced Air Force Systems

OBJECTIVE: Develop and characterize advanced, high-temperature, structural materials and model forming processes.

DESCRIPTION: New approaches are requested to develop and characterize advanced, high-temperature, structural ceramic composites and inter-metallic materials and composites, and to model forming processes for advanced structural materials. For ceramic composites, research may include new, unique, continuous, ceramic reinforcement/ceramic matrix systems and coatings; reinforcement/matrix interactions during processing for use;

continuous fiber development; test techniques to determine mechanical and physical behavior as a function of temperature and loading history; and, analytical modeling of composite behavior. For intermetallic materials and composites, research may include new or novel methods for synthesis of intermetallic materials with emphasis on achieving theoretical density, low defect content, and low synthesis temperatures; methods for identifying, synthesizing, characterizing, and modeling intermetallic composites; and methods of fabricating composites to provide chemistry control on a sub-micron scale while maintaining the ability to vary and control the final micro structural scale. For modeling of forming processes, research may include modeling of the unit between the work piece and the die or mold; and novel methods for obtaining physical property data and constitutive equations for insertion into the models. Phase I will focus on the critical issues which when solved will provide proof of concept. Phase II will be structured to 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.

AF91-116 TITLE: Improved Nondestructive Evaluation

OBJECTIVE: Develop of 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, imaging and characterization of flaws and other integrity-reducing anomalies in flight vehicle and engine materials including metals, and metal and non-metal matrix composites. Improved techniques are also needed for 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, imaging and characterization of bulk and surface anomalies in both metallic and nonmetallic structures; the evaluation of the integrity of bond lines in structures containing adhesive and metal-metal bonds; the determination of the condition of matrix and reinforcing substructures in advanced composite structures; establishing the quality of high temperature material coatings; the inspection and evaluation of electronic device materials and components; and the quantitative characterization of materials properties. 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 clear 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 proof-of-concept. Phase II will perform enhanced development for optimization of the techniques investigated in Phase I.

AF91-117 TITLE: High-Performance Light Metal Alloys and Metal Matrix Composites

OBJECTIVE: Develop improved light metal alloys and composites based on the aluminum, beryllium, titanium, and magnesium systems.

DESCRIPTION: Unique approaches which result in new aluminum, beryllium, magnesium, 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 up to 900 F, and ultra high temperature titanium alloys to replace super alloy for applications up to 1800 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 specifically address three areas: temperature stability p to 1800 F, strength up to 210 ksi, and high modulus/density ratio. Improvements in strength, stiffness, and a reduction in density may be possible using novel alloying additions. Metal matrix composites 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 materials considered should take advantage of unique property improvements available through rapid solidification technology (RST). Research is now needed to explore property improvements and corrosion resistance especially in composite systems based on Mg alloys. Phase I of the program must address application requirements and goals as well as evaluation of specific properties. Phase II will optimize chemistry and processing and also produce larger amounts of material for a full spectrum of mechanical property evaluation. It will also include preliminary evaluation of trade and design studies to give an early indication of future application potential.

AF91-118 TITLE: Advanced Semi conducting Materials

OBJECTIVE: Develop advanced semi conducting materials and improved processes for epitaxial growth of these materials.

DESCRIPTION: Advanced Air Force electronics, radar, control and communication systems will require new and novel semi conducting materials to meet challenging frequency, speed and temperature requirements. Conventional semiconductors such as silicon and gallium arsenide cannot meet these requirements. Material systems of interest include high temperature semiconductors, such as silicon carbide and single crystal diamond for specialized applications, innovative Group IV and III-V heterostructures super lattices, and wide band gap II-IV and II-VI heterostructures for electronic applications. The heterostructures and super lattices require thin film epitaxial growth techniques. A goal of this task is the development of improved growth techniques such as molecular beam epitaxy; metal-organic chemical vapor deposition; and laser deposition are sought as well as new techniques. In parallel with these efforts, advanced in-situ, process monitoring techniques are sought which can be coupled with an expert system to provide automated process control for growth of these ultra-precise epitaxial films. Another goal is investigation of high temperature semiconductors. Process modeling of growth techniques is within the scope of this task. Phase I will address process development and initial testing to show proof of concept. Studies and/or design without actual testing are not appropriate for Phase I. Phase II will optimize the process to show potential for commercialization.

AF91-119 TITLE: Nonlinear Optical Materials

OBJECTIVE: Develop nonlinear optical materials with properties superior to those presently available.

DESCRIPTION: Nonlinear optical materials are required for a variety of potential Air Force applications including optical signal processing and new laser sources. However, presently available materials are unsatisfactory for many applications due to small nonlinearities, poor optical clarity, long response times, difficulty in processing for devices, and other factors. Proposed efforts must address material issues for inorganic and organic materials in either bulk or thin film forms. Innovative techniques for preparing new materials or for improving the growth or processing of known materials are encouraged. Nonlinear optical devices may be examined only for the purpose of evaluating and demonstrating the properties of the materials developed. Phase I of this program would demonstrate the proposed growth or processing techniques. Phase II would perform optimization of those techniques.

AF91-120 TITLE: High-Temperature Superconducting Materials

OBJECTIVE: Develop high temperature, superconducting thin film materials for sensing and modifying electromagnetic radiation.

DESCRIPTION: High-temperature superconducting (HTS) materials offer a variety of application opportunities. Detection of infrared (IR) radiation can potentially be improved through the use of these HTS 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 in order to fully assess their value in electromagnetic sensing. Modeling of the superconducting mechanisms, development of unique thin-film deposition, processing methods which produce films with the required properties, opto-electronic response and temperature dependent noise measurements are examples of topics considered appropriate for this program area. This topic addresses development of thin film fabrication techniques and characterization of the opto electronic response of these films. Device development will not be supported. Phase I will address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II will perform enhanced development for optimization.

AF91-121 TITLE: Characterization of Latent Defects in Avionic Hardware

OBJECTIVE: Develop techniques for characterizing latent defects in avionic hardware.

DESCRIPTION: Technology advances are required in electronic failure analysis and material characterization in order to develop reasonable, failure-free, operating periods for avionic equipment. The level of reliability achieved by most deployed avionics is significantly less than desired by the user, producer, and developer. Additionally, avionics is becoming the driving force for flight safety. Identifying and characterizing latent defects in electronic assemblies and components is of primary interest. Technology areas of specific interest include printed wiring boards, integrated circuits, and hybrid microcircuits. A Phase I effort should determine the feasibility of identifying a manageable number of defects which are associated with one or more of the identified technology areas. Rationale for selecting a given defect should be discussed. Materials behavior and failure analysis experience should be used to discuss how the identified defects can result in hardware failures. A Phase II effort would design and conduct experiments for evaluating latent defects and determining their life limiting characteristics. The environmental conditions necessary to simulate the failure mechanism associated with the defect would also be evaluated. Methods of reducing the occurrence of given defects and minimizing their effects is the overall goal.

AF91-122 TITLE: Non-Chromated Corrosion Inhibitors for Adhesive Bonding and Painting Processors

OBJECTIVE: Develop non-toxic corrosion inhibiting additives for paint and adhesive bond primers for aluminum substrates.

DESCRIPTION: Organic and inorganic materials will be evaluated for use in paint and adhesive bond primers for use on aluminum. Metal organic complexes, quanidienes and quaternary chelating agents and combinations of these materials will be evaluated and compared to the existing chromium containing materials for corrosion resistance effectiveness. This work is vital to the Air For Logistics Command program to eliminate toxic material from production applications. Phase I objectives will be to demonstrate the feasibility of the use of corrosion inhibiting additive packages, either organic, inorganic, or both, to replace existing chromates. Phase II objectives will be to optimize corrosion packages specifically for bonding and painting applications and to do testing and evaluation so that specifications may be written to allow the use of these materials in military applications.

AF91-123 TITLE: Resin Transfer Molding of Thick High-Density Performs

OBJECTIVE: Demonstrate the feasibility of low-cost, high-performance, structural components for aircraft.

DESCRIPTION: High rate, low cost, production processes, including resin injection molding will be modified as necessary and evaluated for feasibility of their use in the production of high performance, aerospace, composite materials. Epoxy and bismaleimide resins shall be utilized in combination with graphite reinforcements in the form of thick high density performs to fabricate laminates for test and evaluation. The development of low cost fabrication processes for high performance composites is of paramount importance in the economical use of composites in aerospace structures. Phase I objectives are to develop and demonstrate injection processes for resin transfer modeling of thick, high density, carbon fibers, filament wound performs. Phase II objectives will be to scale up and optimize the resin injection process to achieve lower costs consistent with aerospace quality and to generate sufficient data to allow materials and process specifications to be written.

AF91-124 TITLE: Cellular Automata for Molecular/Atomic Modeling and Simulation

OBJECTIVE: Develop new approaches to physical modeling of material processes.

DESCRIPTION: Cellular automata are the computer scientist's counterpart to the physicist's concept of field. They provide natural models for many investigations in physics, combinatorial mathematics, and computer science that deal with systems extended in space and evolving in time according to local laws. A cellular automata machine is computer optimized for the simulation of cellular automata. Its dedicated architecture allows it to run thousands of

times faster than a general purpose computer of comparable cost programmed to do the same task. These machines are continuing to improve in terms of price and performance to enable efficient physical modeling and simulation of various material processes where control of molecular/atomic bonding is critical. Phase I should address the feasibility in terms of needed development to enable the modeling of such processes as Molecular Beam Epitaxy and Metal Oxide Chemical vapor Deposition for diamond growth and various electro-optical materials. Phase II will involve the development of a state-of-the-art cellular automata machine to support material design, process planning and control for selected materials.

AF91-125 TITLE: Innovative Metal Matrix Composites Processing

OBJECTIVE: Investigate the development of innovative methods of processing for metal matrix composites.

DESCRIPTION: Investigations are sought to develop innovative processing schemes for continuous fiber, reinforced, metal matrix composites. Principal emphasis is to be placed on aerospace quality materials such as near alpha and beta titanium alloys, and alpha 2 and gamma titanium aluminide intermetallic compounds reinforced with continuous fibers of silicon carbide, alumina, or other appropriate materials. Current processes make use of hot isostatic pressing and, less often, vacuum hot pressing to consolidate alternating layers of foil and fiber, metalized fiber, or multiple layers of reinforced monotapes to produce an intermediate product form. Problems with this approach include high cost of equipment and products, low yield, and potential damage to reinforcing fibers. The establishment of alternative viable approaches to obtaining fully consolidated high quality titanium or titanium aluminide, metal matrix composites are sought in a Phase I program. Phase II follow on efforts will demonstrate the effectiveness of alternate approaches to metal matrix composites consolidation identified in Phase I.

AF91-126 TITLE: Concurrent Engineering

OBJECTIVE: Develop concurrent engineering methodology for the design of electronic products and processes and the product life cycle.

DESCRIPTION: Concurrent Engineering is the integrated design of the product, manufacturing and support processes with emphasis on efficiency, improved quality, and reduced cost. The method developed needs to allow for the interaction of constraints from the various disciplines and employ algorithms for resolving conflicts. The information available from the various experts in each discipline is intended to be unified during the design phase. The Air Force has particular interest in improving the product life cycle of multi-layer interconnect structures used in advanced electronic systems. Three areas of particular interest include: use concurrent engineering techniques to interactively trade-off system parameters, technical parameters, materials, and processes; define an information architecture that includes a product description framework to facilitate interactive communication between experts in each discipline; identify/develop applicable design and decision support tools to facilitate integration. Phase I will address behavior of components and goals for proof of concept. This includes identifying attributes to describe the function, size, and methodology applied to electronic product design. Phase II will establish the information storage-and-retrieval mechanisms for modeling the behavior of complex interconnect structures needed for the design.

AF91-127 TITLE: Ultra-High-Purity Starting Materials for Infrared Detector Crystal Growth

OBJECTIVE: Reduce of trace impurities in IR detector materials.

DESCRIPTION: There is a critical need for the reduction of trace impurities in elemental and intermediate compound materials used in the manufacture of infrared detectors and focal plane arrays, since these impurities severely limit both performance and yield. Other applications of II-VI compounds are equally demanding of high purity. The elements are of major interest, as are all impurities which affect the electronic or crystal growth properties of both bulk and epitaxial crystals. This project will investigate the development of advanced distillation, zone refining and sublimination techniques to yield ultrahigh purity grades of the required starting materials. Integral to the project will be the establishment of measurement methods to prove that purity enhancements have

been achieved. These might be either direct or indirect methods sensitive down to the 10 to 20 ppba level with respect to impurities. In Phase I, the purification and characterization techniques will be developed and confirmed. In Phase II, the process will be scaled up to commercial production levels, and the enhancements with respect to detector performance will be quantified.

AF91-128 TITLE: Computer Graphics for Bearing Dynamic Analysis

OBJECTIVE: Develop computer software for animating the dynamic behavior of rolling element bearings.

DESCRIPTION: Bearing dynamic computer codes are used by the aerospace industry to design and analyze high precision rolling element bearings such as those found in gas turbine engines. The numerical output of these computer codes consists of the three dimensional displacement of the rolling elements and bearing cage. To visualize the bearing interaction, two dimensional plots are generated which depict the displacement, velocity and acceleration of each bearing element in one direction. The designer/analyzer must then take these composite plots and construct a mental image of the interactions to visualize the three dimensional dynamic behavior. A much more efficient means of designing and analyzing rolling element bearings would be to take the numerical output from the bearing dynamic code and input this to computer animation software which would show the interaction of the bearing elements occurring simultaneously. By viewing the bearing from different visual perspectives, a true three dimensional description of the bearing dynamic behavior could be easily translated to the designer/analyzer. It is envisioned the computer software for the animation could be developed for use on today's high speed personal computers. A goal for Phase I of this program would be to demonstrate an animated pictorial of an operational bearing from the axial perspective. This should be accomplished by using the numerical output from an existing, bearing-dynamic, computer code as input to the computer animation software. Phase II would further develop the animation software to include different views of the bearing, as well as thermal and stress contours of the mating and interacting surfaces. As proof of concept, a bearing for an advanced gas turbine engine application should be thoroughly analyzed and documented. The Phase III potential for this effort would be to market the computer software to the aerospace industry as well as other private companies involved in high precision bearing design and analysis.

AF91-129 TITLE: Jet-Fuel Thermal-Stability-Improving Additives

OBJECTIVE: Develop additives to improve the thermal capability of jet fuel, Grade JP-8, by 100 F.

DESCRIPTION: Aircraft heat loads are growing at a rapid pace. Aviation turbine fuels are increasingly being used as a heat sink for the heat loads from the aircraft subsystems. New fuels with improved high temperature stability are required. Fuel additives have the potential of increasing the thermal stability of existing fuels such as JP-8. Phase I of this research and development activity involves the identification and testing of additives that offer the most promise for increasing the high temperature stability of JP-8 jet fuel by 100 F. Phase II research would consist of the selection of the most effective additive(s) for improving thermal stability, development of methods to test additive effectiveness, and determination of thermal degradation reaction mechanisms. In Phase III, the most effective additive for improving jet fuel thermal stability will be selected. Testing criteria for use in jet fuel will be established in conjunction with the Air Force jet fuel specification authority. Qualification testing will then be accomplished on the selected additive.

AF91-130 TITLE: Methodology and Software for Turbine Engine Lubrication Sensitivity Analysis

OBJECTIVE: Develop sensitivity study methodology to assess impact of lubrication systems on turbine engine performance.

DESCRIPTION: For turbine engine design purposes, methods have been developed to assess the impact i.e., sensitivities of compressor flows, efficiencies, etc. on projected engine performance. Such methods typically employ iterative computer algorithms to calculate the sensitivities. The cycle decks are typically restricted to basic performance parameters with, perhaps, some capability to determine the effect of parametric changes on projected

missions. Cycle decks are not available to assess impact of performance of new lubricants and lubricant system designs using software codes for personal computer implementation. Development of these critical methodologies and software are required to perform sensitivity analyses so that Integrated High performance Turbine Engine Technology design goals might be efficiently met. Phase I activities will include assessment of the concept, gathering of pertinent data on lubrication systems performance projected for advanced turbine engine designs, assessment of projected mission profiles and selection of algorithms, software and hardware required to implement the system for sensitivity studies. Phase II activities will include development of the methodology and software sufficient to perform such sensitivity studies using a personal computer. Demonstration and delivery of the software will be required. This effort has Phase III potential to develop software designed for lubrication-systems sensitivity analysis by turbine-engine engineers, aircraft designers, and lubricant and lubrication system component vendors.

AF91-131 TITLE: High-Speed Turbo ramjet Technologies

OBJECTIVE: Develop key technologies for Mach 0-6 turbo ramjet engines.

DESCRIPTION: Studies of combined cycle propulsion systems have shown turbo ramjets to be one of the most attractive engine concepts in the Mach 0-6 flight regime. Such an engine combines the flexibility and efficiency of the turbojet at flight speeds of Mach 0-4 with the simplicity, low weight, and high specific impulse of the ramjet in the Mach 3-6 flight range. Key enabling technologies for turbo ramjet development have been identified. Those technologies which are applicable to any turbo ramjet regardless of configuration are of primary interest in this program. Examples of these technologies include turbo ramjet, ram burner structures, ram burner fuel-injection/flame-holding schemes, endothermic fuel reactor/turbo ramjet integration, fuel/air heat exchangers, air-driven power generation devices and ram burner cooling techniques. Proof-of-concept testing is preferred, but analytical studies will also be considered. The goals of Phase I will be to identify a novel concept, quantify its payoff and conduct a small scale experiment to demonstrate concept feasibility. If a strictly analytical approach is proposed, sufficient analysis must be performed to demonstrate some degree of concept feasibility and plan experiments for Phase II. Larger scale development would be undertaken in Phase II. The goals of Phase III would be to integrate the component developed in Phases I and II into a turbo ramjet engine demonstrator, and evaluate its performance.

AF91-132 TITLE: Non-Chemical, Air-Breathing, Propulsion Technology

OBJECTIVE: Develop novel, air-breathing, propulsion systems which do not use chemical reactions.

DESCRIPTION: Since air breathing chemical propulsion is limited in the amount of energy and thrust it can produce, and since vehicle concepts are reaching the end of that limit, it is becoming necessary to investigate other possibilities. Phase I goals are to identify concepts that could be viable, non-chemical, air breathing, propulsion systems for future vehicles, and to perform a preliminary performance assessment. Phase II would include a further level of refinement in both the concept and performance analysis. Phase III would involve experimental demonstration of concepts.

AF91-133 TITLE: Multidimensional Architectures for Turbine Engine Composite Structures

OBJECTIVE: Develop wearing and/or braiding techniques suitable for advanced composite components for advanced, gas turbine engines.

DESCRIPTION: Fiber-reinforced composite materials offer properties which enable the designers of advanced gas turbine engines to develop lightweight, high-performance, engine components, including ceramic-composite, air-foil structures. Future, highly structurally efficient components will require three-dimensional fiber reinforcement to achieve the required high stress levels. Current fabrication methods rely heavily on manual weaving, braiding or lay up techniques, leading to high fabrication costs and problems with repeatability and quality assurance. The purpose of this effort is to investigate the automated fabrication of performs for composite components for advanced gas turbine engines. The Phase I effort will investigate the feasibility of automating the fabrication of near-net-shape component performs with full control of fiber orientation and geometry to tailor the mechanical properties of the

component. A follow on Phase II effort will build hardware to test and evaluate the automated technique developed during the Phase I activity. Phase III will take the technique to the stage where it can be used for component production on a commercial scale.

AF91-134 TITLE: Turbine-Engine Test Instrumentation

OBJECTIVE: Develop new sensors/systems for accurately determining strain and temperature under actual, engine, operating conditions.

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 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 gauge and thermocouple areas. Current turbine engine tests are particularly impaired by the fact that present instrumentation is commonly temperature limited, short lived, 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 environments of a turbine engine 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 engines 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 Phase I 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 a modern gas turbine engine. Phase III efforts are expected to include optimization and refinement of the sensing technique, as well as clarification of any unresolved production or manufacturing issues.

AF91-135 TITLE: Compression System Design Methodology

OBJECTIVE: Develop enhanced and advanced compression system and secondary flow design methodologies.

DESCRIPTION: This is to be achieved by numerous theoretical and experimental efforts including such work as computer modeling, cascade testing, bench rig tests, etc., all adequately documented to be acceptable to the technical community. A major trend in compression system hardware is the increased utilization of low aspect ratio blading, blisks, and three-dimensional design methodology. The primary and secondary flow system design capability which is currently two dimensional must be extended fully into three dimensions to adequately exploit these trends. Adequate documentation of this work and its influence on turbo machinery is needed as in a comprehensive background document on turbo machinery. Areas of prime technical importance include blade/vane sweep, shock /boundary layer interaction, secondary flow design, time unsteady features of the turbo machinery gas path, and secondary flow systems. Phase I will result in concepts for the development of enhanced and advanced compression systems and methodology for secondary flow design. Phase II will result in software compatible with Wright Research and Development Center systems dealing with advanced compression system and secondary flow design. Phase III will provide hardware to be tested in an appropriate compressor rig for demonstration and proof of concept.

AF91-136 TITLE: Space Power, Energy Conversion, and Thermal Management

OBJECTIVE: Develop survivable and lightweight space power technology for spacecraft applications in the 5 to 100 kilowatt regime.

DESCRIPTION: Develop photovoltaic and thermionic energy conversion source devices, components, materials and subsystems for advanced space power system applications. Proposals should relate to the following technologies: high efficiency, highly radiation resistant photovoltaic cells, survivable photovoltaic cell stack and array configurations, incorporation of novel optical materials and geometries, ultra lightweight cells and lightweight/low cost planar and concentrating arrays for application to space missions ranging from a low threat

environment to a high threat environment including tactical missions and electric propulsion for Orbital Transfer Vehicle, Autonomous power management concepts, novel power conditioning and distribution devices, novel electrochemical devices capable of direct pulse generation, extended life at low earth orbit, and/or lower cost, thermionic energy conversion technology for solar and/or nuclear power applications, including advanced converter, structural, electrode and insulator materials, novel systems geometries promoting system reliability, thermal control and thermal management technologies and components for power system thermal control applications, including heat acquisition, transport, and heat rejection for survivable power applications and cryogenic sensor applications are also included. Phase I efforts will be feasibility studies and developments with the goal to demonstrate feasibility of the proposed concepts. Phase II effort goals will be to fully demonstrate the capabilities of the proposed technology as it applies to survivable space power systems. Phase III efforts are expected to include optimization of performance and final verification of concept capabilities as well as clarification of any unresolved production and manufacturing issues.

AF91-137 TITLE: Aircraft Power and Power Electronics

OBJECTIVE: Develop power electronic devices and systems for aircraft applications.

DESCRIPTION: Develop one or more of the following advanced power and power electronics technologies for future aircraft: high temperature components, fluids, and seals for hydraulic systems; energy-efficient technology; cold weather energy storage technology; highly reliable, fault-tolerant electrical-power generation and distribution technology; solid state power controllers; high temperature electrical power and distribution components; high temperature magnetic materials; lightweight shafts, gearing clutches, housings, and gearboxes with special emphasis on advanced materials; high performance small turbine technology; electrical power generation and distribution technology; hot aircraft surfaces and secondary power components thermal control; high temperature, radiation hardened power semiconductor devices; advanced converter and inverter topologies for aircraft applications; advanced motor and motor drive technology for aircraft actuators, fuel pumps and environmental control systems; smart power electronic technology for aircraft. Phase I goals include study results, analytical derivations and proof of concept experiments. Phase II goals include detailed analytical derivations and prototypical hardware demonstrations. Phase III goals include demonstrating flight qualified flight readiness hardware.

AF91-138 TITLE: Strategic and Tactical Missile Power

OBJECTIVE: Develop novel, high payoff, power system technologies for strategic and tactical missile as well as silo applications.

DESCRIPTION: The battery/fuel cell power source goals/desired characteristics are: strategic and tactical onboard power: peak power in a pulsed mode, active lifetimes, long shelf life, operation over altitude range from sea level to 150 km; operation over temperature range without power from an external heat source; gravimetric energy density for one minute lifetimes; volumetric energy densities for one minute lifetimes to over 60 minute lifetimes; size average power range; silo power source: 15 years' inactive lifetime; active lifetimes; greater thermal efficiency; greater modules; silo energy storage: 15 years' lifetime; round trip energy efficiency 80%; peak power capability; discharges/charges; minimum self-discharge rate. Phase I products will consist of analyses, design studies, experimental verification, and preliminary proof of feasibility demonstration. Phase II products will include prototypical device performance verification, detailed phenomena characterization and performance optimization studies and analyses. Phase III effort will include flight type quality device performance demonstrations at anticipated operational conditions, as well as, qualification testing of units for flight.

AF91-139 TITLE: Pulsed Power for Aerospace Applications

OBJECTIVE: Develop cryogenic, ambient, and high temperature, pulsed power, component technology for aerospace applications.

DESCRIPTION: Development of one or more of the following advanced pulsed power component technologies is needed for future aerospace high power applications: advanced lightweight power sources with power densities less than ..02 kilograms/kilowatt; capacitive energy storage devices with energy densities approaching or exceeding 3 kilojoules/kilogram, output voltage, response time, and lifetimes of greater than 10 million pulses per device; inductive energy storage devices with energy densities approaching or exceeding 100 kilojoules/kilograms; repetitive opening switches capable of hundreds to thousands of cycles when interrupting 2-4 megamperes at several hundred volts; closing switches for repetitive switching of average currents of 10-100 amperes at voltages of 100-500 kilovolts; 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 repetition rates of 10 hertz to 10 kilohertz; high current, density, pulse conductors that are lightweight with high tensile strength and are suitable for aerospace operating environments; advanced, lightweight, high voltage, high temperature, radiation tolerant insulation suitable for aerospace operating environments, high temperature, high dielectric strength, low dissipation factor, radiation tolerant power semiconductor devices with a maximum junction temperature exceeding 5000 Kelvin and the ability to switch tens/hundreds/thousands of amperes at 5-20 kilovolts per device; high permeability, ultra low loss ferromagnetic materials for application in passive and active magnetic systems; development of control algorithms and philosophies for the autonomous or quasi-autonomous operation of high power systems in conjunction with their power source for a variety of pulsed loads such as microwave sources and lasers; power sources for RF generators; high power density sources including batteries, fuel cells, turbo generators, and thermionic energy conversion systems; and 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. Phase III will involve a full prototypical demonstration.

AF91-140 TITLE: Cost Architecture for Future Air Force Aircraft

OBJECTIVE: Provide the architecture for future efforts in the affordability thrust area.

DESCRIPTION: This effort will provide the basic plan for future procurements and will rely heavily on the skill and judgment of the contract in the cost area. The contractor will develop a cost architecture leading to a methodology for assessing life cycle costs of conceptual aircraft with IOCs in the 2005 timeframe. The architecture will reflect the central importance of defining the cost of new and emerging technologies. Due to the uncertainties in the budget, the contractor will define three separate architectures for investments of 1.5, 2.0 and 2.5 million dollars to be spent over four years. The programs will consist of three levels of capability including the impact of the budget force structure on costs and affordability, assessment of unit costs, and the melding of costs with effectiveness. The architecture will include the capability to perform design to cost analysis, assess the impact of concurrent engineering, quantify the cost benefit of multirole aircraft vs. single function aircraft, assess the impact of operational and performance requirements on costs, quantify the cost implications of advanced technologies, and finally, quantify the impact of future force structure and production rates/quantities on life cycle costs. Phase II will implement the architecture into system design. This architecture must result in a system which is user friendly and provides a post processing capability for generating a wide array of graphic presentations of complex analyses in color.

AF91-141 TITLE: 60 GHz IMPATT Power Amplifier

OBJECTIVE: Develop a 60 GHz Power Amplifier for satellite crosslink communications, using IMPATT Diodes.

DESCRIPTION: The purpose of this project is to design and develop a 10 Watt 60 GHz power amplifier using IMPATT Diodes developed by the Raytheon Company Research Division under contract to the Air Force Space Technology Center. The amplifier will require at least a 4 GHz bandwidth and should have no less than 12% overall efficiency. Wider bandwidth and greater efficiency would be highly desirable. The products of Phase I will be an amplifier design, a specification, and the results of trace studies as to the most effective methods of power combining and diode bias control. Phase II products will be a prototype amplifier and a test report giving the results of operational testing of the amplifier. The specification should include size, weight, power consumption and test procedures as well as power output, bandwidth and efficiency.

AF91-142 TITLE: Nitrogen Tetroxide Spill Vapor Mitigation

OBJECTIVE: Develop method for reducing vapor emissions from nitrogen tetroxide spills.

DESCRIPTION: Nitrogen Tetroxide is used as an oxidizer in space propulsion systems by the Air Force. It is a Class A poison and is transported and handled with extreme care. When N2O is spilled in the environment, the liquid rapidly evaporates to form nitrogen dioxide gas. This irritating gas has low worker and public exposure limits.

The Air Force has developed a vapor-suppressing foam system for N2O spills. This solicitation is for development of innovative alternative approaches to N2O vapor suppression. Possible approaches include use of a material to cover the spill until the liquid N2O can be removed or use a neutralizing material to chemically convert the N2O to a non vapor release. The favored approach would not significantly increase the volume of waste material requiring removal and disposal. The safety and ease of material handling and application are key considerations. Phase I will require a demonstration of the innovative method through lab scale testing. Phase II will require demonstration on larger scale spills including demonstration of full scale hardware and material clean up.

AF91-143 TITLE: Lightweight Hydrazine Vapor Detector

OBJECTIVE: Develop an inexpensive, lightweight, hydrazine, vapor detector for monitoring rocket propellant fuel exposures.

DESCRIPTION: A tenfold reduction in the existing threshold limit values of hydrazine, MMH and UDMH propellants to 10 ppb is anticipated to take effect in 1991. However, no reliable monitor that can be widely deployed to detect the presence of such low hydrazine levels in real time is currently available. A small lightweight monitor that can be deployed at numerous, potential, hydrazine leak, sources is needed. The Phase I proof of concept study will emphasize not only sensitivity, reliability and size but also operational costs. Of the three amine fuels, the Phase I effort shall concentrate on UDMH but not to the exclusion of hydrazine and MMH.

Phase I of this effort will demonstrate, with supporting experimental data, that the proposed approach is capable of meeting the specified requirements. Although several approaches may be initially investigated, one will be selected by the end of Phase I and a preliminary breadboard design of the detector system will be developed. If any features of the monitor fall short of requirements, the contractor must show how and why the specific shortcoming can be alleviated if not eliminated. During Phase II, the breadboard detector developed in Phase I will be optimized to improve sensitivity, reliability, and selectivity of the instrument. The work will emphasize monitor refinement and design of a compact total device as opposed to performing a new major research effort. Sufficient quantities of the prototype detectors will be fabricated for field evaluation at an operational facility. Minor modifications based on field test results will be incorporated into a final design of a lightweight, real time detector.

AF91-144 TITLE: System to Measure Currently Unfulfilled/Partially Satisfied, Environmental, Data Parameters

OBJECTIVE: Develop component and subsystem prototypes to measure unsatisfied or partially satisfied, environmental, data parameters.

DESCRIPTION: This effort should concentrate on the environmental data parameters in Joint Chiefs of Staff Memorandum: MJCS 154-86, Meteorological Requirements for Defense Environmental Satellites. The 43 MJCS 154-86 parameters include clouds, wind, moisture profiles, electron density profiles, and visibility. More than one parameter may be investigated in the proposed effort. Phase I should effort address a conceptual design development or analysis of currently available technology for optimum data collection components or subsystems. The effort should be aimed at satisfying currently unfulfilled or partially satisfied MJCS 154-86 requirements. The Phase I design should consider satisfying as many related parameters as possible in a single cost effective

subsystem. Pros and cons of the proposed subsystem should also be addressed. Power, weight, cost, and state of technology constraints should be considerations. Active or passive sensing technologies may be investigated. Phase II should include further development of the Phase I concept into development of a prototype of the optimized component or subsystem.

AF91-145 TITLE: Innovative Approaches for Advanced Space Transportation Systems

OBJECTIVE: Define and develop innovative systems which improve military space transportation capability.

DESCRIPTION: Specific approaches are sought to improve the responsiveness, resiliency, and operability of military space transportation capability. Cost reduction of launch and orbit transfer operations, vehicle production and processing should be high performance orbit transfer capability. Phase I will establish the technology and methodology requirements necessary to validate the concept and will provide proof of concept feasibility to include technical and operating analyses. The contractor will estimate increase in capability over current space transportation systems. Phase II will develop, validate, and demonstrate the approach.

AF91-146 TITLE: Innovative Approaches for Force Support from Space

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

DESCRIPTION: Space systems provide critical support for operational military forces, including ground, sea and air. The key support functions include navigation, communications, meteorology and surveillance. The Air Force seeks innovative improvements in these particular capabilities as well as innovative new methods and capabilities to support worldwide military operations. This support may involve current systems or new system types. Changes to current support types might be accomplished with new approaches or the application of new technologies. New support types should be described in sufficient detail to permit evaluation. An example of new technology might include improvements, changes or modifications to computer data links which would ultimately improve military capabilities. To better support terrestrial forces, innovative, small, inexpensive, user friendly equipment is required. Phase I will further the concept and support the feasibility of developing force support from space. Phase II will develop a laboratory model, validate the technology and demonstrate in the laboratory the concept proposed in Phase I.

AF91-147 TITLE: Innovative Approaches for Improved Space Object Surveillance and Classification

OBJECTIVE: Develop new technologies and innovative systems which improve space object surveillance and classification.

DESCRIPTION: New technologies and innovative systems 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 the following: pattern recognition techniques; improved resolution and cloud penetration techniques; and high speed image processing. Phase I will define the approach and establish the technology and methodology requirements to validate the approach. The contractor shall provide a rough estimate of anticipated improvements over the existing systems, as well as projected cost savings. Phase II will develop, validate and demonstrate the approach.

AF91-148 TITLE: Variable Power Arc jet

OBJECTIVE: Develop an arc jet which operates efficiently over a power range of six to 14 kilowatts.

DESCRIPTION: Chemically powered orbit transfer vehicles can only deliver 40 percent of initial low earth orbit mass to geosynchronous orbits. Electric rocket engines can double the mass delivered to geosynchronous orbit. These high performance engines use one-half to one third the propellant of chemical engines, this reduction in

propellant mass enables a corresponding increase in payload. The most technically mature electric rocket is the low impedance ammonia arc jet. However, its performance is a strong function of input power. Recent mission studies indicate an operational arc jet may have to accommodate power reductions, due to solar array degradation, of as much as 60 percent without loss of performance. This project will develop a low impedance arc jet capable of operating over a power range with an efficiency and a specific impulse. Phase I will design the variable power arc jet based on low impedance ammonia or hydrazine arc jet designs. The design emphasis will be to maintain at least 35 percent efficiency and 950 seconds specific impulse over a power range of 6 to 14 kilowatts. Phase II will fabricate and test this new thruster on a thrust stand to verify its performance and determine its lifetime. Proposals will be judged on the understanding of the problem, demonstrated expertise in the field, and the innovative nature of the approach.

AF91-149 TITLE: Innovative Advanced Battery Test Concepts

OBJECTIVE: Develop an accelerated battery testing concepts with a high degree of reliability.

DESCRIPTION: Current accelerated advanced battery testing concepts have a low degree of reliability due to the severe stresses placed on the battery cells. To date the only solution has been to conduct real time testing with a few cells for comparison, or simply a run only real time test. Both these options, though superior to accelerated testing alone, have significant drawbacks. Correlating accelerated test data, with a small sample of real time data, still does not provide a high degree of statistical reliability. Real time testing requires a significant period of time to develop a statistically significant data base, usually a minimum of 5 years to calculate 7 to 10 year operational life in LEO. Low reliability and a long lead time for testing are major concerns for satellite designers. Availability of test data and the relevance of that data play a key role in the design of satellite battery systems. Phase I will analytically prove an innovative battery testing concept for an advanced satellite battery design. Proposals are not limited to only these technologies and other advanced satellite battery technologies may be explored. Due to the radical differences in these technologies, separate proposals may be submitted for differing technologies. Phase II will experimentally verify the results of Phase I.

AF91-150 TITLE: Critical Technology Demonstration for Pulsed Plasma Propulsion

OBJECTIVE: Demonstrate the scalability of a mega joule class, Magneto Plasma Dynamic plasma theater.

DESCRIPTION: The extension of small, anode centered, MFD plasma thrusters to useful sizes has been limited because the scaling laws were not well understood and because of unforeseen adverse operational characteristics such as parasitic currents. A better understanding of the physics and scaling laws now exists and a number of ideas have been suggested to solve the operating problems at higher energy levels. Thus a thruster operating in the mega joule regime can be envisioned. At this level, meaningful experiments can be conducted related to particle emission and transport, the assessment and extension of scaling laws, the evaluation of the physics and stability issues, and the measurement of energy coupling. Demonstration of significant levels of exhaust energy should also be a major objective. Phase I should be a limited effort consisting of facility and diagnostic development and subscale tests that provide confidence in the approach proposed for Phase II. Phase II will consist of the development, modeling, and demonstration of a full scale, mega joule plasma thruster. Proposals will be judged upon understanding of the problem, demonstrated expertise in the field, and innovative approaches.

AF91-151 TITLE: Photovoltaic Array Designs

OBJECTIVE: Assess the cost and schedule to construct and space qualify a lightweight, low cost, photovoltaic array.

DESCRIPTION: For most Air Force satellite mission, photovoltaic arrays are used to generate required electrical power. In accordance with Project Forecast II PT 05, innovative proposals for advanced photovoltaic array designs are solicited. Proposed work plans should assess the cost and schedule to construct and space qualify a lightweight, low cost photovoltaic array. Array hardness to man made threats is not a primary concern for this solicitation. Long

term, reliable array performance against known mid-altitude orbit environmental conditions is a requirement. Techniques need to be developed such that an array can withstand prolonged exposure to the high energy electrons and protons found in the Van Allen radiation belts. Array performance losses caused by micrometeoroid damage and other environmental effects need to be minimized or eliminated. Array vibrations caused by satellite orbital operations, such as station keeping or electric propulsion orbit transfers, should be estimated and accounted for. Provisions need to be made for stowing/deploying, and orienting the array. Efficient concepts for transferring electrical power from the individual solar cells to the array satellite attachment point need to be developed. Phase I will produce an engineering design for a 1 to 5 kW array. It will identify the cost and technical drivers for scaling the array design. Emphasis should be placed on near term technology development, large scale producibility and low manufacturing cost. Design parameters are: array specific power greater than 60 W/kg after 5 years in mid-altitude orbits. Phase II will fabricate sample pieces of array hardware. Component and subsystems testing under simulated orbital conditions will be conducted. Extensive analysis will identify the best approach for constructing, testing, and space qualifying a 1 to 5 kW array.

AF91-152 TITLE: In-Flight Solid Rocket Motor Sensors

OBJECTIVE: Development of innovative sensors to monitor solid rocket motor behavior in flight.

DESCRIPTION: New and innovative approaches are being solicited to develop cost-effective, flight weight sensors to monitor the behavior of specific characteristics within a solid rocket motor during flight. Some examples of these specific characteristics are: the accumulation of slag in the aft end of burning solid propellant rocket motors and the slags position in the motor as a function of time; the changing propellant web thickness and the heat transfer rate to the motor case; and the ability to determine the nozzle throat erosion rate. Possible approaches which might show some promise are: acoustic sensors; light weight x-ray and real time radiography; sonar and other sonic measuring devices; and strain gages. Proposed sensors should not have a negative impact on system reliability nor compromise the motor case's integrity and should be applicable for both small tactical motors and large scale ICBMs/space boosters. Phase I will be the proof of concept of the approach. Phase II will be the design of the device using the phase I approach, adaptation of the device to flight qualified motors, and ground test verification. Phase III will be flight test complete with telemetry for data acquisition, retrieval, and data analysis. Particular attention will be given to revolutionary approaches based on sound scientific principles.

AF91-153 TITLE: On-Orbit Supervisor for Controlling Space Systems

OBJECTIVE: Investigate methods for developing on-orbit supervisory control functions for space systems.

DESCRIPTION: Several proposed Air Force missions call for large precision space structures with stringent performance demands and increased operational life. These spacecraft present new challenges in the areas of structures, dynamics and control, and on-orbit health monitoring. Innovative knowledge-based artificial intelligence systems or neural network systems are sought for providing on-orbit spacecraft subsystem supervision and decision making functions. The expert system should be capable of identifying failures or performance degradation in subsystems and take appropriate actions to either rectify the problem or reconfigure the controls in an adaptive manner to account for the degradation. The subsystems of interest include spacecraft structure, including sensors and actuators required for attitude and vibration control; power and thermal management systems; etc. The proposed AI system should address the following concerns: interaction of the on-orbit supervisor with the satellite subsystems; data storage requirements for implementing the system; real time data processing requirements. In Phase I, the contractor will identify and evaluate a framework for such a system and study its feasibility. In Phase II, a detailed development will be carried out and the system will be demonstrated on a ground tested.

AF91-154 TITLE: Concentrator Technology

OBJECTIVE: Develop 9m x 7m off axis, parabolic, thin film, seamless, gore less, concentrator systems for space flight demonstration.

DESCRIPTION: Two different types of seamless and gore less thin film solar concentrators, one type a flat heliostat 28 feet in diameter, and another type providing a geometric concentration ratio of 10,000; possessing less than .2 mrad rms slope accuracy error and less than 2mm rms surface accuracy error in an off-axis configuration 9m x 7m. The concentrations are required to increase the state-of-the-art in concentrator technology. It is unknown whether seamless and gore less concentrators greater in size than 1 m can be fabricated and be optically accurate. Seams and gores cause localized surface deviations which cause localized deviations. The heliostat is required to have a torus and back plate such that its reflectivity and accuracy may be verified in the Solar Lab at the Aeronautics Laboratory. One off-axis parabolic 9m x 7m concentrator with a canopy, reflector, torus, and truss is required to produce 25 Kw output within a focal length of 4.26m. The concentrator shall be installed and inflated in the Solar Lab to verify its optical accuracy. Four more off-axis parabolic thin film concentrators, complete with canopy, reflector, torus and truss systems will be required; such that they may be packaged one by one in a Getaway Special (GAS) canister to be tested for inflation deployment reliability, in a simulated space environment, then tested for optical accuracy when still inflated. Phase I shall consist of a literature search and a single preliminary design of a seamless and gore less 9m x 7m off-axis thin film parabolic solar concentrator and the methodology for fabricating one. Phase II shall consist of the detail design and fabrication of the required reflectors, the installation of the heliostat, and the concentrator to be tested in the Solar Lab for accuracy measurements, and packaging into the GAS canister each of the four remaining concentrators before deployment and accuracy testing.

AF91-155 TITLE: Longitudinal Tomography for Solid Rocket Motors

OBJECTIVE: Demonstrate a longitudinal X-ray computed Tomography (CT) scan of a firing Solid Rocket Motor (SRM).

DESCRIPTION: SRM computational models predict the conditions and behavior of an SRM as a function of time during a burn. SRM designers/analysis want to see processes that range from the normal case to the effects of defects, and in particular how closely reality parallels their computer models. Currently, the only feedback on the events occurring within the motor during a test fire is very indirect or nonexistent; such information derives from either strain gages or embedded thermocouples, the latter being very indirect or nonexistent; such information derives from either strain gages or embedded thermocouples, the latter being very expensive and requiring implementation during SRM component manufacture. An approach to provide data is Real Time X-Ray Computed Tomography. Real Time CT can provide transverse cross sectional images of the burning motor as a function of time. Cross-sectional images of density as a function of time are a major step forward, but the SRM engineer is more interested in longitudinal cross sectional images. With currently available CT technology, it is possible to obtain a series of contiguous transverse slices so that longitudinal scans are partly realized. Another approach involves cone-beam CT but this approach is far less mature. During Phase I, the contractor will determine the requirements of a CT system capable of providing real time longitudinal scans of a burning SRM, and shall design a system meeting those requirements. Some issues key to making longitudinal CT practical are: access to very high intensity x-ray sources; access to high speed x-ray detectors and corresponding circuitry for data acquisition; ability to configure a CT system to obtain the necessary data without unduly complicating the test procedure, fixturing, or safety provisions; cutting edge algorithm development that allows for reconstruction of images, particularly from incomplete data, cone beam CT, or a combination; and familiarity with SRM analysis requirements including an understanding of the density/strength implications of various materials, and an understanding of bond line problems. Also during Phase I, the contractor will demonstrate Longitudinal CT. This small scale test, as agreed between the contractor and the Program Manager will show a knowledge of the problem and its solution. Phase II shall consist of feasibility demonstrations of the designed CT system. The results from this project will be used to provide direction for future technology programs; to achieve a real time CT system capable of being integrated into a motor test, and providing longitudinal scans during a live firing.

AF91-156 TITLE: Advanced Global Positioning System Receiver for Space Application

OBJECTIVE: Develop innovative technological designs and concepts of Global Positioning System receivers for space application.

DESCRIPTION: The current evolution of defense strategy will undoubtedly place increased emphasis on monitoring and surveillance of adversarial strategic and tactical systems. One of the most suitable and reliable platforms from which such remote sensing objectives can be achieved is the low Earth orbiter. One of the most suitable and reliable platforms from which such remote sensing objectives can be achieved is the low Earth orbiter. Improved efficiency and accuracy in the deployment, operation, and versatility of such monitoring platforms will require new capabilities in space based navigation, tracking, and attitude control. Current operations rely on a panoply of ground tracking, attitude sensing, and navigational systems which by the nature of their diversity make it costly to integrate them and difficult to achieve an optimal synergism. As an alternative, much analysis and diversity make it costly to integrate them and difficult to achieve an optimal synergism. As an alternative, much analysis and several programs are in progress to exploit the Global Positioning System (GPS) of satellites to perform some of the navigation, tracking and attitude determination objectives for space vehicles. Receiver developments for space application currently build on conventional technology and methodology designed for Earth bound user systems and adapt this to the space environment. For example, the Miniature GPS Receiver chipset developed with funding from Defense Advanced Research Projects Agency is a small, lightweight, and low power receiver suitable for manifesting on virtually and satellite, but it has only conventional navigation capabilities. There is a need to depart from conventional receiver architecture in order to address specifically unique operational frame of space, the dynamics of spacecraft, and the potential for high precision, real time, and multifunction application in navigation, tracking, and attitude control. The ability for one GPS receiver to perform the functions not only of a precise navigator, but also of orientation and pointing, normally accomplished by star trackers, or horizon and sun sensors, would translate into savings of weight, power consumption, integration costs, and computer requirements, in addition to potential improved operational accuracy. Therefore, non-conventional, innovative, and novel approaches are solicited for technological concepts and designs of GPS receivers to accomplish high precision spacecraft navigation, tracking, and attitude determination. Simple proposals include the following, but responses should consider going beyond these basic approaches: modifying the tracking loop bandwidth; providing output frequency in addition to delta phase; and exploiting multiple antenna configurations. Emphasis will be on measuring the GPS carrier signal, but utilization of the coded signals should be considered. All approaches should be oriented toward real time or near real time navigation/attitude control of spacecraft in 160 km to 10000 km altitude orbits and possible integration with on board inertial measurement units for autonomous application. Technological design should emphasize application accuracy, but package weight and power requirements figure significantly in the applicability to and success of space mission objectives. Phase I: This phase will investigate and propose novel receiver design approaches and provide preliminary analyses showing the anticipated payoff. Phase II: This phase will design, build, and prototype test a prototype receiver. Space qualification will not be part of Phase II.

AF91-157 TITLE: Doppler Imaging Photometer for Ionospheric and Thermospheric Dynamics

OBJECTIVE: Design an imaging photometer with Doppler capability to measure ionospheric and thermospheric velocities.

DESCRIPTION: Remote optical measurements of aurora and airglow, both natural and artificial, yield important information on ionospheric structure, dynamics and interaction processes. Because of the lose coupling between the ionospheric and thermospheric the relative motion of these regions, especially near auroral arcs, is a critical input parameter to studies of ionospheric irregularity generation and transport. A need exists to couple a Charge Coupled Device based imaging photometer with a high resolution Fabry-Perot etalon to obtain Doppler shift information, and thus line of sight velocities, over the entire area of the image. To obtain the required temporal resolution to study auroral arcs, the Fabry-Perot etalon should be scanned as rapidly as possible through one free spectral range, equivalent to a total Doppler shift of 10 km/sec. A sequence of 21-15 all sky images during the spectral scan would provide the ionospheric and thermospheric capacity to process these images to produce Doppler maps of dynamics in near real time. The instrument should be capable of detecting low brightness airglow sources. Other important instrument characteristics would include system conceptual development with key hardware components and system specification identified. Prototype development would be conducted in Phase II, based on results from Phase I.

AF91-158 TITLE: Lidar Mapping of Cloud Tops and Cloud Top Winds

OBJECTIVE: Develop a satellite-borne lidar sensor to map the location and height of clouds and determine the velocity of cloud top motion.

DESCRIPTION: Ranked first and fourth, respectively, in priority on the list of environmental properties in military requirements for defense environmental satellites, global measurements of the properties of clouds and tropospheric winds have been addressed in several studies, many of which are based on the use of lidar techniques. In general these approaches have been characterized by systems acquiring data only along the spacecraft nadir or by high complex, and costly, systems demanding extensive spacecraft resources. This solicitation is intended to examine a compromise approach based on lidar backscatter returns from clouds alone. Limiting the observations to cloud returns should allow simplification in hardware and signal processing and, it is hoped, easier adaptation to existing or planned space platforms. Work under this effort is to concentrate on simulation, sensitivity, and general hardware issues; other efforts currently under way will evaluate how data limited to cloud returns will apply to weather predication models. The Phase I effort should examine the lidar mapping of clouds using cross track scanning and a level of detection consistent with the anticipated backscatter from thin cirrus and, additionally, such related issues as sampling techniques, slant ranged effects, response to irregular cloud structures, and non-nadir viewing. Analogous factors should be investigated in connection with the determination of cloud top winds. For these simulations, the transmitter should be taken as an eye safe solid state laser operating in the 1.4 to 2/5 micron region. If the Phase I effort demonstrates the reasonableness of this approach from a hardware aspect and OSSEs at GL establish that data limited to cloud top returns are of value to the models, the Phase II work would consist of expansion of the simulation of the cloud top lidar, the specification of critical system parameters, and the characterization of measurement approach.

AF91-159 TITLE: Balloon-Borne Solar Vector Magnetograph

OBJECTIVE: Improve solar flare prediction techniques through very high resolution mapping of solar magnetic fields.

DESCRIPTION: Solar flares interfere with Air Force communications and space operations. While the expected effects can be estimated once a solar flare has been detected, flare onset is unpredictable with present telescopes, both because of image degradation caused by the earth's atmosphere, and limitations of current solar vector magnetographs. One way to avoid the former limitation and to develop effective flare forecast methods is to make high resolution observations from space or near space. This could be accomplished with a balloon borne vector magnetograph, an instrument capable of mapping all three components of the solar magnetic field. Several flights of the magnetograph should lead to significant improvements in understanding solar flare physical processes and preflare signatures. The instrument should be capable of sub arc second spatial resolution with a magnetic sensitivity of 10 gauss in the line of sight component and 50-100 gauss in the transverse component. The instrumentation should also be capable of measuring the transverse flows that drive the magnetic field. Phase I of the effort is for design of a magnetograph, including a telescope of 90 to 120 cm aperture, that can be operated on a balloon borne gondola at 85,000 – 100,000 feet. To achieve the desired sensitivity the magnetograph must be able to detect partial circular and linear polarization at 250 parts per million over a field of view of at least 3 arc minutes. Spectral resolution must be better than 0.12 Angstrom, achieved, for example with a tunable band pass filter. Provision should be made for recording and storing or transmitting at least three magneto grams per hour for flights of 10 – 50 hours. The instrument must be able to make several flights per year, with minor refurbishment after each flight. Phase II of the effort is for construction and assembly of the magnetograph including the mechanical support structure and optics for the telescope and specialized optics and image detector . A fine pointer must be provided to stabilize the solar image to better than 0.05 arc second. It is anticipated that a pointed platform will provide 10 arc second coarse pointing for the instrument.

Data recorded at various speeds and formats, and can accommodate data aiding from external navigation sources. Digital processors could also directly process digital translator data, greatly reducing the front-end processing required for analog translator data. Development of a state-of-the-art processing system would allow test ranges to process translated GPS data for a variety of programs and provide common processing instrumentation among the test ranges. Phase I of this project will develop a system concept for an innovative GPS data processing

instrumentation that will accommodate present GPS translator data tape formats including the Navy Trident Flight Test Support Systems (FTSS) II and the Range Application Joint Programs Office (RAJPO) Translator Processing System plus other pre-detection recorders with I&Q data rates up to 16 Mbps. The processor should be capable of tracking the GPS C/A code from up to 10 satellites in view and extract contiguous delta range parameters for the flight vehicle. Compatibility with existing VAX computers used at many DoD test ranges should also be considered. Data aiding inputs such as radar, IRU's and optical instrumentation should be included in the processing architecture. A design goal would incorporate algorithms minimizing the number of data repeat cycles to achieve optimum resolution of vehicle trajectory data. The final report should provide a detailed description of a system design and identify the key algorithms. Phase II will develop a demonstrate a prototype processing system.

AF91-160 TITLE: Small Rocket High Altitude Lidar

OBJECTIVE: Develop a high altitude lidar to measure water vapor and possibly other trace gases.

DESCRIPTION: The design of a novel, compact, solid state high altitude, rocket borne, lidar system for the detection of water vapor, and possibly other trace gases, is solicited. Water vapor in this region is important because of the effects it has on the absorption of infrared radiation and its effects on surveillance system. This payload would seek to quantify the levels of water vapor and variability as a function of altitude, and seasonal and latitudinal variability, between 15 and 90 kilometers. Other trace gases such as methane, NO2 and CFCs are also of interest because of their possible effects on atmospheric chemistry and climate. Also of interest is the possibility of detecting atomic oxygen, CO2, and NO in the region between 90 and 140 kilometers. The use of solid state lasers, detectors, and diode pumping should be strongly considered in the design of this system because of the limited power and weight capabilities of the anticipated Nike-Orion launch vehicle. If measurements of atomic oxygen, CO2, or NO appear feasible consideration to using a Black Brant vehicle, if required, will be given. Conventional Raman, differential absorption, and heterodyne lidar measurement techniques should be considered. Different system viewing geometries should be evaluated to maximize the system sensitivity. Use of eye safe wavelengths is not necessarily required. It is expected that the evaluation of its sensitivity with other existing sensors such as frost point hygrometers, spectrometers, radiometers, and cryogenic samplers will be performed. Tradeoffs between onboard data storage verses telemetered data should also be evaluated. Recovery and multiple launches of this lidar payload are planned. Fabrication of the lidar payload would be undertaken under the Phase II effort, if justified by the Phase I results, with the completed payload being delivered to the Air Force for launch. It is anticipated that payload verification and test facilities at the Geophysics Laboratory would be made available for flight qualifying of the lidar payload.

AF91-161 TITLE: Transportable Lidar for Density and Temperature Measurements to 110 Km

OBJECTIVE: Develop a trailer transportable lidar capable of measuring density and temperature to an altitude of 110 km with high accuracy.

DESCRIPTION: AF Rayleigh Lidars are utilized to routinely measure neutral density in the region from 20 to 75 km with a mobile unit and to 95 km with a stationary unit. However, the requirement to measure dneisty above 75 km with current lidar systems has demanded a large receiver and/or a powerful transmitter and thus ruled out the use of a trailer platform. It is envieionsed that new alternative lidar techniques with large backscatter cross sections could be developed to overcome this limitation. Requirements for the lidar system are as follows: the receiver aperture to be used should have moderate dimensions, the transmitter laser should not require more space than is available in a 8x25 ft trailer, and density and temperature profiles in the region from 80 to 110 km should be specified to an uncertainty better than 10 percent for vertical smoothing of 3 km and a temporal resolution of 15 minutes. In Phase I, we anticipate the development of the concept allowing high altitude measurements, a design to integrate all identifiable hardware components, and a careful assessment of the expected lidar performance. In Phase II, the proposer will optimize efficiencies, fabricate, and test the system. To minimize the final cost, the use of a 24 inch telescope as well as the existing Rayleigh lidar system, already in place, should be considered.

AF91-162 TITLE: Dissipation of Warm Fog

OBJECTIVE: Determine the feasibility of employing directed infrared energy in the dissipation of warm fog at airfields.

DESCRIPTION: The impact of fog, in particular warm fog, on airfield operations is significant at certain Air Force bases. The problem has received theoretical study and has been the subject of field experiments using various dissipation schemes. To date, all amelioration efforts have had very limited success in terms of operational techniques for avoiding the closing down of airfields during dense fog episodes. The evaporation of airborne water droplets by directed infrared irradiation has been demonstrated in the laboratory environment. This proposal is to investigate the feasibility of transitioning the technology into an airfield environment, specifically, the energy needs and component requirements for an operational directed infrared energy fog dissipation system. The minimum capabilities of the DEFDS are to maintain runway visual range of at least 400 m within the volumes of the approach, touchdown and roll out zones of an airfield on portions of 50 or more days per year. Phase I is a research effort to quantify the dimensions of the problem and to explore design options for DFEDS. Given present and forthcoming directed infrared energy hardware, the research must address the system architecture options, the energy requirements, the power levels, the fog characteristics, the wind conditions, costs, reliability, aircrew safety, design specifications for a DFEDS. Phase II is a developmental effort which requires the construction and demonstration of a prototype subscale DEFDS. Subscale means that the prototype DEFDS must maintain RVR > 400 m within an environment having RVR > 400m. The volume to be so maintained will be commensurate with the employment of a single moderate power, commercially available directed energy device. In addition to a test site, standard supporting equipment, specifically electrical power and pump components, will be provided by the government. The Phase II deliverable is a final report containing a thorough exposition of the prototype DEFDS and a comprehensive digest of all demonstration results.

AF91-163 TITLE: Microwave/Millimeter-Wave Field Sensors

OBJECTIVE: Develop an electric field and/or magnetic field sensor whose response to electromagnetic fields at frequencies of 10 GHz or greater can be calibrated and hwose perturbin effect on the field quantity being measured is minimal.

DESCRIPTION: Available microwave/millimeter wave field sensors in the 100 MHz-100GHz range are limited to a useful frequency response below 10 GHz. In addition, at 10 GHz, the electrical size of such sensors is becoming large enough to cause a significant perturbation of the field being measured. It is also quite possible for the field to couple to any conducting leads or cables that are present which can not only perturb the field but also introduce error into the voltage/current signal being carried on the conducting lead. There is a growing requirements for more precise diagnostic capability with an upper frequency response approaching 100 GHz to support planned testing activities in the mw/mmw frequency spectrum. Phase I: This effort will be directed toward identifying a physics principle which can be used as a basis for high frequency electromagnetic sensor operation. Several physics principles are used as the basis for existing electric/magnetic field sensors which can function for making measurements at frequencies as high as 20 GHz. This research is directed toward development of approaches which directly measure the field magnitude and not toward methods which only detect the envelope of the field component. The principle to be applied could be previously or newly identified but would have to have supporting analysis which would explain the operation of an EM sensor using it as a basis. The sensors to be developed should be capable of detecting a continuous wave field produced by radiating sources of 10-200 watts and should have a dynamic range of 60 dB. Pulse sensor should be able to be placed inside a cube approximately 30cm on a side without appreciably disturbing the field. The sensors should have a response bandwidth of one octave or more. They should be polarization sensitive with the ability to combine two to detect both polarizations. New sensor concepts proposed under this program do not need to satisfy all of the above requirements; significant improvements in any area will warrant serious interest. The effort should eventually lead to a demonstration by laboratory measurement(s) of the ability of the physics principle to function as an EM sensor. The potential sensor to be derived from a successful physics principle must be of such a nature that it is a candidate for practical operation in the field. THe operating parameters required of a field operational sensor include small size, minimal perturbation of the field component to be measured, reasonable detecting/recording electronics and acceptable calibration procedures. Approaches which require exotic/very expensive materials or very cumbersome support equipment are

not likely to be acceptable. On the other hand, any principle which offers capability not currently available will be evaluated. The problem of transporting the signal from the sensor to the recording device with minimal perturbation must be addressed. Phase II: This effort will be directed toward the fabrication and test of a working model of a sensor and identification of problems associated with constructing field worthy models. Phase III: This effort would be directed toward the design of an operational sensor if the problems identified in Phase II can be resolved. The final step would be a demonstration of the functioning sensor and identification of any special operating procedures or constraints. Successful sensors developed under this program would find use in diagnostics performed under the Air Force Tactical Micorwave Effects program and the SDI space system susceptibility testing program. Such sensors would also find extensive use in high frequency measurement programs being conducted at Lawrence Livermore, Los Alamos and Sandia National Laboratories.

AF91-164 TITLE: Nonlinear Optical Waveguides

OBJECTIVE: Develop nonlinear optical waveguides that are efficient media for degenerate four wave mixing, phase conjugation, or two-beam coupling.

DESCRIPTION: Nonlinear coupling mechanisms such as degenerate four wave mixing and two-beam coupling have been successfully applied to current technical challenges such as laser phase locking, aberration compensation through phase conjugation, and probe wave amplification. The majority of this work is conducted using bulk media to host the nonlinear interaction. Optical waveguides offer properties that could enhance the efficiency of many nonlinear coupling mechanisms. For example, the effective length over which nonlinear coupling occurs could be significantly enhanaced by the beam confining properties of an optical fiber. Presently, the small nonlinearities of available optical fibers can be utilized by making use of very long fiber lengths. For certain applications however, such long fiber lengths are not acceptable. The purpose of this proposal is to encourage the development of optical waveguides that possess the high nonlinearities of today's popular bulk nonlinear media. Such an innovative development might allow for essential technology to become practical and usable, not just a laboratory effect. Phase I research efforts will be directed towards the optimization of a waveguide design for a specific application such as wavefront conjugation or laser coupling for use in the laboratory. A finished product must also be delivered. Phase III will consist of design of a waveguide suitable for field use by the Weapons Labroatory. It will also consist of the demonstration of and the identification of operating procedures for a prototype.

AF91-165 TITLE: High Power Dnesity Microwave Components

OBJECTIVE: Develop and test techniques and technology for high power handling microwave components.

DESCRIPTION: High Power Microwave (HPM) sources are being developed by the Air Force for military purposes. These sources generate radio frequency fields with amplitudes near a breakdown threshold which limits the power handling capability and performance of the HPM system. The precise physical mechanisms for this breakdown are not well understood. Differences in surface quality, cleanliness, composition, and microwave characteristics seem to be important. It may b possible to increase the power handling capability of microwave systems by using special materials, treating the structure surfaces, or by designing components in which the electric field strength at the surfaces of the RF structures are low. Proposals are therefore sought for innovative technologies and design techniques which will allow high microwave power densities to be achieved in HPM sources and componetsn without RF breakdown. Phase I will be an experimental and theoretical proof of conept investigation of the mechanisms for RF breakdown, with the objective of developing materials, surface treatment techniques, etc. which will significantly raise the RF breakdown threshold. Phase II will apply this technology to develop proof of principle high power handling microwave compoentsn with low surface fields and high breakdown thresholds. Phase III will transition high power handling microwave component technology to commercial applications in the areas of high gradient compact particleaccelerators, RF plasma heating, advanced radars, directed energy weapons, and a variety of other uses. The immediate customers for Phase III products will be the triservice HPM program, but other, non defense, customers in the research community, electronics industry, medicine, power generating industry, etc. should be very interested in utilizing this technology.

AF91-166 TITLE: Measurement of Fluid Quality in Microgravity

OBJECTIVE: Choose concept, develop and demonstrate an instrument to measure gas fraction of fluid in a circulating system in microgravity.

DESCRIPTION: Phase I effort will result in defining and evaluating concepts for measuring the gas fraction of Quality of a circulating fluid in microgravity and choosing the most promising concept for additional development. Currently, the gas fraction can be measured by gamma density gauges by vision observation in a transparent section of the loop, or by inference from measurements of temperature, pressure, and flow rate; none of these methods are entirely satisfactory. The method chosen for evelopment must be capable of indicating remotely, and applicable to fluids which may be used in power conversion and thermal control of spacecraft, such as water, ammonia, the Freons, oxygen, hydrogen, nitrogen, Li, Na, and Nak. One instrument may not cover all fluids of interest, but concepts which cover several fluids or which may be modified to cover several will be of greater interest. The instrument should have a minimum interference with the flow. It would be desirable that the instrument operate in the one-G environment on earth alos. The initial instrument should be operable with ipies of ½ to 1 inch diameter, and should be scalable to other sizes. Volume, mass, power requirements, sensitivity, speed of response, reliability, ruggedness, and lifetime are other factors by which instruments will be judged. Phase II will entail constructing and demonstrating the instrument in aircraft parabolic flight, sounding rocket, or satellite tests. Phase III will result in a commercial grade instrument which can be used on spacecraft thermal control systems, on spacecraft power conversion systems, and possibly in terrestrial applications. This instrument will permit the accumulation of more accurate data at a faster rate, and will allow a two phase space system to be designed with greater confidence and fewer trials. Two-phase systems for space have the promise of reduced mass and much smaller temperature gradients, resulting in a potential for improved design and larger payloads possible for Air Force space based radar, space based communications and other space assets.

AF91-167 TITLE: Lead-Salt Materials Development for Long Wavelength Diode Laser

OBJECTIVE: Design and fabricate a lead-salt laser diode operating efficiently at or near room temperature in the 3-5 micron wavelength region.

DESCRIPTION: Laser diodes can potentially provide low cost, low weight, highly reliable mid infrared sources for many Air Force applications, including optical communications. These applications, however, require sources which operate at high temperature and efficiently. Currently, there are several candidate material systems including compounds and alloys of the II-VI, III-V, and IV-VI families; the latter being the lead salts. Each of these systems requires increased development of the materials technology for fabrication of suitable laser diodes. The lead salts are a superior choice in the Auger recombination of free carriers, which detrats from efficient laser operation. There are several areas, however, in which further study is required to ultimately formulate an optimized laser design from which an appropriate device may be fabricated. These areas include:

- Current substrates, upon which epitaxial active layers are grown, and are beset with large concentrations of defects. In addition, it is difficult to cut, polish and otherwise process lead salt materials without damage.
- The materials have poor thermal conductivity and there have been instances of unstable interfaces and contacts. Thus, it has been difficult to successfully cycle lead salt devices. In addition, there are problems with the electrical conductivity of these materials, including the effect of allow scattering.
- Differential quantum efficiencies of existing lead salt diode lasers are rather low. Possible contributing factors include leakage currents and non-radiative free-carrier recombination at dislocations and interfaces.

Phase I of this program is to conduct an analysis of current state-of-the-art lead-salt materials technology. This analysis should highlight the previously mentioned areas of concern and other possible deficiencies which may limit the ultimate performance of a lead-salt laser diode device operating in the 3-5 micron wavelength range at or near 300k. Theoretical and, if possible, experimental consideration must be given to these issues so that an optimized laser diode design, including the laser's predicted operating characteristics, will result from Phase I efforts. Phase II of this program will initially involve fabricating lead slat laser diode devices, operating in the 3-5 micron wavelength range at or near 300K based on the design of Phase I. Operating parameters of these devices such as threshold current versus temperature, differential quantum efficiency, and near and far field characteristics must be quantified. Following characterizations of the intial devices, appropriate design iterations and device fabrication

will be performed to optimize laser performance. The laser diodes will be deliverable at the end of the Phase II effort. Commercial applications which will result from a successful Phase II effort include laser sources for optical communication and pollution control systems.

AF91-168 TITLE: Generation of Singlet Delta Oxygen at High Pressures

OBJECTIVE: Develop a singlet delta oxygen generator that operates at atmospheric, or higher, pressure with yields of 60 percent or higher.

DESCRIPTION: Singlet delta oxygen, an electronically excited state of molecular oxygen delta is produced through a reaction of gaseous chlorine and a solution of hydrogen peroxide in a base. This excited state of oxygen is then used to both dissociate molecular iodine and collisionally excite the atomic iodine lasing species in oxygen-iodine lasers. Presently, singlet delta oxygen is produced in generators that operate at relatively low pressure though it has been produced at in generators (reactors) that operate at relatively low pressure though it has been produced at pressures up to 100 torr. It is suggested that if singlet delta oxygen can be effectively produced at much higher pressures, then the pumping requirements for chemical oxygen-iodine laser systems will be considerably reduced. Higher generator pressures would also allow for higher pressures in the oxygen-iodine laser cavity. Higher cavity pressures would have the added effect of forcing the oxygen-iodine laser to saturate homogeneously. A homogeneously saturated laser would allow for efficient coupling to fiber optics used for potential remote applications of oxygen-iodine lasers. The goal of this effort is to determine the feasibility of producing steady flows of singlet delta at generator pressures approaching one atmosphere and cavity pressures approaching 50 torr. Then, if feasible, the development of an efficient, high pressure, chemical oxygen iodine laser. The end product of Phase I will be a feasibility study of methods for high pressure singlet delta oxygen production, a design for a high pressure singlet delta oxygen generator and, if feasible, a design for a high pressure oxygen iodine laser. The end products of Phase II will be a detailed design, fabrication and testing of a 0.2 mole per second oxygen generator coupled to a 50 torr or greater iodine laser cavity.

AF91-169 TITLE: Highly Overmoded High Power Microwave (HPM) Source

OBJECTIVE: Design and construct a highly overmoded HPM source.

DESCRIPTION: The Air Force is developing high power microwave (HPM) technology for advanced directed energy weapons and to assess the vulnerability of U.S. systems to high power microwave energy. A critical element of HPM systems is the source of microwave energy. Conventional sources employmicrowave structures with dimensions comparable to the wavelength of the electromagnetic radiation generated. The power generated in these HPM sources scales like the wavelength squared. A figure of merit for HPM sources is therefore the power divided by the wavelength squared. It has been empirically determined that approximately 1 GW/cm**2 is an upper limit to this figure of merit for microwave tubes with single mode resonant circuits. One strategy for improving the output energy per microwave tube is to build sources which use highly overmoded microwave structures, so that the dimensions of the microwave circuits are much larger than the wavelength of the radiation. Researchers in the USSR have long been developing highly overmoded HPM sources that have demonstrated more than a factor of ten increase in the figure of merit. These MWCGs operate with a diameter to wavelength ratio of nearly twenty. In these hghly overmoded microwave sources, the output power appears to scale like the wavelength, not the wavelength squared. Innovative proposals for the design, construction and testing of highly overmoded HPM sources are therefore sought. Phase I of the program will consist of a theoretical proof of concept investigation of MWCGs and other promising overmoded HPM soures to demonstrate source physics and feasibility. A design for the proposed overmoded HPM source will be produced. Phase II will consist of a series of proof of prcinple experiments to construct and test a highly overmoded HPM source with a figure of merit and a full width half maximum (FWHM) microwave pulse length of at laeast 0.5 microseconds. Phase III will transition the hghly overmoded HPM source technology to the defense industry for incorporation into the tri service HPM program. This technology will also be useful in t he construction of high power radar systems, and compact lightweight charged particle accelerators for medicine, research, and the electronics industry.

AF91-170 TITLE: High Speed, Digital Post Test Processor for Translated Ground Processing Systems (GPS) Data

OBJECTIVE: Develop a high speed, digital, post test processor for translated GPS data with external navigation aiding.

DESCRIPTION: GPS translator data from DoD missile tracking programs is presently received and recorded on specialized ground systems using analog recording equipment. Vehicle performance data is extracted from data tapes by playing them back through program specific ground processing systems which is time consuming and the existing processors are not compatible with each other. These systems are large, compelx ,expensive and inefficient due to the iterative processing methods employed. Advanced in digital recorder and processing technology suggest that a post test processor can be developed to handle GPS data recorded at various speeds and formats, and can accommodate data aiding form external navigation sources. Digital processors could also directly process digital translator data, greatly reducing the front end processing required for analog translator data. Development of a state of the art processing system would allow test ranges to process translated GPS data for a variety of programs and provide common processing instrumentation among the test ranges. Phase I of this project will develop a system concept for an innovative GPS data processor that will accommodate present GPS translator data tape formats including the Navy Trident Flight Test Support Systems (FTS)) II and the Range Application Joint Programs Office (RAJPO) Translator Processing System plus other pre-detection recorders with I & Q data rates up to 16 Mbps. The processor should be capable of tracking the GPS C/A code from up to 10 satellites in view and extract contiguous delta range parameters for the flight vehicles. Compatibility with existing VAX computers used at many DoD test ranges should also be considered. Data aiding inputs such as algorithms minimizing the number of data repeat cycles to achieve optimum resolution of vehicle trajectory data. The final report should provide a detailed description of a system design and identify the key algorithms. Phase II will develop and demonstrate a prototype processing system.

AF91-171 TITLE: Miniature Ground Processing Systems (GPS) Digital Transistor

OBJECTIVE: Develop a low cost, miniaturized, GPS, digital translator with a capability to integrate data into the downlink data stream.

DESCRIPTION: Analog GPS translators have been in use for several years supporting DoD missile tracking programs, however, they have several important limitations: their data stream cannot readily be encrypted, supporting ground stations are highly complex and costly, real time data is difficult to relay and recording requires specialized processing equipment and techniques. Encryption will be required on many new programs which mandate a digital design approach. Digital translators would provide downlink signal margins equal to analog translators plus provide several system advantages. Digital circuitry, especially in the transmitter output stage, would reduce host vehicle power requirements, simplify airborne really and ground receiving equipment configurations, reduce phase linearity design constraints for the S-band downlink antenna, allow encryption capability, allow data to be input directly to processor digital tracking loops, and allow the use of optimal telemetry diversity combiners at receiving sites. Digitized data could be received at any conventional telemetry facility without significant upgrades. The addition of inertial reference unit (IRU) would provide position and velocity data during periods of GPS signal tracking low and would aid real time signal acquisition and post test data recovery. Phase I will investigate methodologies to digitize GPS satellite signals received by a flight test vehicle translator for transmission to a receiving station over an S0band data link. Innovative methods are sought to integrate IRU data into the S-band data link. The design goal should be a low cost digital translator smaller than the RAJPO state of the art analog translator which is 20 cu. In. and 2 lbs. Design tradeoffs should address high dynamic capabilities to 50 g and include operating in a space environment. Phase Ii will develop and demonstrate a prototype digital translator with the capability to integrate IRU data.

AF91-172 TITLE: Miniaturized Integrated Ground Processing Systems (GPS) and Inertial Navigation Instrumentation

OBJECTIVE: Investigate the feasibility of developing an integrated, microminiaturized, GPS receiver and inertial sensor package for flight test applications.

DESCRIPTION: Current range applications and military GPS receivers with associated navigation aids are too large and heavy for use on a number of flight test programs. Innovative approaches are needed to develop a fully integrated microminiaturized GPS and inertial sensor instrumentation package to improve overall capabilities at reduced cost, size, and weight. Potential applications of a microminiaturized GPS/inertial system are for missiles, space vehicles, National Aerospace Plane, Hypersonic Vehicle Technology program and commercial vehicles. Recent advances in GPS and inertial sensor technology indicate substantial reductions in size, weight and cost are possible. A design goal for the package volume, excluding power supply, antenna and cables, should be less than 200 cu. In. Performance goals are to maintain an absolute accuracy of 50 position, 0.5 feet/second velocity and 0.5 degrees attitude when operating within the conditions up to 20g acceleration and 10,000 feet/second velocity with intermittent GPS data dropouts of up to 30 seconds followed by 60 seconds of GPS track. Differential accuracy should be 6 ft in the X-Y axes and 12 ft. in the Z axis under the same dynamic conditions. The system should output inertial sensor and contiguous delta range measurements for post-test analysis. Phase I will develop a conceptual design of a system to meet the packaging and performance characteristics described above. A tradeoff analysis will be accomplished to evaluate GPS receiver and inertial sensor capabilities on system performance. The conceptual design should include a layout of a proof of concept system and estimate of physical and electronic specifications for the primary components. Phase II will develop and demonstrate a prototype system.

AF91-173 TITLE: Rawinsonde System with Radio Frequency (RF) Rejection Capability

OBJECTIVE: Develop an advanced rawinsonde system with improved RF interference rejection characteristics.

DESCRIPTION: Balloon launched rawinsondes are regularly used on test ranges to measure upper atmospheric winds and telemeter temperature, relative humidity and barometric pressure. The data is used to support meteorological reporting for the National Weather Service and on DoD test ranges to validate vehicle wind load limits during day of launch. Present sondes use super regenerative receivers which provide very little rejection to RF interference. The number of users within and adjacent to meteorological frequency bands has increased significantly during the last two years, and Loran C sondes experience degradation during storm activity due to electromagnetic discharges. These interference conditions have resulted in considerable data 90sondes, especially on the Western Test Range. For example, up to 25% of sondes launched during a 4 month period in 198 receiver/transmitter and signal processing technology, hardware miniaturization and the use of precision navaids should allow environment. Phase I will develop innovative concepts for a balloon launched rawinsonde system to measure atmospheric winds at altitude in 100 ft. increments, sonde horizontal position within +200 ft, and vertical position with +_250 ft. In addition, it should be possible when operating in a man made or natural RF interference environment within or adjacent to the meteorological telemetry bands, and the system should maintain continuous track when two or more sondes are aloft simultaneously. Phase II will demonstrate the system concept and produce a sonde prototype with the potential for fabrication in quantity at a cost comparable to those commercially available.

AF91-174 TITLE: Ballistic Missile Research

OBJECTIVE: Develop new concepts and innovations for Intercontinental Ballistic Missile (ICBM) systems and/or 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. Emphasis is placed on potential long term planning concepts. Topics as diverse as new weapon system concepts and improved operational techniques can be submitted. This could include studies of basing system, propulsion technology, maintenance free systems, facility threat, countermeasures, innovative R&D, organizational

concepts, battle management needs, etc. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF91-175 TITLE: Advanced Antenna Window Technology

OBJECTIVE: Improve the existing state-of-the-art for reentry vehicle antenna window technology in terms of radio frequency (RF) performance.

DESCRIPTION: Specific areas include:

a. Advanced Antenna Windows: Innovative techniques are sought to address the problem of providing trajectory updates/corrections in both the high endoatmospheric and terminal phase of a Maneuvering Reentry Vehicle (MaRV) trajectory.
Phase I will show prediction techniques for determining errors associated with plasma and antenna ablation/heating using electromagnetic signals for terminal guidance. Phase II will deliver a prediction code validate with BMO supplied flight test data.
b. RF performance of Transpiration Cooled Antenna Windows: Design and develop an aero thermal experiment capable of measuring the dielectric performance of a transmitting, transpiration cooled antenna window under simulated reentry – C – to Ka-band frequencies. The dielectric properties should be measurable during the heating portion of the test. Combined and separate dielectric properties of real gas boundary layers, coolants, and antenna window materials should be measurable. Structural distortion effects resulting from thermal gradients should be characterized as to their influence upon antenna window dielectric performance. Phase I will design the experiments while Phase II will conduct the tests and analyze the results fro BMO specified materials.

AF91-176 TITLE: Intercontinental Ballistic Missile (ICBM) Flight and Aerodynamic Studies

OBJECTIVE: Continue to advance the state of the art in aerodynamic code development and the modeling of RF reentry conditions.

DESCRIPTION: Specified areas include:

a. RV Flow field Measurements: Innovative techniques for measuring flow field properties of reentry vehicles (RVs) during reentry are sought. Information on electron density profiles in the RV boundary layer, temperature, and other flow properties are needed. The measurement method or combination of methods should be able to provide quantitative data over the reentry regime from an altitude of about 60 km to sea level. This encompasses reentry conditions from laminar to turbulent flow boundary layers. Phase I will develop these measurement techniques. The Phase II effort should consist of testing the technique or techniques in a ground test facility which can provide some information on validating the concept.
b. Prediction Tool for Aero elastic RV Body Motion: Innovative analyses are sought to simulate the flexibly body motion under the influence of reentry aerodynamic loads, plume impingement forces, and the body's own spin dynamics. Various modes of body motion should be considered and they should be included in the multi degree of freedom simulation. The aerodynamic motion should be coupled with the body elastic motion. Attention should be focused on the possible onset of dynamic flutter and the determination of the flutter boundaries. Comparison should be made to any ground/flight test data available. The offeror should be familiar with hypersonic aerodynamics, flight dynamics, and aero elasticity analyses. Phase I will develop the algorithms and outline the necessary model. The Phase II effort should consist of developing a computer model which couples the aerodynamics with the deformed body motion in a dynamic analysis of a multi degree of freedom code.
c. Simulation of Multi Body Motions in Free Space: A computer code is needed to predict the multi body six degree of freedom motions in free space as well as in atmospherical reentry conditions. This code shall be capable of assessing missile/RV interaction, shroud removal performance, chaff, etc. The algorithm must allow for input of body geometries and be capable of calculating the free molecular, transitional flow and continuum aerodynamic coefficients. The position history of the multi bodies relative to the radar optical

sensors and to one another should be the major output. The numerical algorithms could use various coordinate systems but must have an accurate earth model. Innovative is expected in the areas of six degree of freedom aerodynamic coefficients in both exo and endo atmospheric, selection of the initial conditions, computational time, and the number of bodies allowed. Phase I will formulate numerical algorithms and begin code development. Phase Ii will focus on code completion and validation against flight test data.

d. Exploratory Real Gas Effects Test with Free Piston Shock Tunnel: Plan, perform, and reduce data for an exploratory free piston shock tunnel test for real gas ballistic missile reentry aerodynamics. The testing should include design and fabrication of the model and installation of appropriate instrumentation. The purpose of the testing is to explore the usefulness of shock tunnel facilities for obtaining high altitude real gas measurements for aerodynamic code validation. Data reduction should incorporate results into an appropriate reentry code. Phase I will consist of test plan preparation while Phase II will conduct testing and validation.

AF91-177 TITLE: Intercontinental Ballistic Missile (ICBM) Electronics Design

OBJECTIVE: Explore critical electronics which improve projected ICBM mission capability.

DESCRIPTION: Dielectric Resonator Oscillator: Some Ballistic Missile Organization (BMO) avionics require stable sources for flight hardware. Stability of 1 part per million must be maintained over somewhat broad ranges of environmental conditions. A viable base for any reference signal is a well controlled oscillator. The stable oscillator resonant oscillator is dependent upon just such a frequency firing device. The envisioned oscillator should run at a high enough rate that 1 x 10 represents a data sample which is large enough to be easily manipulated with the stable wide band conditioning circuitry, e.g., translate zero crossing into voltage level. Hardware must be MMIC producible for missile usage. Phase I should consist of designing a microwave oscillator based upon dielectric resonator which demonstrate an operating stability of 1 PPM. The study/design must evaluate stable operation over environmental conditions fro USAF Ballistic Systems environmental parameters to be supplied by BSD. Study/design(s) must indicate capability to be produced in microwave monolithic integrated circuit. If hybrid circuit is required, the remainder of the oscillator and its associated circuitry must employ the maximum of monolithic hardware. Phase II should design 3 oscillators, plus associated circuitry to demonstrate oscillation stability of 1 PPM plus associated reference transformation at the same degree of stability.

AF91-178 TITLE: Weather Prediction for Reentry Test Launch Decisions

OBJECTIVE: Develop analytical tools to evaluate the performance of existing cloud modeling models in the use of reentry test launch decisions.

DESCRIPTION: Atmospheric water content inhibits the collection of infrared data from missile reentry tests. To facilitate weather related launch decisions, new analytical tools need to be developed or existing codes must be refined for Kwajalein area weather prediction. This prediction shall be utilized in making launch decisions which optimize infrared (IR) data collection. Phase I will investigate the existing state-of-the-art codes and tools in this area and identify an approach for broad use at Kwajalein. Phase II will develop a new or hybrid model based on the Phase I recommendation.

AF91-179 TITLE: Advanced Battery Technology for Intercontinental Ballistic (ICBM) Missions

OBJECTIVE: Develop increased battery efficiency for ICBM basing and reentry power/packaging requirements.

DESCRIPTION:

a. High Energy Density Rechargeable Batteries: The Air Force currently uses rechargeable lead acid batteries of conventional design for emergency power and high energy, lithium, primary batteries for long term survival power in Minuteman and Peacekeeper silos. In the future, these batteries may be replaced with improved rechargeable batteries if performance and cost can be enhanced. Significant performance

parameters of the desired batteries include energy storage capacity of up to 10,000 amp hours for a 28 volt system, a minimum of 100 cycles over a ten to 15 year time period, minimum maintenance requirements, and a storage life of ten to 15 years under float charge if necessary. Additionally, high hardness of the battery for nuclear weapons environments is also desirable. During Phase I, anode, cathode, and electrolyte systems should be explored and cells of up to 100 amp hour should be tested. In Phase II, a 1000 amp hour cell should be demonstrated and battery designs provided that establish the feasibility of scale up to at least 4000 amp hours capacity.

b. Bipolar Lead Acid Technology: Secondary battery systems offer advantages for systems which have long stand times but also require periodic operations in test cycling models. The lead acid battery offers high energy density, mature chemistry/material technology, and high cycling life. Basically, this battery capability incorporates over 100 years of product fine tuning. The bipolar construction offer improved power/energy density, and more rugged construction. Sealed operation projections indicate the bipolar construction offers smaller, more compact, battery design with a possibility of missile sized rechargeable units. Phase I of this effort would investigate designs of sealed bipolar lead acid batteries for two sizes of a USAF missile platform i.e., RV and decoy sized flight vehicles. Phase II would consist of the fabrication and testing of 40-50 test batteries in each of the two sizes design in Phase I. Ten units of each design would be delivered to BMO for independent evaluation.

c. High Voltage Cathodes: Cathode couples for voltage cells operate in the range of 1.5-2.5 volts, although some proposed lithium based designs promise voltages approaching 4 volts. For operation as a battery vs. cell, a string of cells must generally be connected to achieve desired operating voltage levels. Concepts are sought which explore new cell cathode/electrolyte approaches which give a minimum of 4 volt. The objective is to investigate the design of a high power short lived battery capability where packaged minimum cell voltage ranges from 4-6 volts. Battery voltages desired for missile systems would range from 12-40 volts. Phase I will investigate designs of cathode/electrolyte chemistry offering a 4-6 volt cell in the packaged configuration. Designs must show battery capability of 10-40 amps over a 30 second discharge with 12-40 volts. Phase II will develop 50 “AA” sized batteries which demonstrate the values delineated in Phase I. 10-20 battery units will be delivered to BMO for independent evaluation.

AF91-180 TITLE: Intercontinental Ballistic Missile (ICBM) Basing Security Techniques

OBJECTIVE: Increase the capability to detect and deter enemy surveillance of land based ICBM systems.

DESCRIPTION:

a. New concepts for Security Surveillance Systems: Mobile ICBM systems create severe challenges for physical security. Rough terrain with vegetation, public access potential, poor visibility in bad weather, and countermeasures all make intrusion detection, classification of nuisance alarms, and estimation of intruder intent difficult. New approaches to signal and image processing are under intensive study for both defense and commercial applications. Continuous sensor improvements have resulted from a better understanding of the physics and chemistry of detectors or from superior manufacturing processors. Applications of these advances in innovative ways can lead to better surveillance system performance at lower cost. Phase I should investigate one or more advanced technologies or innovative system concepts, and include technical feasibility and performance improvement analyses. Phase II should consist of hardware or software test demonstrations of key innovative features.

b. Innovative Surface Mapping Techniques for Tag/Implant Detection: Detection of concealed electronic or other devices, design to support hostile location and attack of missile launchers or control centers, is currently a time consuming undertaking, involving complementary procedures and equipment. Surface mapping techniques using one or more novel phenomenologies may be able to significantly reduce the time, manpower, and cost of such operations. The mapping device must sense surface anomalies such as concealed ports, slots, wires, solid state devices, or infrared (IR) reflectors. It must also be able to discriminate between man made features and natural or unplanned irregularities caused by aging, manufacturing imperfections, or damage. The mapper must be non-destructive and non-hazardous. Potential techniques might involve eddy currents, ultrasonics, stress concentrations, laser holography, and signal processing. Phase I should consist of an investigation, selection, and feasibility analysis of candidate concepts. Phase II could involve further investigation, exploratory testing and concept demonstration.

AF91-181 TITLE: Advanced Heat shield Studies

OBJECTIVE: Improve the existing state of the art for reentry (RV) vehicle heat shield capability under extreme thermal and structural parameters.

DESCRIPTION:

a. Enhanced Heat shield Capability: Develop innovative methods to improve circuit ablative performance and weight characteristics of heat shield for a maneuvering reentry vehicle flying long, heat soaking trajectories. Perform ground testing to determine the amount of ablation, surface temperatures, and material strength required under MaRV conditions. Develop analytical capability to perform heat shield weight and sizing requirements specifications with a PC based CAD code for input/output. Special emphasis will be on a high performance heat shield material that can demonstrate superior ablative performance while providing a weight advantage. Phase I will define the requirements and begin code development or modification. Phase II will continue validation and perform ground testing.
b. A New Heat shield for Advanced Reentry Vehicles: Current carbon phenolic heat shield material does not provide the strength properties necessary for advanced RV applications. Innovative concepts are sought which investigate material candidates that provide RV substructure strength properties and heat shield thermal properties while utilizing a single composite. The composite material should be tailored into desirable strength properties with good ablation characteristics. Phase I will investigate potential concepts and either select or reject candidates based on analysis. Phase II will concentrate on the ground testing of composite material.

AF91-182 TITLE: Air Blast Response of Low Drag Shape Launcher Vehicles

OBJECTIVE: Explore innovative concepts involving fixed and variable profile aerodynamic shaping to increase vehicle slide resistance to air blast.

DESCRIPTION: Very hard surface, mobile launch vehicles must resist sliding motion when exposed to the side on or head on air blast from a nuclear burst. Innovative ways of aerodynamic launch vehicle shaping can help limit sliding. Blast overpressures of 100 to 150 psi are of interest with maximum, vehicle, width to height ratios of less than six. Phase I will explore the various aerodynamic shapes and identify promising options using simplified loading analysis based on available data and methods. Phase II will involve more detailed analysis and shock tube/wind tunnel tests to determine the transient loading characteristics. A simplified transient slide motion response model will be developed to evaluate the selected shapes.

AF91-183 TITLE: Seismic Detection Countermeasures for an Advanced Basing Concept

OBJECTIVE: Characterize and evaluate low cost techniques to counter seismic signature detection of Intercontinental Ballistic Missile (ICBM) launcher vehicles.

DESCRIPTION: We are seeking innovative means of countering detection of the movement and location of mobile ICBM systems from seismic signatures. Focus of this study is on launch vehicles in tunnels 30 to 50 feet below the surface. Launch vehicles of upwards of 500 Klbs traveling at speeds of one to ten mph are of interest. The basing area of approximately 200 miles may be fenced; however, threat sensors deployed either inside or outside the fenced area should be considered. Phase I will characterize the signature characteristics and countermeasure techniques for various threat sensor/jammer location scenarios and define the analytical models and evaluation techniques. Phase II will analyze selected full scale and subscale validation example scenarios and conduct small scale validation tests.

AF91-184 TITLE: Aerodynamically Stable Intercontinental Ballistic Missile (ICBM) Booster Design Improvements

OBJECTIVE: Explore and analyze innovative means of improving aerodynamically stable ICBM designs.

DESCRIPTION: Fast burn boosters can be designed in such a way as to reduce system weight and improve aerodynamic stability when compared to conventionally designed boosters. Improved stability may lead to other design enhancements which could result in reduced systems cost, reduced complexity, and improved reliability. Suggestions for such booster design improvements are sought. Phase I will identify candidate booster design improvements and characterize to first order their performance, manufacturing, and maintenance implications. In Phase II, booster design improvements identified and tentatively verified in Phase I will be assessed through detailed analysis. Uncertainties that could threaten concept viability will be noted. Detailed test programs for verification of concepts will be generated.

AF91-185 TITLE: Unconventional Antennas for Intermittent Transmission from Mobile Intercontinental Ballistic Missile (ICBM) Assets

OBJECTIVE: Provide the capability for long wave or other radio transmission from mobile assets without large structures or support equipment.

DESCRIPTION: Large antennas can be difficult to deploy, susceptible to nuclear and other damage and limit the mobility of missile assets. The purpose of this effort is to develop concepts which eliminate these disadvantages. In addition, the antennas and communications mode must not reveal the location of mobile assets to long range, enemy, direction-finding equipment. The antennas must be capable of rapid automated deployment in a hostile environment. A large number of transmissions, each lasting up to five minutes, is a system requirement. Phase I proposals should suggest possible candidates and present a plan for feasibility analysis and selection of preferred concepts. Phase II should involve additional investigation, testing, and concept selection.

AF91-186 TITLE: Freon (CFC 113) Solvent Replacement

OBJECTIVE: Develop Replacement(s) for Freon (CFC 113) Solvent as a Cleaning Agent.

DESCRIPTION: Chlorofluorocarbons (CFCs), and Methyl Chloroform are two major sources of Atmospheric Chlorine that is devastating the ozone layer. CFCs will probably be completely banned by the year 2000. Both of these chemicals are widely used flushing/degreasing agents in the production of metallic and electronic DoD materiel. In some applications they are used as simple hydro carbon solvents, but in other applications they are used not only as a solvent for specific, complex contaminates but also a high shear rate particulate remover. The intent define and categorize the contaminates for which CFC, Trichlorethane 1.1.1, and Hydrogenated Chlorofluocarbons (HCFCs) are used in relation to DoD missile guidance system hardware and to determine the effects they have on the surface chemistry/physics of the components of which they are applied. Then, using this knowledge, select alternative materials that will produce similar benefits.

As an example the manufacture of reliable, inertial guidance, system gyros require cleaning processes that involve particulate removal under high shear forces together with dissolution of silicon, bromine, and halo alkane materials from the surfaces of beryllium components. To date no aqueous-based cleaning fluids or other environmentally acceptable solvents have been found that will produce required levels of cleanliness. The relatively new HCFC family of solvents may be effective but they must undergo extensive testing and, if they become approved, may cost 3 to 4 times the cost of Freon CFC 113. Adequate cleaning of electronic components is another totally different problem. The Phase I deliverable is anticipated to comprise a detailed report plus a proposed test program for potentially successful cleaning materials and/or systems. Phase II will consist of the actual test program implementation.

AF91-187 TITLE: Freon-Type, Solvent-Recycling, Spray Booth

OBJECTIVE: Develop a design for a Class 100 environment spray cleaning booth to completely contain and recycle Freon, Hydrogenated/chlorofluorocarbons HCFCs and other chlorinated low boiling point solvents in a manner that is environmentally acceptable.

DESCRIPTION: The manufacture of reliable, inertial guidance, system gyros require cleaning processes that involve patifulate removal under high shear forces together with dissolution of silicon, bromine, and halo alkane materials. To date so aqueous based cleaning fluids or other environmentally acceptable solvents have been found that will produce required levels of cleanliness. CFC 113, TRIC 1.1.1, and HCFCs will provide the required cleanliness but must be completely contained because of the adverse effect the decomposition products of these materials have on the atmosphere. When these solvents are used to clean inertial guidance systems components, typical contamination levels of the sprayed apparatus should be capable of up to 100 psi nozzle pressure. In addition to the laminar flow spray capability of the booth a vapor degrease capability would be a desirable addition. Contamination products resulting from the solvent recycling process must be contained an capable of being removed from the unit in a manner that does not release any solvent to the atmosphere. Similarly parts to be cleaned and cleaned parts must be able to be loaded and unloaded from the unit without any solvent loss. Online, real time monitoring of the solvent contamination to the atmosphere detection capability should be integral to the design concept. Phase I deliverables shall encompass a complete system design. Final product cost, operational efficiency and maintenance costs will all effect the commercial acceptance of the unit. Phase II activity will involve a demonstration of a prototype unit.

AF91-188 TITLE: Fiber-Optic Cable Connector

OBJECTIVE: Develop high-reliability, optical, cable connectors for missile related, laser, ordnance, firing systems.

DESCRIPTION: Fiber optic cables are utilized in missile ordnance firing systems. A vital component in such systems is the fiber optic cable connector used to join one optic cable segment to another. Serious power loss through the connector is frequency experienced after relatively few functional test cycles. Analysis has shown that the causes the power and/or attenuation losses are varied:

1. Input cable to connector mismatch
2. Improper preparation of the end of the input cable that interfaces with the connector: improper cut off; improper polishing cracked or split cable
3. Contamination and/or improper cleaning of cable to connector interface during mating/demating operations.
4. Fiber-optic breakage during laser, ordnance, firing system, component manufacture.
5. Burning and/or melting of the fiber optic cable sheath at the input cable to connector interface as a result or one or more of above power loss causes.

A need exists to enhance fiber optic cable connector design, producibility, manufacturability and functionality to a point that will insure extremely high reliability over a minimum of 10-30 operational cycles. The firing systems that relate to this SBIR solicitation requires each fiber optic cable, to handle 500-1000 millijoules of pulsed laser energy with an optical loss of less than 1.0 db per fiber through the connector. Laser energy sources that may be used in various systems include: Ruby Laser – 694.3 nanometers, Gallium Arsenide Laser Diodes – 860 nanometers, Neodymium Laser – 1060 nanometers, and CO2 Laser – 10,600 nanometers.

The connector design requirement dictates that the connector will be producible in both single channel and multiple channel configurations.

Phase I SBIR activity will result in a generic, fiber optic, cable connector design wherein emphasis has been placed on: Producibility, Factory repair/rework, Easy/accurate/contamination-free assembly/disassembly, Single channel/multiple channel configuration, the “match” between the input cable and the connector must be precise and maintained during the operational temperature and vibrational load test environment, and Ease of cleaning without fiber damage and freedom from contaminate infiltration retention. Phase I SBIR activity will also address the end of the Phase I activity is desired. A demonstration should be conducted utilizing one of the above laser sources at 500 millijoules of pulsed laser energy at less than 1.0 db of energy loss after each successive disassembly/assembly. The demonstration should be conducted in a non vibrational, room ambient temperature environment. Phase II will involve construction and test of selected designs in the operational test environment.

AF91-189 TITLE: Fluid Mechanics

OBJECTIVE: Improve understanding of flow to improve performance of aerospace systems.

DESCRIPTION: The Air Force invites basic research in fluid mechanics to provide scientific knowledge and information on the behavior of complex flow fields associated with aerospace vehicle configurations and flight regimes of importance to the Air Force. The research seeks to understand key fluid flow phenomena, to devise improved theoretical models for aerodynamic prediction and design based on that understanding, and to originate flow control concepts to expand current flight performance boundaries. Research emphasizes the development of computational methods for accurate and efficient numerical solution of the equations of fluid dynamics, the role of turbulence in the prediction and control of shear flows, the dynamics of separating unsteady flows such as those occurring in rapid dynamic maneuvers, and the complex internal flow environment of gas turbine engines.

AF91-190 TITLE: Multifunctional Nonmetallic Materials Processing and Characterization

OBJECTIVE: Develop new nonmetallic material concepts for unique combinations of electro-optical and nonlinear optical, electromagnetic and structural properties.

DESCRIPTION: Advances in ceramics, glasses and polymers are expected to come from the control of features at the 00 A to 1000 level via chemical synthesis and processing methods. These materials may take the form of ultra structural level structures and composites which will perform a combination of active and passive functions. Processing includes new and improved materials based on the methods of organic, inorganic and organometallic chemistry as well as sol gel, micro morphology processing, transformation processing, emulsion chemistry and other innovative processes. Imaginative combinations of these processes are of interest for materials with nonlinear optical, magnetic, superconducting and/or semi conducting properties and phenomena and structural integrity. Subpicosecond, nonresonant or near resonant low power optical polymers, organics and inorganics or combinations thereof are specifically required. Molecular composites, which would include the analogs of macroscopic composites, particularly where the ultra structured material will serve as a self contained functional entity. New organic and inorganic polymers as well as oxides and on oxides nonmetallics are needed for these multifunctional ultra structures. New provide sufficient material for proof of principle. Phase II must make available both well characterized material and processing know how for high volume, high yield.

AF91-191 TITLE: Quantum Structures and Devices

OBJECTIVE: Improve capabilities of high resolution radar systems and high capacity communication systems.

DESCRIPTION: Recent advances in materials processing and fabrication techniques have made it possible to produce device structures with characteristics dimensions down to a few atomic layers. New classes of devices are emerging or being conceived. Many of these manifest quantum mechanical effects such as tunneling, quantum phase interference or coherence. Proposals are invited addressing processing, fabrication, characterization and modeling of quantum devices. It is important that fundamental issues be addressed while concentrating on devices with realistic potential for DOD applications. Particularly relevant are devices with possible high frequency or high speed applications. In modeling efforts, proposals are encouraged that incorporate self consistency and dissipation as well as realistic boundary conditions. As this topic addresses a subject at the cutting edge of technological and theoretical capabilities, rapid progress may not be possible in Phase I. However, it is expected that Phase I clearly demonstrate the feasibility of the proposed approach and establish a convincing Phase II research program.

AF91-192 TITLE: Novel Precursors for Very High Temperature Composites

OBJECTIVE: Develop new precursors for very high temperature, ceramic matrix, and carbon/carbon composites.

DESCRIPTION: Ceramic matrix and carbon/carbon composites hold great potential for use in advanced structural applications where lightweight, strong components must operate in harsh environments. Microstructure and interface control is crucial in determining the final properties of these materials. We seek now, innovative precursors for the matrix that allow control of the stoichiometry tailoring of the microstructure to give control over properties such as thermal expansion and oxidation resistance. Precursors for liquid and chemical vapor infiltration are preferred, although those for other processing techniques will be considered. Problems of interest include, but are not limited to atomic scale incorporation of oxidation inhibitors, precursors that contain molecules with the final matrix stoichiometry and structure, variable molecular weight precursors, and precursors for selective area deposition. Phase I must provide enough material for proof of principle. Phase II must make available both well characterized material and processing know how for high volume, high yield.

AF91-193 TITLE: Growth of Organic Semiconductor Heterostructures

OBJECTIVE: Develop new, organic, semiconductor, heterostructure systems with unique, electronic electro optic, nonlinear optical properties.

DESCRIPTION: For many years, hope has been extended that organic materials have potential in active electronic device applications. Although this promise has remained largely unfulfilled, it has developed out of the realization that the variety of organic compounds with a wide range of both optical and electronic properties is unlimited, with several thousand compounds being readily available. In spite of these difficulties, considerable progress has been made in the last decade in realizing practical, active electronic and optoelectronic devices where an organic material forms an integral part of the device structure. One promising approach employs an organic film that is layered onto the surface of a conventional inorganic semiconductor substrate such as Si, GaAs, or InP to form an insulating or conducting layer that controls the distribution of electric fields and hence the transport of charge within the device. An attractive feature of such devices is that the composition of the organic film can be altered only slightly to effect large changes in its optical and electronic properties. Furthermore, the cohesive forces that bind molecules are somewhat soft and can be layered without inducing strain onto a variety of semiconductor substrates. Thus, the organic/inorganic semiconductor growth process need not be limited by the constraints of lattice matching. We invite research to develop new organic inorganic devices employing thin layers of crystalline organic semiconductors layered onto inorganic semiconductor substrates. The goal is to demonstrate the growth of these organic on semiconductors layered onto inorganic semiconductor substrates. The goal is to demonstrate the growth of these organic on inorganic semiconductor heterojunctions followed by possible device applications. Phase I of this program should demonstrate the growth of selected new crystalling organic semiconductor layers. Phase II should allow for the appropriate material characterization of the layers grown in Phase I and demonstrate particular device structures. Both phases should provide enough material or structures for proof of principle.

AF91-194 TITLE: Ecotoxicology Research

OBJECTIVE: Develop inexpensive techniques for long term monitoring, contaminated site treatment, and environmental toxicology.

DESCRIPTION: The Air Force recognizes that inadvertent and accidental spills of hazardous materials can occur. Hazardous materials life fuel components, solvents, pesticides, and heavy metals have made clean up and monitoring of contaminated sites formidable. Inexpensive methods for monitoring contamination levels and mobility of contaminants at spill sites is needed. Clean up of hazardous waste materials, by means which are not intrinsically toxic or which result in more toxicants, presents another demanding obstacle for the Air Force restoration program. In expensive and effective measures for site clean up are needed. Finally, the mechanisms whereby hazardous materials cause their toxic effects on the environment, at any ecosystem level, also require analysis and explanation. Phase I products are expected to be a source design of approaches to site clean up options. Any Phase II effort must demonstrate mechanisms/techniques efficacy at clean up.

AF91-195 TITLE: Efficient Techniques for Signal/Image Analysis and Reconstruction

OBJECTIVE: Investigate innovative techniques for the reconstruction of multidimensional data objects, such as visual scenes.

DESCRIPTION: Many Air Force systems involve the processing and interpretation of visual and other electromagnetic data. Examples are remote sensing systems, terrain following systems in missiles, and arrayed radar systems for tracking. In many cases, theoretical limits on computational power in the active environment necessitate the use of data compression to enable enough scenes to be transmitted and processed. Furthermore, distortions introduced into the transmission through noise, blurring and attenuation must be taken into account. New paradigms such as wavelet analysis, inverse diffusion processes, and computational geometry appear to be useful in developing more efficient signal/image reconstructive methods. Proposers may have one of these methodologies, or some other innovative technique, in mind. A sound theoretical framework for the particular mathematical approach is essential. Viability of the approach should be demonstrated on problems arising from sensor fusion, terrain recognition, transmission through distorting medium, or a similar problem of Air Force interest. Any phase II effort would demonstrate prototypes to the point where phase III production and marketing funds could be attracted.

AF91-196 TITLE: Compact, Spectrally Bright, Short Wavelength Sources

OBJECTIVE: Study, demonstrate, and develop compact, coherent, radiation sources in the ultraviolet to x-ray spectral regions.

DESCRIPTION: The Air Force would have many important uses for compact, efficient, coherent, radiation sources within the wavelength region between the x-ray and ultraviolet spectral regions. Electronic material, device, and circuit processing and diagnostics, real time flow diagnostics and control, and surface preparation and studies are some important examples. A variety of new possibilities for achieving such sources are becoming available, including laser, nonlinear optical, and electron beam/material interactions. Sources based on these, or any other innovative suggestions, will be considered. Phase I products are expected to be a source design, experimental plan for demonstrating that design, and resolution of any major uncertainties in achieving a sources based on that plan. Any phase II effort would demonstrate prototypes to the point where phase III production and marketing funds could be attracted.

AF91-197 TITLE: Tire-Wear Prediction Techniques for the National Aerospace Plane

OBJECTIVE: Determine the tire-tread wear mechanisms and develop tread-wear prediction techniques for the NASP.

DESCRIPTION: Tire tread wear for the NASP will be more rapid than that currently experienced on high performance fighters and the space shuttle. The NASP tire will push the durability limits of existing tires in terms of takeoff/landing speed, spin up inertia, and inflation pressure. Wheel well soak temperature prior to landing is also a consideration. An analytical prediction technique is required to advance tire technology for NASP applications. An understanding of tire tread wear mechanisms associated with high speed fire operations will be used to guide the development of the tire wear model. Sensitivities to such parameters as tire construction/properties, vehicle operational characteristics, and runway condition must be considered in the development of the tire wear model. Phase I must provide a preliminary tire-tread-wear prediction technique with some validation based on limited data. In Phase II, experimental techniques will be developed, laboratory tests will be conducted, the tire wear prediction technique will be fully validated, and model parameters will be adjusted to achieve better model to test data correlation.

AF91-198 TITLE: Development of Improved Carbon-Carbon to Carbon-Carbon Joints

OBJECTIVE: Improve the structural properties of high temperature, bonded or brazed carbon-carbon to carbon-carbon joints.

DESCRIPTION: In order to meet its performance goals, the NASP will require complex, built-up structures fabricated from structurally efficient, refractory materials. Carbon-carbon is a leading candidate because of its high strength to weight and stiffness to weight property ratios at elevated temperatures. In addition to material availability, however, attainment of required structural weight fractions will require structurally efficient joining methods. Area joining is particularly attractive since it can offer weight advantages over fastened or bolted joints. Brazing and bonding of carbon-carbon to carbon-carbon have been investigated, but joint properties have not been uniformly acceptable or reproducible. Phase I will investigate and establish the feasibility of methods to improve the mechanical properties of high temperature, brazed or bonded, carbon-carbon to carbon-carbon joints. As a part of Phase I, a clear understanding and familiarity with the technical issues must be demonstrated. Phase II will address processing and scale up issues, establish characteristics mechanical properties for both static and cyclic load situations, and culminate in a small component demonstration of the selected joining method.

AF91-199 TITLE: Methods for Joining Refractory Composites to Dissimilar Materials

OBJECTIVE: Join hot, non-metallic, refractory composites to other, dissimilar material components for the NASP engine and airframe.

DESCRIPTION: Advanced, structurally efficient joining methods are required in regions of the NASP where hot, non-metallic refractory composites, such as carbon-carbon and ceramic composites, transition to dissimilar material components. Because of differences in thermal expansion coefficients between the constituent materials and the likely presence of severe thermal gradients through the joint regions, the normal mechanical stresses are exacerbated by potentially severe thermal stresses. These joints, then, must be capable of sustaining the combined operating stresses over multiple mission cycles. Phase I will establish the technical feasibility of candidate joining methods. To do this, a clear understanding and familiarity with the technical issues must be demonstrated. Limited, small specimen, mechanical testing should be performed to aid in assessing feasibility. Phase II will require establishing the parameters of the joining processes, scaling up of the joining methods, and generation of characteristic test data to verify structural integrity over required lifetimes.

AF91-200 TITLE: Diagnostic Measurements of Supersonic Flow Fields

OBJECTIVE: Develop techniques for mapping scramjet flow fields with fuel penetration and mixing.

DESCRIPTION: Obtaining accurate measurements of the various flow parameters – velocity, temperature, density, and species concentrations – in a scramjet test cell environment without disturbing that which is measured is a formidable task. Flow field mapping is important to the understanding of fuel penetration, mixing, and combustion and to the validation of computational fluid dynamics (CFD) models. Measurements of recombination in the exhaust nozzle and of skin friction and heat transfer on all surfaces likewise will further understanding. Electronic processing of the instrumentation signals is an integral part of any mapping technique. The objective of the Phase I program will be to demonstrate the feasibility of the measurement method in a shock tunnel or blow down tunnel. In Phase II, the contractor will develop the concept so that it can be used in a production mode in a test cell. It must tolerate high temperatures, high levels of vibration, and extended periods of continuous operation while requiring a minimum of recalibration and maintenance. Phase III would see the concept applied to scramjet combustor development programs.

AF91-201 TITLE: Optical Communications Window for Hypervelocity Vehicles

OBJECTIVE: Test procedure to evaluate optical windows for communications at hypersonic speeds.

DESCRIPTION: Hypervelocity vehicles will operate at high altitudes and at speeds above Mach 4 for extended periods. These conditions exert extreme stresses, e.g. plasmas, shock waves, and high temperatures and pressures, on the airframe. Proposed missions include long range reconnaissance using synthetic aperture radar and electro-optical sensors. Flying at high speeds, the HVV will be able to collect data at very high rates and will need a high

bandwidth data link, e.g., a laser link to a satellite, which then relays the information to the ground. In order to support laser communications and the electro-optical sensors on board an HVV, an optical window must be developed. The window must be able to withstand the external stresses of hypervelocity flight, be transparent to the optical signals, and cause a minimum of distortion and attenuation. During Phase I, the contractor will formulate a test procedure to evaluate candidate designs for an optical wavelengths and data rates required. The contractor will analyze how the candidate windows distort the beam intensity, phase front, and direction. Since the external environment varies greatly over the surface of the aircraft, the window shape and location must be considered. In Phase II, the contractor will design, fabricate, and test at least three different window designs in a representative environment. The final report will discuss the results of the tests and make recommendations for further work.

AF91-202 TITLE: Molecular Computing for Aerospace Applications

OBJECTIVE: Explore the feasibility of molecule scale computers in the aerospace environment.

DESCRIPTION: Research at Johns Hopkins University and at Wayne State University indicates that organic "chips" which function chemically instead of electrically could potentially be made into computers ten thousand times faster than current mainframes at less than one tenth the cost. If such a computer could survive, the wide range of pressures and temperatures of a NASP-type environment, its advantages would extend beyond the obvious savings in cost and weight. Extensive monitoring of the vehicle structure might, for instance, be feasible. Phase I research will explore the environmental limits of molecular computers and their potential will design a molecular computer for a selected aerospace application so that in Phase III he can build a prototype.