AIR FORCE
Proposal Submission

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Department of the Air Force
HQ AFSC/DLS (Mr. J. R. Meeker)
Andrews AFB DC 20334-5000

Under no circumstances shall a SBIR proposal be submitted to the above.

Five (5) copies of each Phase I topic proposal shall be addressed to office as designated in the following:

You may also hand deliver your SBIR proposals, except where otherwise indicated.

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AF88-169 thru AF88-174	AFAL/TSTR SBIR Program Manager Building 8252, Room 12 Edwards AFB CA 93523-5000
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AF88-180 thru AF88-189	AFWL/PRC SBIR Program Manager Building 413, Room 282 Kirtland AFB NM 87117-6008
AF88-190 thru AF88-229	BMO/MYSC SBIR Program Manager Building 523, Room 302 Norton AFB CA 92409-6468
AF88-230 thru AF88-242	AFOSR/XOT SBIR Program Manager Building 410, Room A-113 Bolling AFB DC 20332-5000

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Air Force Office of Scientific Research, Bolling AFB DC

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AF88-001 TITLE: Armament Research

OBJECTIVE: To develop new and innovative ideas/concepts and analysis methodologies 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, fuzes including safe and arm devices for air-to-air missiles, dispensers, guns, rockets, ammunition feedsystems, sensors and seekers, explosives, propellants, carriage and release equipment, aerodynamic and structural technologies, fiber optics, solid-state inertial components, exterior ballistics, analysis, an dlethality and vulnerability assessment techniques. Some examples of desired research are low drag/observable weapon airframes, conformal ejector racks, integrated fuzing, millimeter wave seekers/sensors for mid-course and terminal guidance, heavy metal self-foraging fragment warheads, heavy metal shaped charges, long rod penetrators, reactive fragment warheads, and computational fluid dynamics including interactive grid generation techniques.

AF88-002 TITLE: Solid-State Imaging Array Development

OBJECTIVE: To develop a prototype high-speed and/or high-resolution solid-state imaging array sensor.

DESCRIPTION: The Air Force is interested in developing a solid-state imaging array for use in instrumentation video cameras which can replace present photographic cameras. There are two problems into which research and development is desired. One is high-speed imaging where specific goals are frame rates to 10,000 per second and resolution of at least 400 by 400 TV lines. Other areas to be addressed concerning high-speed imaging are sensitivity, dynamic range, spectral response, size, pixel geometry, gating for image capture, on-the-chip image processing, integral image storage buffers, and number of video outputs.

The other problem needing research and development is high-resolution imaging for shadowgraph and similar instrumentation applications. The pixel density desired is 4096 by 4096 for high-resolution applications. Sensitivity is of concern because the sensor would typically be used in low-light situations or with short pulses of illumination. Other areas of interest concerning high-resolution imaging are spectral response, consistency on pixel geometry, physical closeness of pixels, long-term image storage ability, and gating for image capture. Of less concern for this particular application is video output rate (since only one frame high resolution data is required per camera), and shades of gray (since the picture would be shadowgraph, a binary sensor may be acceptable).

Initial research efforts (Phase I) should result in evaluation of the most promising imaging chip architectures (including new architectures) and fabrication processes, expected values for each of the above areas of interest (including supporting derivations), and development cost estimates. The short-term goal (Phase II) is exploration of the most promising architectures to give proof-of-concept through hardware demonstration experiments. The long-term goal (Phase III) is prototype sensor development and detailed performance testing.

AF88-003 TITLE: Fiber Optic Instrumentation in Explosive Environments

OBJECTIVE: Determine the effects of explosive environments on fiber optic sensors and data links and develop/demonstrate compatible high bandwidth data recording techniques.

DESCRIPTION: The Air Force Armament Laboratory is interested in (a) the development of fiber-optic/electro-optical sensor systems and (b) compatible cost effective multiple channel transient data recording methods to improve the measurement techniques for weapon development and testing. Compatibility with direct optical sensor output and optically augmented electrical transducers is required.

a. Current test techniques employing piezo-electrical and other electrical measurement techniques either do not have sufficient measurement bandwidth, are too expensive, or suffer from induced electro-magnetic effects. This effort is to investigate the application of fiber/electro-optic sensors within the explosive environment and/or embedded in the explosive material. Of particular concern or interest is the direct effect of the dynamic environment

on the sensor or transmission medium itself and ways to exploit/prevent these effects as needed. The Phase I effort is a study of the effects of the explosive environment on the fiber and sensors, along with demonstration of experimental techniques for making measurements in both the transient and post event phases. The Phase II goal is to determine sensor and data transmission link design characteristics usable in explosive experiments via feasibility experiments. Phase III will be to fabricate and test prototypes and document the designs and results for use by the weapons development and test community.

b. Large numbers of transducers are used to collect performance data about the munition or explosive device under test. As discussed above, to obtain the required performance data, new high bandwidth transducers are under investigation wherein the output is either directly a light signal or is converted at the transducer to a light signal for transmission through the severe test environment. Current state-of-the-art instrumentation recorders are too costly, have insufficient channels, lack sufficient bandwidth, and are difficult to synchronize and trigger. This effort (Phase I) is to define and investigate cost effective high performance instrumentation recording techniques for the new generation of sensors. The Phase II goal of this related effort is to design and demonstrate advanced transient instrumentation recorder systems concepts compatible with both electrical and optical transducers, with at least 100 channel input capacity, picosecond timing resolution, high measurement repetition rates and compatible high density storage/analysis techniques. Phase III efforts will be to develop a field to transition to test range and laboratory users.

AF88-004 TITLE: Hypervelocity Launcher Research

OBJECTIVE: Advance the state-of-the-art hypervelocity launcher technology through progress in related subsystem technologies or development.

DESCRIPTION: New and innovative ideas and concepts are desired in the area of hypervelocity launcher technology. Programs stressing either experimental research or theoretical analysis are acceptable. Proof-of-principle experiments at the system level as well as subsystem technology research addressing critical issues for electrothermal, electromagnetic and advanced gas gun concepts are of interest. Some examples of desired research include but are not limited to hypervelocity launcher diagnostic techniques emphasizing data integrity in launcher hosted environments, launcher concept specific power conditioning, distribution and feed emphasizing high efficiency and application of recent developments is superconducting materials to launcher specific subsystem technologies.

Phase I should include trades and analyses investigating the relative merits of the advanced system or subsystem technology being developed. In addition, subscale component experiments and/or theoretical analysis shall be included.

Phase II should include system level proof-of-principle experiments based on the analysis and experimental research performed in Phase I. Emphasis shall be placed on validating system performance.

A88-005 TITLE: Dynamic IR Simulation Techniques

OBJECTIVE: To investigate methods of improving Bly Cell performance with application toward dynamic IR target simulation.

DESCRIPTION: Military infrared imaging systems are becoming increasingly complex. They employ advanced focal plane array technology and complex processing algorithms. However, the technology to effectively evaluate these systems has been lagging. There are no techniques currently available for simulating real-time broadband IR imagery. The majority of IR seeker testing involves large scale range testing. The problem with this approach is that test conditions are never exactly reproducible, and costs are high in time and money. The alternative to field testing is a laboratory test set-up. This would offer the advantage of repeatability of test parameters and lower cost. However, current IR display devices lack sufficient dynamic range and resolution. Some IR display devices which are being considered are the Bly Cell, the IR light valve, and the thermoelectric array. The Bly cell has been proven feasible in providing dynamic IR scenery in the 3-12 um waveband. However, current generation Bly Cells suffer

from relatively low resolution (less than 4 cy/mm) and low dynamic range (max 70 degrees delta temp). The objective of Phase I of this program is to investigate methods to improve resolution, dynamic range, time constant, and methods of driving the Bly Cell so as to produce flicker-free IR imagery. The Phase II effort will concentrate on a more detailed design and analysis culminating in the development of a test cell for evaluation. Long range goals are for development of a full dynamic range IR simulator in which the Bly Cell will be used for background simulation.

AF88-006 TITLE: Warhead Fragment Characterization System for Arena Testing

OBJECTIVE: To design a warhead fragment scoring system to obtain fragment mass, velocity and spatial distribution data.

DESCRIPTION: The Air Force is interested in studying methods of obtaining fragment mass, velocity and spatial distribution data from non-nuclear munitions which are statically detonated in a test arena. Fragmentation tests are required for high explosive munitions, such as small-caliber ammunition, cluster submunitions, bombs and bomlets, rocket and guided missile warheads, etc. There are two main devices presently used to obtain this data. A thin velocity screen is placed a known distance from the explosive and each time a fragment passes through, a pulse is produced. The time of flight and distance to explosive are used for determining velocity. Behind these velocity screens are large recovery boxes made of wood fiberboard or granular vermiculite. These materials are stacked thick enough to stop the heaviest expected fragment. There are two main problems with this system. First, thousands of man-hours are needed to set up the test, record each fragment hit, weigh each fragment, and analyze the data. The second problem is that this system limits the data that can be taken to a few degrees wide, fan-shaped area. There are requirements to take data from various orientations around the explosive including directly above it. For Phase I, innovative techniques for obtaining fragment mass, velocity and spatial distribution data are needed. These methods should obtain data continuously from the point where the fragments leave the explosive until they reach their effective distance. Phase II involves exploiting the results of Phase I to perform validation experiments to determine the feasibility of a warhead fragment scoring system.

A88-007 TITLE: Impact Sensor for a 20mm Projectile

OBJECTIVE: To develop a 20mm projectile impact sensor capable of discriminating between impacts with rain drops and aircraft at 5000 FPS.

DESCRIPTION: The Air Force is currently developing a small inexpensive electronic-delay base mounted fuze to be used in 20mm aircraft gun projectiles for new high velocity ammunition; however, a sensor that can adequately distinguish between an impact on an aircraft's skin and a rain drop impact does not currently exist. The Air Force is interested in developing such a sensor. The sensor should be simple and inexpensive. The total fuze cost, including the sensor, must not exceed $5 in production rates. The sensor must be able to withstand a muzzle velocity of 5000-5500 ft/sec, a gun launch setback of 60K-140K g's and a projectile spin rate of 120,000 revolutions per minute. The impact velocity of the projectile will be 2500-5500 ft/sec with an impact angle of 0-80 degrees.

The Phase I effort includes a study of potential sensor concepts and an analytical assessment of the concepts' potential to meet performance, volume, and cost constraints. A potential follow-on Phase II effort would include hardware design, fabrication, test, and analysis to demonstrate proof-of-concept.

AF88-008 TITLE: Materials for Suppression of Shock Propagation

OBJECTIVE: Identify and evaluate materials which can be placed between explosive filled munitions to suppress shock propagation from accidental detonation.

DESCRIPTION: The Air Force is interested in suppression of propagation of detonation in munitions stored in quantities in igloos or other storage areas. This may be accomplished by placing various materials between bombs

to prevent propagation of the stacks if one item is accidentally detonated. Some work has been done by the Air Force to address this and it appears that various materials (e.g., plexiglass, wood and metals) to attenuate the shock.

Phase I will establish relevant material and geometric properties of potential buffer materials, establish a calculational method for prediction of shock transmission and attenuation, devise an experimental method for confirmation of predictions, and demonstrate the methodology by a combination of calculation and experiment.

Phase II will use the Phase I methodology to evaluate a variety of materials and the influences of material geometry so that inexpensive buffers can be designed for various types of munitions.

AF88-009 TITLE: Search for New Intermolecular Eutectic Explosives

OBJECTIVE: To characterize new melt-castable eutectic explosives for emulsion explosives and/or melt-slurry explosives.

DESCRIPTION: The majority of military explosive research in the recent past has concentrated on the problem of replacing existing explosive fills with considerably more insensitive but equally powerful explosives, i.e., to develop an insensitive high explosive (IHE). One approach that has been investigated is to combine two or more compounds which are by themselves not adequate explosives but when intimately mixed form a eutectic mixture which exhibits better explosive properties than any of the individual components. These eutectic explosives are also known as intermolecular explosives. Most eutectics studied to date utilize ammonium nitrate as the oxygen contributing component and nitrogen-containing organic nitrate salts as the explosive fuel (e.g. ethelenediamine dinitrate, guanidine nitrate, diethylenetriamine trinitrate). Only a handful of intermolecular explosives have been studied to any degree and although they perform well, they are still not insensitive enough to meet the IHE criteria. Many other intermolecular explosives which may perform well and exhibit the required insensitivity have not been studied by need to be. Intermolecular explosives are also used in two other types of melt-cast explosives: (1) intermolecular eutectic emulsion explosives and (2) intermolecular slurry explosives. New intermolecular explosives exhibiting a variety of physical, chemical and explosive properties are needed for these types of melt-cast explosives.

The goal of Phase I is to find new intermolecular eutectic explosives which are melt-castable (80-110°C), which theoretically show an ability to perform well, and which exhibit thermal and impact insensitivity. When selecting new components emphasis must be placed first on the melting point of the resultant eutectics as these will be melt-cast systems (a eutectic composition melts at a lower temperature than any of the components). Insensitivity and performance, not necessarily in that order, should be the second and third considerations when selecting eutectic components. The follow-on Phase II goal will be to formulate and load a variety of test hardware to evaluate the shock sensitivity, performance and thermal stability of the selected materials.

AF88-010 TITLE: Surfactants for Emulsification of Intermolecular Explosives

OBJECTIVE: Identify new surfactants capable of emulsifying molten intermolecular explosives.

DESCRIPTION: Intermolecular (non-ideal) explosives are being explore as candidate materials for various military applications under the Air Force Insensitive High Explosive (IHE) program. These explosives consist primarily of eutectic mixtures of oxidizers such as ammonium nitrate or sodium nitrate and fuels such as guanidine nitrate, ethylenediamine dinitrate or nitroguanidine. It is possible to emulsify these molten intermolecular formulations (dispersed phase) with various desensitizing agents such as waxes, polymers and oils (continuous phase). However, the number of surfactants known to emulsify these explosives is extremely limited with respect to surfactant class, chemical type, hydrophilic/lipophilic balance (HLB) and thermal stability. Also, the type of continuous phase material known to participate in the emulsification process is presently limited to relatively hydrophobic substances.

The purpose of Phase I is to identify and/or develop new surfactants capable of emulsifying these explosives with a much wider variety of desensitizing materials. The follow-on Phase II effort will examine the emulsification process and explore methods for reducing dispersed phase cell size to 0.1 micrometer or less.

AF88-011 TITLE: Infrared Sensitive Spatial Light Modulator

OBJECTIVE: To exploit new developments in high temperature Super Conductive materials to design and develop an infrared sensitive spatial light modulator.

DESCRIPTION: Much work has been accomplished by the optical processing community to develop efficient holographic filter designs for optical correlation. The progress in this aspect of optical processing will shortly yield light efficient filters capable of detecting and identifying spatially complex objects with a high degree of success. New filter design and developments are continuously relieving restrictive limitations so that optical correlation can now be considered a viable technique to accomplish the target acquisition and identification function for tactical missile seekers.

The fundamental goal of this task is to develop the components needed to enable the use of the correlation function in the infrared regime. If one could sense the object scene in infrared light, translate it into the visible domain and process the spatial and/or phase information by using the maturing optical correlation filters, then analog signal processing would permit real time scene processing at virtually unlimited frame rates.

The technique challenge is to develop or exploit “high temperature” super conductive materials that are photo sensitive in the infrared regimes (3U-5U) or (8U-12U) and at the same time possess properties that permit the sensed information to be used to directly modulate a laser beam in the visible domain.

Phase I of this SBIR task is to conduct a survey of potential material candidates for such a spatial light modulator, accomplish preliminary designs to exploit the material properties, and to report the advantages and disadvantages of each proposed concept. Finally, the Phase I task will culminate with the recommendation of a candidate approach to be demonstrated in Phase II. The follow-on Phase II task will be expected to demonstrate, in the laboratory, the material properties that accomplish infrared sensing and visible processing off the input signals.

Phase III is expected to produce a prototype imaging device that on a small scale can demonstrate the desired analog processing scheme. Ideally, the image recording medium can ultimately be manufactured so it will permit 0.25 milliradian resolution, or if it is an emulsion on thin film device, about 40 to 60 line per millimeter resolution.

AF88-012 TITLE: Shallow Depth Plastic Rotating Bands

OBJECTIVE: To investigate various retention methods for shallow (.02 inch) plastic rotating bands for high velocity projectiles.

DESCRIPTION: The Air Force is interested in developing a family of low drag, high lethality projectiles for use in the advanced technology gun systems. These projectiles must be of thin wall design to insure maximum high explosive content and must utilize a relatively soft rotating band material to minimize barrel erosion and maximize gas sealing at 5000 ft/sec muzzle velocity. These projectile requirements, together with the requirement to reduce drag to an absolute minimum, necessitate the use of a plastic rotating band retained in a shallow depth (.020 inch) band-seat. The band material must be an injection-moldable thermoplastic capable of withstanding the high shock and torsional loads involved in projectile launch. The band seat retention technique must be a simple, reliable, inexpensive method of attaching the plastic band to the parent projectile.

In Phase I, band seat fabrication methods, band/band-seat bonding and band materials will be studied with recommendations for materials and methods to be testing in Phase II where those materials/methods found to be most promising in Phase I will be tested on gun-fired projectiles. The results of Phase II will be one or more actual rotating band technologies ready for use.

The program will concentrate on band materials and retention methods that can be developed for use in full-scale ammunition production (up to 10 million rounds/year).

AF88-013 TITLE: Loading System for Advanced Gun Technology (AGT) Cased Telescoped Ammunition

OBJECTIVE: Develop light-weight, simple prototype loading system for AGT cased telescoped ammunition.

DESCRIPTION: The Air Force Armament Laboratory (AFATL) has a 20mm Gatling gun under development which fires cased telescoped ammunition. A linear linkless ammunition handling system with a continuous conveyer will be used to feed the gun and store ammunition. The cased telescoped ammunition is percussion fired, 5.5 inches in diameter, and has the shape of a circular cylinder.

This new and unique gun system and ammunition will require a small, simple ammunition loading system that must be capable of simultaneously loading and downloading ammunition into and from the gun system at a rate of 100 rounds per minute. The loading system that must insure proper ammunition orientation, protect the ammunition from handling hazards, and function under a wide range of environmental conditions. The capability to operate the loading system with optional power sources (electrical, pneumatic, hydraulic, and manually) is required. Also the loader must be maintainable and supportable. Existing ammunition loader technology, loading concepts, and ammunition containers should be applied whenever possible.

In Phase I, existing ammunition loading technologies that could be adapted or modified for cased telescoped ammunition will be identified and evaluated. Also, new components development required for loading cased telescoped ammunition will be identified and assessed.

Phase II will provide a detailed design of the critical or modified components required for the handling and loading of cased telescoped ammunition.

AF88-014 TITLE: Ultra-High G Acceleration Measuring Techniques

OBJECTIVE: To develop and test a device to measure acceleration induced when a projectile impacts armor or other structures.

DESCRIPTION: The Air Force is interested in developing a transducer that will survive the shock of a projectile impacting the structure it is mounted on along with measuring the resulting acceleration. The vulnerability of armored vehicles to projectile produced shock impact is an issue that must be considered in the design and testing of new weapon systems. The present testing techniques utilizing accelerometers have proved unsatisfactory. Direct measurement of acceleration with conventional accelerometers in impossible in the ballistic shock environment near the impact point due to the high level (millions of G's) and short duration (microsecond) of the pulses present. State-of-the-art sensors, presently limited to 250,000 G's, could possibly be modified to meet a mega-G requirement, but innovative technologies such as fiber optics, surface acoustic waves, etc., should also be examined for development of this accelerometer. Methods of calibrating a mega-G accelerometer should also be researched as a part of this effort. The Phase I effort should provide conceptual designs of a mega-G accelerometer and calibration system. A Phase II effort will involve fabrication/proof of principle tests of conceptual mega-G accelerometers and calibration methods.

AF88-015 TITLE: Miniature Guided Projectile Components and Software

OBJECTIVE: Develop miniature components and software to support autonomous guided projectiles.

DESCRIPTION: The Air Force is interested in developing lighter weight autonomous guided weapons with enhanced performance. Enhanced performance may include innovative, light-weight approaches to conventional seeker design, focal plane array design, signal processing, focal plane array materials, inertial measuring devices, data processing, structures, guidance laws, filters, estimation, on-board power supplies and power management, and other areas.

The Air Force is interested in innovative techniques which reduce the projectile weight, size, and power requirements while increasing performance. Any hardware or software approaches are of interest.

The Phase I effort will consist of feasibility studies and analysis of approaches, techniques, or designs to meet the topic goal. On the follow-on Phase II effort, concepts will be refined and evaluated and "breadboard" devices tested to demonstrate the validity of the approach.

AF88-016 TITLE: Melt Copolymers with Low Melt Viscosity and Sharp Melt to be Used in Explosive Formulations

OBJECTIVE: Identify and evaluate various copolymers which can be formulated with explosive ingredients.

DESCRIPTION: Current explosive fills are geared to be loaded by melt cast techniques. These systems now use TNT based explosives which melt at around 78° C. There are many polymers and/or copolymer systems which melt in this range that are being investigated as binders for granular explosives. These polymers cab be either inert or energetic in nature. It is desired to have a variety of properties, e.g., low melt viscosity, sharp melt point, tough adhesion, thermally stable above 220° C and flexible.

The Phase I effort will identify and evaluate melt castable polymer or copolymer systems which can be used to formulate various explosive ingredients. These will be melted and loaded with solid monomolecular explosives to form castable mixes which may contain up to 80-85 percent solids. The follow-on Phase II project will concentrate on loading these formulations into test hardware to characterize the shock sensitivity, performance and thermal stability.

AF88-017 TITLE: Improved Methodology for Distinguishing Mass Detonation from Non-Mass Detonation

OBJECTIVE: Develop instrumentation to measure the energy release of individual munitions in storage arrangement during en-mass reaction.

DESCRIPTION: Energetic materials are categorized in accordance with their susceptibility to support and sustain mass propagating reactions. Explosives are classified as 1.1 mass detonating, 1.2 non-mass detonating, 1.3 mass fire, and 1.4 moderate fire. Many military explosives fall in the 1.1 category. The most crucial test challenge is meeting the criteria of the non-detonating propagation test called sympathetic detonation. When one round of six bombs in a standard storage pallet is intentionally detonated, a detonation reaction must not propagate to neighbor rounds. The severity at which the neighbors react determines their hazard classification. Present methods to determine reaction severity of neighbor rounds include witness plate markings, warhead case fragment sampling and explosive collection. These methods, however, are often too crude when attempting to differentiate between a detonation or a deflagration. They do not distinguish the levels of reaction within each category which is of importance in setting quantity distance criteria. Thus, each explosive's hazard area must be determined and then quantity distance calculated. In addition, as testing proceeds from a two body to a storage pallet (6 body) and a multiple pallet (6 pallets or 36 warheads for MK82 bombs) test, determining even the crudest of reaction severity and categorization is impaired due to the number of reacting items. The Phase I effort should examine and define the feasibility and engineering design of externally mounted (exterior of the bomb case) instrumentation and monitoring devices. Number and types of instrumentation, data acquisition systems and associated electronic hardware required to implement the system design should be specified. This system will determine the total energy output of each individual warhead in a MK82 scale stack test conducted in accordance with Department of Air Force Technical Order 11A-1-47. The follow-on Phase II effort should include: (a) Fabrication and testing of externally mounted instrumentation system as described in Phase I and (b) Internally mounted (internal to the bomb case) instrumentation and monitoring device feasibility and engineering design study. Develop an integrated system to determine the total energy output of each individual warhead in a MK82 scale stack test conducted in accordance with Department of the Air Force Technical Order 11A-1-47. The system shall be installed prior to loading of explosive and should be designed to minimize impairment of the loading process or load quality. The design should further account for possible variations in explosive fills and should be suitable for present USAF melt cast or PBX explosive fills.

AF88-018 TITLE: Model for Chaff Radar Returns for Missile Target Detecting Devices (TDD)

OBJECTIVE: Develop a method of predicting RF energy return from chaff at the frequencies used in air-to-air missile TDD.

DESCRIPTION: Current and forecast Air Force missile test programs involve attacks by air-to-air missiles on drone aircraft that are dispensing radar defeating chaff. It is important to know what effect this will have on the TDD function of the missile warhead. A method must be developed to model the radar returns from various sizes and shapes of chaff particles at the frequencies involved in radar TDD. This model would then be integrated in the current radar fuze model to predict when the warhead would function so vulnerability estimates could be made and verified by empirical data. The desired end product would be a model written in FORTRAN V to describe the radar returns and characterize this phenomenon.

The Phase I effort will encompass a study and the proposal of algorithms for the prediction of effects of chaff on TDD in the near field. The contractor will investigate all sources of data to include a literature search and interviews with the most knowledgeable experts in the radar field. The next step will be to propose the basic plan which may include several options for chaff modeling. The algorithms will be tested on simple cases to estimate their worth for future refinement. The final product of Phase I will be a fully documented methodology that shows promise to develop into a computer model that can be integrated into present and future air-to-air missile endgame programs.

The Phase II effort will entail the writing of the computer program and refinement of the methodology developed in Phase I. The contractor will write a program in FORTRAN V for use by the effectiveness and vulnerability community. This model should be validated by empirical results obtained through Service test programs or by specific testing to fill data voids. The model will be internally documented and be accompanied by a user and analysts manual. Full compatibility with the Joint Service Endgame Model (JSEM) is mandatory.

AF88-019 TITLE: Improved Test Reference Systems

OBJECTIVE: To develop improved time, space and position reference systems for the evaluation of aerospace hardware.

DESCRIPTION: The 6585th Test Group at Holloman AFB, New Mexico has a variety of test facilities which are used for the quantitative evaluation of aerospace hardware. Major test facilities include the High Speed Rocket Sled Test Track, the Air Force's Central Inertial Guidance Test Facility, a Radar Target Backscatter Test Facility, and Air Force flight test activities on the White Sands Missile Range. Examples of immediate requirements are:

a. Real time velocity of propagation measurements. The Test Group has a completely integrated reference instrumentation system which gives aircraft position to 13 feet, velocity to 0.1 ft/sec and attitude to 6 arc minutes all one sigma. This measuring system is the reference system for the evaluation of airborne navigation systems of the Department of Defense. About half the errors in the existing measuring system are due to the uncertainty in measuring the location of ground transponders to an absolute reference while the remaining half are due to uncorrected variations in the velocity of propagation. The requirement is to make real time measurement of the velocity of propagation between the ground transponder and the airborne interrogator. The Phase III requirement would be to propose a system to incorporate into a set of up to 150 ground transponders and an airborne interrogator making range and range rate measurements at a 10 Hz rate using S-band radio frequencies.

b. A requirement exists for a general purpose Position Proximity Sensor (PPS). The sensor must deliver a discrete signal at the time of closest proximity. These reference system requirements include the high speed rocket sled test track, mobile test vans, precision centrifuges, rate tables, and linear displacement devices. The requirement is to produce discrete events at the time of closest approach of two predetermined objects. For example, the high speed rocket sled uses a knife edge to interrupt a light beam to determine sled position and time. The discrete event should have a rise time of .1 micro seconds or less and the discrete event should occur within 100 micro inches of the point of closest approach. The point of closest approach can be anything from one foot per second to 10,000 ft per second. The Phase III requirements would be to propose a system to incorporate into one or more of the following:

(1) Augmenting or replacing the existing high speed test track space system with sensors.

(2) The installation of sensor sets along mobile test van paths.

(3) The addition of sensors to precision centrifuges to determine angular position as a function of time.

(4) New applications yet to be determined.

Phase I consists of a literature search and a theoretical study evaluating alternatives and recommending the most promising solution. Phase II requires the design of an approach, the building of a brass board system and verification of the technique. Phase III is the proposed implementation of the system as described above.

AF88-020 TITLE: Artificial Intelligence Generalized Research

OBJECTIVE: Devise new and innovative ideas/concepts for application of artificial intelligence to assessment methodologies.

DESCRIPTION: Major methodology efforts have been directed toward developing analytical tools and techniques. These analytical tools and techniques rely on experimental data to make reasonable assessments. The data is usually digested and analyzed manually to determine a realistic assessment or if a response is required, what response will be more effective. Often there is a data deficiency from which the analyst is asked to use expert opinion in employing the method(s) of assessment. Application of an automated approach to store, retrieve and analyze data is desirable. Advancements in Artificial Intelligence (AI) have produced a potential to substitute machine intelligence for the human assessment process. Some examples of specific research in application of Artificial Intelligence are target vulnerability assessment, survivable base communication systems and air base ground defense detection.

Phase I efforts will evaluate and analyze new methodologies and techniques in the application of AI. The concept(s) shall be defined and an assessment made in comparison to existing methods. The goal of Phase I efforts is, at a minimum, to demonstrate analytically the feasibility of the concept(s).

Phase II efforts will expand the concept(s) presented in Phase I, concentrating on more detailed definition and analysis of the concept(s) with appropriate experimentation/tests to demonstrate the proof-of-concept.

AF88-021 TITLE: Dust Particle Dispenser System

OBJECTIVE: Develop a repeatable and controllable system to dispense dust particles into a pressurized gas flowing vessel.

DESCRIPTION: The dispenser must be capable of dispensing particles, mainly graphite spheres, from 50 to 150 microns in size into a vessel containing high pressure to 150 atmospheres flow gas. The system must have a storage capacity to 1,000 grams with a dispensing repeatable flow rate of $\pm$ 10.0 percent at any point within the range from 1.0 to 30.0 grams/second. The system should have a startup and shutoff time within a range of 0.20 to 0.50 seconds with no back flow either in the on or off condition. A carrier gas up to 0.25 lbs/sec (either air or nitrogen) can be utilized to dispense the particles into the pressure vessel. The dust flow rate control should be referenced to the pressure sensed inside the pressure vessel so that a constant dust flow rate can be maintained at various pressure levels.
A concept is needed, leading to the building of such a system to be incorporated in the HEAT-H1 and Dust Erosion Tunnel at the Arnold Engineering Development Center.

AF88-022 TITLE: High Temperature Surface Emissivity Measurement System

OBJECTIVE: Develop a measurement system capable of providing emissivity data on samples of various types of materials for maximum sample temperatures of 2000 to 5000 degrees R.

DESCRIPTION: Radiometric measurements are often used to monitor surface temperature during materials tests performed in the hypersonic tunnels, the arc tunnels, and the ranges. The conversion of the measured radiant energy emitted to actual surface temperature requires that the spectral emittance of the surface be known for the sample material under test. Unfortunately, the emittance of most materials varies with temperature and is generally only available for room temperature conditions. By using the room temperature emittance values to convert measured radiance to surface temperature (as is currently done), significant errors can be made for tests performed in high temperature environments. Capabilities for measuring material emittance at elevated temperatures exist at other locations, such as Purdue University, NASA Langley and Lockheed Space and Missiles (Palo Alto, CA); however, each of these systems has drawbacks in terms of accuracy, temperature range, spectral range, and/or timeliness of response.

A system for obtaining elevated temperature emissivity measurements should be capable of making measurements on relatively small material samples (2 in. diameter) at temperatures up to 2000 to 5000 degrees R. Spectral measurements are required over the range from 0 to 10 microns. Emphasis should be placed on achieving isothermal material sample conditions, minimizing errors due to radiant energy loss/gain, and providing a system which is affordable and sized for use as a piece of bench equipment in an existing thermal laboratory.

The system described above may be pursued concurrently by AEDC via the Aerothermal Materials Technology Project (DC06).

AF88-023 TITLE: Cooling Tower Ice Detection Techniques

OBJECTIVE: Instrumentation needs to be developed, along with techniques for its use, that will detect ice build-up.

DESCRIPTION: AEDC currently operates a mechanically-induced draft, counterflow cooling tower. The tower is designed to handle 200,000 gpm of heated water which is distributed over eight cells. The tower support structural members are Douglas fir timbers treated with a preservative. During winter, when the ambient temperature drops below freezing, ice can form on the timbers and cause severe structural damage.

There are existing operating modes which help to prevent ice build-up but no known means of detection other than the human eye. This leaves open the possibility of human error and prohibits automation or “unmanning” of the cooling tower.

The instrumentation must be reliable and suitable for installation in an extremely wet environment. Also the number and location of sensors required for a given cell need to be determined.

AF88-024 TITLE: Nonconventional Precision Traverse System

OBJECTIVE: Develop a nonconventional, precision 3-axis traverse system to support laser velocimeter operations in the AEDC Hypersonic Tunnels B and C.

DESCRIPTION: A precision 3-axis traverse is an essential component of a laser velocimeter system. However, in Tunnels B and C, conventional, commercially available traverse systems mechanically interfere with essential tunnel structures and test monitoring equipment (schlieren system, video and film cameras, etc.). A nonconventional traverse system must be developed before the laser velocimeter test support needs of Tunnels B and C can be met. The traversing range for each axis must be: axial – 45 inches, vertical – 20 inches, and traverse – 18 inches. The load capacity must be at least 500 pounds. The position resolution for each axis must be 0.001 inch or better and the position accuracy must be +0.001 inch/inch or better.

AF88-025 TITLE: Thrust Stand Motion Visualization

OBJECTIVE: Develop an imaging system capable of visually displaying the relative movement of structural components of a thrust stand and a turbine engine.

DESCRIPTION: The system must be capable of making non-contact measurements of the planar motion of a thrust stand and associated turbine engine. The field-of-view of the system should be 10 feet, with the ability to remotely zoom-in on selected regions. Motion sensitivity should be better than 0.01 inch. The system should be complete with illumination source, video detector and image processing for enhancement and mensuration. It should be able to operate reliably in a turbine engine testing environment (i.e., it should withstand high vibration and acoustical noise levels). Continuous operation up to 12 hours without servicing is required.

AF88-026 TITLE: Remote Track Tapering

OBJECTIVE: Develop a variable taper track for high velocity testing.

DESCRIPTION: At Arnold Engineering Development Center, a 1,000 ft. long four-rail track is used for high velocity testing. The track consists of a precision bored straight 7-in. bore tube which has four orthogonal rails mounted internally to provide running surfaces for a 2.5 in. diameter model. Individual track sections are 10 ft. long, flanged and bolted together. The present rails are 0.75 in. wide mild steel tapered to 0.311 in. wide rubbing surfaces which are bolted at six-inch spacings to the tube. Between the rails the tube is isolated for instrumentation access.

For some tests, it is very desirable to taper the rails inward to make up for wear on the test model. This prevents the model bouncing around between the rails. At present, the only technique for changing rail taper is by shimming the individual bolts by hand, which is very time consuming.

The requirement to develop a technique for quickly and remotely changing the taper, initially for the last 200 ft. of travel, later the entire 1,000 ft. The track centerline must be maintained straight to 0.005 in./ft. and there must be no kinks at track joints. The track can be swung into a storage box at the side of the vacuum tank for free flight testing. The test area is temperature controlled. The track test can be evacuated to 0.1 torr and pressurized to 1300 torr. It would be preferable if the present track could be modified rather than being replaced by a variable taper track.

AF88-027 TITLE: Rocket Nozzle Position Management

OBJECTIVE: Develop a position sensing system with continuous readout of rocket nozzle position during firing.

DESCRIPTION: The system must be capable of a continuous noncontract position measurement of the rocket nozzle during firing. The working distance of the system must be at least 48” and a measuring range of at least 20” with a resolution of 0.025.” The system should be complete with position sensing head, drive electronics, data acquisition and reduction software. The sensing head must survive the environment associated with an altitude rocket test cell; i.e., high temperature, vibration and acoustical noise levels.

AF88-028 TITLE: Command, Control and Communications Systems/Subsystems

OBJECTIVE: Develop innovative concepts for Air Force Command, Control and Communications (C^3) Systems and Subsystems.

DESCRIPTION: This covers all aspects of AF C^3 systems and subsystems. Proposals may address subjects not specifically given in other SBIR topics. Proposals may be for any aspect of AF C^3 missions including: Strategic C^3; Tactical and General Purpose Forces C^3; Ballistic Missile Tactical Warning/Attack Assessment C^3; Atmospheric Surveillance and Warning; World C^3; Air Traffic Control; all AF ground based and airborne early warning systems; all communications systems; and C^3 Countermeasures and Electronic Warfare. This topic offers great flexibility to

both proposers and Air Force managers. Past submissions included: advanced communications systems concepts, data base management systems, novel information processing systems, multilevel communications security equipment, artificial intelligence applications to AF systems, air surveillance systems and target detection systems.

AF88-029 TITLE: Automated Air Traffic Control System Concepts

OBJECTIVE: Develop new concepts for safe movement of aircraft using passive identification methods and data link interchanges.

DESCRIPTION: Future air traffic control (ATC) systems will need new concepts for the safe movement of aircraft. Systems using passive identification methods and data link interchanges are possibilities. Current systems use high-power emitters (e.g. radar) for identification and active UHF/VHF radio for communication requirements. Current navigation equipment does not provide a common grid reference nor does it lend itself to long-range relative accuracy. The future system must allow for information distribution and processing flexibility and be precise enough for safe ATC operations. Potentially applicable technologies for possible interface and/or merger would be the Inertial Navigation Systems, NAVSTAR GPS, Joint Tactical Information Distribution System (JTIDS) and other related ongoing programs.

AF88-030 TITLE: HF Communication System Enhancements

OBJECTIVE: Develop Advanced HF capabilities and technologies to reduce size, weight and enhance performance of HF communications systems.

DESCRIPTION: The Air Force cannot fully use HF radio systems because of the size of associated antenna subsystems and various transmission problems brought about by use of sub-optimum length antenna elements. HF Antennas are required which conform to the physical size, shape, and space requirements of the aircraft or vehicle. These antennae need to be broadband and efficient to accommodate wide-band or fast frequency hopped HF transmissions. The optimum solution would be an antenna design capable of handling the entire HF spectrum at high efficiency levels of performance. A passive antenna design is preferred if reliability and efficiency are not substantially compromised. A lesser option, acceptable as a near-term solution might be more efficient antenna coupler that is affordable and not physically prohibitive. Current coupler technology use PIN diodes and mechanical relays for rapid switching, but these have not proven reliable or economical. A lightweight, low-volume, reliable, economical, fast hopping HF antenna coupler would enable the Air Force to immediately capitalize on the advantages of adaptive HF radio for command and control of its fighter aircraft.

AF88-031 TITLE: Advanced Technology Application for Small/Manpack UHF Satellite Terminals

OBJECTIVE: Design Concept for a new lightweight advanced technology UHF Satellite manpack terminal with DAMA 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 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. Prepare a functional description/top-level design of a new Advanced UHF Satellite Terminal incorporating the results of the device survey.

AF88-032 TITLE: Multiple Satellite System (MSS)

OBJECTIVE: Assess Multiple Satellite System (MSS) configurations in terms of their vulnerability to interference and physical attack and develop a survivable system.

DESCRIPTION: Several MSS configurations of proliferated satellites promise significant improvements in survivability and thereby play an important role in strategic communications. The vulnerability of such systems to electromagnetic interference (natural and man-made), scintillation, and physical attack require detailed quantitative situations. Proposed solutions should consider various satellite constellations with different numbers of satellites and orbits. Requirements for bandwidth and processing requirements for each case to give the required survivability must be addressed. A functional description of the system components and implementation options are required.

AF88-033 TITLE: Manufacturing Support Systems

OBJECTIVE: Manufacturing functional area support system concepts for ESD System Program Offices.

DESCRIPTION: ESD Systems Program Offices are responsible for specifying and procuring new AF systems. Increasing work loads with no increases in personnel will require new concepts for Manufacturing Support activities. Manufacturing support includes: activities to insure that quality and producibility are engineered into new designs; efforts to effect a smooth transition from design to production; and initiatives to encourage contractors to modernize their facilities. ESD has an Industrial Base Planning function to ensure that the manufacturing base is continuously upgraded. Manufacturing support is presently done on a task basis by a matrixed organization. ESD wants proposals for Manufacturing Support Systems concepts which will enable managers to properly perform manufacturing functional area support more effectively with less people. Manufacturing Support Systems concepts should provide improved management visibility into resources application and priorities, and capabilities to exploit opportunities within program resource limits. Program managers are looking for automated systems and methodologies to increase the existing manufacturing support resource base productivity.

AF88-034 TITLE: Design for Producibility Guidelines for Electronic Systems

OBJECTIVE: Develop a general set of producibility guidelines for electronic systems manufacturing.

DESCRIPTION: Electronics systems acquisition programs do not consistently emphasize producibility during the design phase. Standard producibility analysis tools are lacking, which means that no disciplined and institutionalized approach is possible during systems acquisitions. ESD wants proposals for developing a set of design-for-producibility tools and guidelines for electronics systems. The guidelines will cover all levels of electronic system interconnection: base materials, bare boards, board assemblies, connectors, wire and cable harnesses, racks, chassis, cabinets, and peripheral assemblies. The guidelines will include good manufacturability, testability, inspectability and maintainability practices. Electronic equipment manufacturers will use the guidelines for in-house design practices. Electronics systems customers will use the guidelines for evaluating contractor performance. The guidelines will incorporate relevant parameters from applicable military specifications and standards. Guidelines will be published in both hard copy handbook and computer software (preferably d-BASE III) versions. Guidelines must have a continuous updating capability, preferably through a subscription service. The updating feature will account for changes in the state of the manufacturing art with new materials, manufacturing, test and inspection equipment techniques.

AF88-035 TITLE: Measuring Expert Systems: The Process and the Product

OBJECTIVE: Define requirements for measuring quality of expert systems. Provide models and methodologies for assessing expert systems and their products.

DESCRIPTION: The Air Force is keenly interested in the application of knowledge-based expert systems in order to increase the automation of the specification, design, implementation, testing and validation processes. However, the development of knowledge-based expert systems may not conform to the phases in the development life cycle as described in DOD-STD-2167. Furthermore, there is no agreed upon or fully developed methodology for assessing expert system attributes and quality. Prior work at RADC has resulted in the development of the Software Quality Specification Guidebooks (RADC-TR-85-37) and an Automated Measurement System. A model describing the procedural development and assessment of expert systems is required. This model is to indicate milestones in the

development of a typical expert system. Points in the development where both formal and informal reviews should take place are clearly mapped out along with methods for how these reviews are to be performed. Also to be included are a group of qualitative and/or quantitative indicators of deficiencies or superiority in measured performance for each phase of development. Ideas to be explored include: incremental development of a system via refinement or rapid prototyping, specifying requirements, and cataloging inference rules. Phase I products: A Technical Report will be delivered which defines a strategy for assessing the quality of expert systems, identification of attributes for measurement, and a plan for continued research and development for measuring expert system development, performance, and behavior. Phase II products: In phase II, selected indicators may be developed and a feasibility analysis and/or demonstration conducted.

AF88-036 TITLE: Language Sensitive Quality Indicator

OBJECTIVE: Develop a software tool capable of assessing, in near real time, the realization of established software quality goals.

DESCRIPTION: Current software development practices generally consist of developing various software products such as requirements and design documents, and code, and then performing tests on the products as they are completed. The results of these tests then provide information concerning product quality. The problem with this approach (produce a product then review) is that the initial quality assessment is not obtained until the product is fairly complete. If, at the end of each software life cycle phase, the quality of the product is poor the additional expense of reworking the product becomes necessary. The result is a potential impact in cost and schedule. The technical challenge of this effort is to provide the capability to interactively measure product quality as it is being developed, provide appropriate feedback to the user, and advise the user how to improve the product quality. This interactive tool would, in a manner similar to an editor, display the current quality level as the language source is being developed. The tool should provide analysis of both the syntax and semantics of the languages in which the software products are specified. Consideration should be given to all languages used in developing life cycle products, including requirements languages, design languages, and code. The language sensitive quality indicator should: -- provide for user selectable levels of quality feedback and advice regarding how to achieve high software quality such that the user cab specify the amount of quality “help” desired. – provide composite quality analysis collected from individual software life cycle products. – provide as a minimum an analysis of source language complexity, coupling, and completeness. – be capable of integration with a life cycle software engineering environment. – be expandable for future enhancements. – exhibit acceptable performance and not negatively impact the software development process. Phase I products: Technical Report Software Requirements Specification (DOD-STD-2167/DI-MCCR-80025) – Software Development Plan (DOD-STD-2167/DI-MCCR-80030). Phase II products: Software Top Level Design Document (DOD-STD-2167/DI-MCCR-80012) – Software Detailed Design Document (DOD-STD-2167/DI-MCCR-80019) – Prototype Language Sensitive Quality Indicator

AF88-037 TITLE: Knowledge Based Decision Analytic Structure for Decision Aiding

OBJECTIVE: Combine best features of multiple techniques for decision aid design.

DESCRIPTION: Early effort to improve Air Force Command and Control system capabilities through the development of decision aids, centered primarily upon decision analytic technology. As artificial intelligence gained favor, numerous expert system based aids were developed. It has become clear that each approach has its advantages and disadvantages and that the best approach may be to define a structure based on the best features of both approaches. Research is sought under a Phase I effort to systematically examine this issue and define an approach for validating a multi facetted solution. Phase II shall demonstrate a structure or architecture which will support the multiple technology approach to the development of decision aiding.

AF88-038 TITLE: Support for Persistent Objects in a Distributed Software Environment

OBJECTIVE: Develop a system which will support software development objects (i.e., specification , requirement, code, etc.) in a distributed environment.

DESCRIPTION: The goal of this effort is to address the unique problems associated with distributed software development. In particular, what are the unique demands on the knowledge representation of persistent software development objects (i.e., specification, requirement, code, test, documentation, etc.) when the development takes place in a distributed environment. The most apparent problem is the dynamic data base. The contractor will explore mechanisms which will preserve the correctness and currency of the object base. Due to the nature of software development a special case solution to the general dynamic data base problem will be found. Phase I will consist of a description of how a distributed persistent object base would be implemented. Phase II will consist of an actual implementation.

AF88-039 TITLE: Verification and Validation of AI Software

OBJECTIVE: Identify methods for verification and validation of AI software to be used for systems acquisitions within the Air Force.

DESCRIPTION: Verification and validation (V&V) techniques for conventional software exist and are currently used for Air Force system acquisitions. Artificial Intelligence software is now becoming an important technology for new system components that will be integrated with conventional software into future systems. However, no techniques exist to verify and validate AI software. V & V methods are needed to provide high confidence in the reliability of AI software without seriously compromising the powerful development environments and productivity of AI software developers. Phase I will categorize types of AI software and identify potential V & V sources; select V & V activities and analyze their applicability to the AI software development environment; and document the results. Phase II will analyze the human V & V activities that may be implemented in AI software and incorporated in the development environment; develop alternative software development models that incorporate V & V and analyze their impact on the development methodology, cost, and expected reliability of AI systems; and recommend V & V model, define and perform an experiment that would demonstrate its effectiveness.

AF88-040 TITLE: Three-Dimensional Displays

OBJECTIVE: Develop three-dimensional stereoscopic and/or holographic display technology for battle management.

DESCRIPTION: Current off-the-shelf display technology is limited to two-dimensional high resolution graphics. In a battle management environment, it is necessary to display three-dimensional data, such as maps with terrain features in 3-D and battle situations with air and ground forces in the proper 3-D relationships. It must also be possible to include animation in the displays. The object is not to produce a 3-D photograph of the battlefield, but to create a graphic representation of the battle from which the commander can quickly gain an understanding of the current situation. Color coding and representation of items such as roads, rivers, forest, and military units should be considered in the displays. Phase I should produce a thorough report that proposes innovative techniques for portraying 3-D information in a realistic way. Included in the report will be an approach to be taken for the production of a 3-D stereoscopic and/or holographic display system prototype to be implemented in Phase II. Phase II should deliver a prototype of a high resolution 3-D display system with animation included. Proposals should consider implementation issues associated with both stereoscopic and holographic displays. For prototype development the proposal may select and focus on either stereoscopic or holographic technology.

AF88-041 TITLE: Light Weight Tactical Tower

OBJECTIVE: Design and develop a light weight, high stability tactical tower to support radio systems.

DESCRIPTION: Tactical towers are required for the rapid deployment and reconfiguration of LOS millimeter wave radio systems to support military communications networks. These towers must be very mobile and require minimal time and space to erect. Furthermore, since millimeter wave radios utilize very narrow beamwidths for covertness and power efficiency, these towers must be very stable under wind loading so that the communications link doesn't

become misaligned. The tactical towers which are currently available are quite bulky and require guy wires to prevent twist and sway effects. The goal of this effort shall be to design and develop a compact, light-weight tactical tower which can be easily pulled behind a small vehicle such as a jeep, and which can be quickly erected to provide a stable platform for millimeter wave radios. The desired end product of Phase I will be a detailed design and analysis for the tactical tower. The desired end product of Phase II will be a prototype tower constructed from ultra-light, ultra-strong materials such as carbon fiber composites. The tower shall be erectable to a maximum height of 100 feet and shall remain stable without the use of guy wires while carrying a load of 200 lbs under a range of wind loading conditions. The tower shall be tested using RADC radios at a test range near Griffiss AFB NY.

AF88-042 TITLE: Terahertz Technology

OBJECTIVE: Innovative Research in Superconductive Materials, Components and Terahertz Radar and Communication System Technology.

DESCRIPTION: Active/Passive detection, tracking and imaging systems, along with communication systems, operating in the terahertz frequency regime offer many advantages over those in the lower microwave or higher optical frequency regime. Superconductivity, especially with the dramatic discovery of new high critical temperature materials, will provide the means to develop these systems. Innovative research proposals for the development of superconductive materials and components for the generation, transmission and reception of energy in the vicinity of one terahertz are desired. Analog signal processors are required along with preprocessors to interface between the hyper speed superconducting analog domain and the more conventional high speed digital domain where imaging, detection, and discrimination are accomplished. Proposals for higher speed analog to digital converters and digital signal processors are also solicited. Proposals leading towards the application of superconductive electronics to active or passive surveillance, detection, discrimination and communication systems operating at sub-millimeter wavelengths are also sought. A Phase I contract will involve analysis of the theoretical background and preliminary experiments and test to demonstrate the technical feasibility of the proposed development concept. The Phase I report will clearly present the study results, evaluate benefits and inherent risks, and detail the procedures required to make the proposed concept work. Based on the Phase I work, the Phase II contract will require the development, testing, analysis and conclusive proof of the concept.

AF88-043 TITLE: Thin Film Permanent Magnets

OBJECTIVE: Develop thin film permanent magnet capability for biasing magnetostatic waves (MSW) delay lines and ferrite phase shifters.

DESCRIPTION: Present MSW delay lines are magnetically biased using large, inefficient permanent magnet structures. New design criteria and techniques are required to provide miniature and lightweight magnetic biasing fields for microwave/millimeter magnetic devices. Factors such as magnetic bias filed uniformity, elimination of undesirable magnetic flux leakage, field orientations for generating the three pure MSW modes in yttrium iron garnet (YIG) films, plating of permanent magnet films with conductors/superconductors to prevent RF fields from entering the films, and temperature sensitivity are to be considered. High field strength magnets, such as those provided by SmCo5 and Nd2Fe14B, are to be incorporated in the program. Provide a laboratory demonstration using the film magnets in a complete MSW delay line. Phase I: Investigate magnetic and physical characteristics of state-of-the-art high field strength thin film, 5-50um, permanent magnets of SmCo5 and Nd2Fe14B, and other related rare earth magnets. Phase II: Fabricate high field strength thin film permanent magnets, 1-5 sq.cm. on various substrates which are used in microwave/millimeter wave devices. Films are to be magnetized both perpendicular and in plane. Provide demonstration of self-contained MSW delay line.

AF88-044 TITLE: Adaptive Array Near-Field Measurement Technique

OBJECTIVE: Develop a near-field measurement technique for characterizing adaptive array antennas.

DESCRIPTION: Adaptive array antennas are vital to cope with intensive jamming environments. Determination of the adaptive performance of an array antenna by illuminating it with multiple, mobile jammers at an outdoors antenna range is both time consuming and costly. Hence, it is important to develop a new technique for determining the far-field properties of an adaptive array antenna (e.g., null depth, pattern response to platform and jammer dynamics, loss of main beam gain, efficiency of adaptive algorithms) from measurements taken in an anechoic chamber using near field jammers. Such techniques should allow for efficient data collection and calculation of the predicted far field adaptive properties of the antenna. The goal of Phase I will be the design of a near-field adaptive measurement facility and the development of methods for predicting the far-field response from the near-field measurements. Phase II should result in the actual construction and testing of a new-field adaptive array measurement facility in an anechoic chamber, the development of computer software to RADC. For the purpose of sizing the problem, all efforts should consider an antenna of the order of an 80 element S-band phased array.

AF88-045 TITLE: Epitaxial InP Based Materials on Silicon

OBJECTIVE: Develop epitaxial technology for and deliver device quality Indium Phosphide based alloys grown on silicon.

DESCRIPTION: Heteroepitaxial growth of III-V semiconductors on silicon has recently attracted much attention. The possibility of combining sophisticated silicon integrated circuit technology with the inherent high speed and optoelectronic capability of the III-V's is especially attractive. In addition high quality silicon substrates are readily available at low cost with diameters that range up to ten inches. III-V substrates on the other hand are expensive, have orders of magnitude more defects, are limited to small diameter (2 or 3 inches) and are extremely fragile. Most of the recent research in this area is concentrated on the growth of GaAs on silicon. InP based alloys however have a high payoff potential for Air Force Photonic, Forecast II and space based applications such as MILSTAR and SDI. The higher speed and power advantage of InP based alloys over GaAs microwave and millimeter wave applications has long been recognized by the scientific community. Recent advances have demonstrated actual devices that outperform their GaAs counterparts. In the photonics area InP alloys provide 1.3 and 1.55 micron laser diodes that can be directly modulated at high frequency as well as detectors for fiber optic communication systems. The present quality of the available substrates restricts the potential of all of these InP based devices. The nonavailability of large diameter substrates further limits large scale integration of these technologies for microwave or photonic applications. This program contemplates the development of an epitaxial technology that can provide device quality indium phosphide based alloys on silicon. This technology will provide a low cost, stable, high quality platform for the purpose of medium and large scale integration of photonic, electronic, microwave, millimeter wave and electro-optic waveguide devices and functions. Phase efforts will involve modeling and initial attempts at proposed growth techniques. Proving the viability of a technique should the primary goal however, testing and delivery of actual epitaxial layers is highly desirable. Phase II will involve refinement of the technology and delivery of a variety of characterized epitaxial layers grown on silicon. In addition experimental devices such as laser diodes, photodetectors, and FET's will be fabricated in the epitaxial layers as a means to test the quality and efficiency of the technology.

AF88-046 TITLE: Ultrastructures for Cold Cathode Emitters

OBJECTIVE: Chose material systems that are thermodynamically compatible, and process the ultrastructures to limit high field breakdown electromigration and oxide diffusion during operation.

DESCRIPTION: High power radar signal generation is limited by current vacuum tube technology. Klystron tubes operating at high voltages and temperatures have unacceptable operating lifetime. Operation at lower temperatures and voltages will increase the lifetime, reliability and cost effectiveness of Air Force radar establishments. Alternating layers of refractory metals and insulators with nanoscale thickness can now be processed in macroscopic dimensions. This Ultrastructure technology has direct application for cold cathode research. Nanometer thick metallic layers with low work functions will be isolated by micron thick insulating layers to provide geometric enhancement of the near surface electric fields. Phase I will be devoted to choosing a favorable materials system and optimizing deposition parameters to achieve abrupt layer structures. The ultrastructures will be fabricated into a vacuum tube assembly and treated for critical current densities. Phase II efforts will be directed towards optimizing

the layer thicknesses and compositions to achieve very high current densities at low temperature and low applied voltage. The successful structures will be fabricated into an operational Klystron tube for field testing.

AF88-047 TITLE: Advanced Packaging Techniques for Optoelectronic Devices

OBJECTIVE: Seeks innovative solutions to contacting problems. Responses must address the contact metallurgy as well as processing concepts. Contact area must be reduced in size and the contacting probe must be controllable at low applied pressure.

DESCRIPTION: Contact Lead Technology developed in the silicon industry is inadequate for contacting III-V compound devices. Forces applied by soldering arms are sufficient to cause damage in these softer materials systems. High frequency operation is currently limited by the size and electrical characteristics of contacts formed by ball or wedge bonding. Low temperature operation and repeated thermal cycling to room temperature degrade device performance due to fatigue of the contact. Phase I should demonstrate a technology to reduce the size of bonds to less than 15 sq um with significant reduction in temperature and pressure. With the growing number of leads required by new chips, speed is also important. Phase II should emphasize an order of magnitude increase in speed over present technology, along with a continued reduction of contact area to less than 10 sq um.

AF88-048 TITLE: Fabrication of High Temperature Superconducting Oxides

OBJECTIVE: Produce bulk homogenous oxides which exhibit a superconducting transition temperature of at least 100 K.

DESCRIPTION: Very recently superconducting oxides which exhibit a transition of temperature above 90 K have been discovered. In order for these materials to be used for the fabrication of thin film devices, it is necessary to first obtain homogenous oxides in bulk form. (To date, these materials have been composed of yttrium-barium-lanthanide oxides combined with copper oxide.) Initially under Phase I it will be necessary to determine the proper composition and preparation techniques required to produce superconducting oxides which exhibit zero resistance below 100 K. Having demonstrated the ability to produce these materials under Phase I, the Phase II goal would be to find ways to produce and deliver large quantities in the form of discs, rods and powders.

AF88-049 TITLE: Optically Addressed Modulator Materials

OBJECTIVE: Develop materials to improve performance of electro-optics devices, (speed, spatial resolution, uniformity, robustness, price of non-linear or electro-optic materials).

DESCRIPTION: Significant advances are required in the development of real-time optically addressed two-dimensional spatial light modulator materials for use in directing and modulating light for designing and implementing optical signal processing, optical computing, optical interconnect, and optical interface technologies. Phase I: Concentrate this effort on the growth and preparation of 1) a bulk material with a large effective third-order nonlinear optical susceptibility, 2) a thin material sample with a large index of refraction change resulting from an available photogenerated physical process separate from the material or at the surface of the sample, and 3) a material capable of operating in both the bulk Bragg diffraction and the longitudinal thin phase-modulation modes described above. These initial material samples should be of high optical quality and potentially meet the Phase II specifications. Phase II: Material samples produced in this phase will be optimized for optically addressed two-dimensional spatial light modulators meeting or exceeding the following specifications: a response time of 1 ms at a total optical power density of 1 efficiency of 1% (or a capability of half wave modulation) in the response time with a spatial uniformity over the full aperture of +/- 10%, a volume of 1cmx1cmx1cm for the bulk sample, and incident area of 1cmx1cm and thickness of less than 0.1 mm for the thin samples, cascadeable operation, and robust physical and optical operation. The offeror should have in-house facilities for the material growth.

AF88-050 TITLE: Read/Write/Erase Optical Materials

OBJECTIVE: Develop new materials for optical disk that exhibit extremely superior performance.

DESCRIPTION: Currently, three different types of materials are being developed for read/write/erase optical disk: magneto-optic, phase change, and dye polymer. Each of these materials has its own drawbacks that have prevented erasable optical disk from moving quickly into the marketplace. Magneto-optic materials have very low signal levels that make tracking difficult; phase change materials have stability and lifetime limitations; dye polymer materials have stability and reflectivity problems. It is desired to find materials with optical/electronic properties that have the potential for performance that is superior to current read/write/erase materials. The material should have the potential for: high carrier-to-noise ratio (greater than 50db), long retention (greater than 60 days), long cycle lifetime (greater than one million), and fast response time (less than .5 microsecond). Phase I should include an investigation to prove the feasibility of the material for optical storage. Phase II should include fabrication of optical disks and both static and dynamic tests of disk performance.

AF88-051 TITLE: High Data Rate Optical Head

OBJECTIVE: Develop innovative concepts for lightweight optical heads that provide multiple data channels.

DESCRIPTION: Optical disk technology has demonstrated the potential for very high data capacities and write once systems are now commercially available. Optical disk also has the potential to support very high data rates, utilizing the multiple input and output channels possible with optics. This project seeks to develop innovative concepts for lightweight optical heads that support parallel data channels and can focus to spot sizes of one micron or less. Possible approaches include holographic optical heads and fiber optic heads. Phase I will provide proof of concept feasibility, and Phase II will provide design, fabrication and demonstration of an optical head.

AF88-052 TITLE: Neural Network Applications

OBJECTIVE: Identify, develop, and demonstrate neural network techniques potentially useful for digital image processing and image understanding.

DESCRIPTION: Recently, there has been a renewed interest by university, industry, and Government in neural network technology. Researchers have proposed important, potential applications for these networks in such areas as data compression, image processing, image understanding, and speech recognition. However, because of the dynamic nature of this technology, it is difficult to assess the extent and value of neural network research to date. This effort seeks to assess the current status of neural network research and to identify and develop those techniques with potential image processing and surveying the field of neural network technology and identifying specific neural network techniques with potential image processing and image understanding applications. Simple proof-of-concept demonstrations of these techniques is desireable. For Phase II, a subset of these techniques should be refined and applied to the problem of automated target recognition in digital imagery. The end product should be a software package which incorporates these techniques in an automated target recognition paradigm.

AF88-053 TITLE: Membrane Mirror Instability

OBJECTIVE: Develop a method of overcoming the demonstrated instability of membrane mirrors used in wavefront correctors.

DESCRIPTION: Membrane mirrors for use as wavefront correctors exhibit an inherent instability which precludes scaling the mirror to the future SDI requirements of 10,000 to 100,000 actuator systems. A recent optimization study concluded that the maximum number of actuators for a stable system in vacuum was 392 actuators in a circular boron nitride membrane of 79mm radius. This doesn’t approach the specified requirement. This effort would study and analyze alternatives to the above approach including, but certainly not limited to, investigations of alternate membrane materials, fluid or gaseous media, or different optimizations to achieve the desired final mirror

characteristics. Phase I would study several alternatives and Phase II would expand on these and perhaps other alternatives or, depending on the success of Phase I, fabricate a model to demonstrate proof-of-concept.

AF88-054 TITLE: Environmental Extreme Recorder

OBJECTIVE: Build an unpowered, small, convenient-to-use recorder of temperature, humidity and vibration.

DESCRIPTION: Data on environmental extremes only is not as good as a complete record of environmental values, but would be valuable when the other could not be obtained. The proposed card would be small enough to be used almost anywhere in almost any conditions. A card would be built which is less than 2" x 1" x 1/16" which could be attached to equipment. This card would be a totally passive device which would record approximately the highest temperature, humidity, and acceleration to which the card has been subjected. For example, there are "paints" which change color at a well defined temperature. If a series of spots of such paints (each for a different temperature) were printed along the side of the card, the last spot which changed color would be an indication of the higher temperature. It should be possible to use a paint or varnish which would discolor, or change color, with humidity. Unfortunately, temperature might affect this. Acceleration is more difficult. Several devices have been suggested, but none appears satisfactory. For a slightly thicker card, several methods could be used. Several hundred would have to be built on this contract. Phase I would be a study effort, mainly to determine if the card can be built within the space constraints. There are AF temperature decals which record temperature. There is a plug used to record humidity, and there are one shot shock detectors. Phase II would be construction of a number of the cards.

AF88-055 TITLE: Development of New Technique to Prepare the Semiconductor Material – In0.5Ga0.47As

OBJECTIVE: Preparation of Epitaxial Layers

DESCRIPTION: Epitaxial layers of In0.5Ga0.47As have electrical properties which make them important materials for microwave and optoelectronic devices. InGaAs epitaxial layers can be grown by a number of techniques, e.g., LPE, MBE, MOCVD and VPE. A new variation of the VPE-hydride technique has been discovered where an alloy source is used with hydrogen chloride added to the mixing zone. This discovery has been described in the Journal of Crystal Growth, vol. 71, pages 246-248 (1985). The results show that the ternary, In0.13Ga0.87As, is formed exclusively using an alloy source containing 88.2 mole % indium and 11.8 mole % gallium. The objective of Phase I of this project is to see whether the ternary, In0.53Ga0.47As, can be formed exclusively using alloy sources containing less gallium. The concentration of hydrogen chloride in the mixing zone is a critical parameter. The epitaxial layers will be grown on Indium Phosphide substrates. Phase II of the project has two objectives: 1. Characterization of the epitaxial layers, e.g., carrier concentrations, mobilities, impurities, interfaces, etc. 2. Scale-up method for mass production of InGaAs Layers.

AF88-056 TITLE: Low Back Pressure Nozzle

OBJECTIVE: Design, construct, and test a fire fighting handline nozzle with low reaction forces.

DESCRIPTION: Low reaction force nozzle designs have not been incorporated into fire fighting handline nozzles. The resulting nozzle reaction forces that are experienced over time at structural fires create tiring, unsafe conditions for firefighters. Current practice involves spiraling hoselines, standing on them, and using multiple fire fighters to control thrust at nozzle grips. Hydraulic theories can be applied to alter handline nozzle hydraulics. The concept of counteracting flow forces via external pipe bends for monitors cab be applied to bend the flow inside a handline nozzle because of the smaller dimensions. Flow force neutralization by changing internal nozzle design to employ proven pipe bend concepts may significantly reduce the nozzle reaction force. The Phase I effort is to design a low force nozzle technique which is compacted to occur within the nozzle, prototype development, and field testing of the nozzle using a 2 ½ inch hoseline.

AF88-057 TITLE: Shelter – Highly Erectable Dome

OBJECTIVE: Investigate lightweight, easily erectable weather shelters to be used for aircraft maintenance on the flightline.

DESCRIPTION: Because of the harsh environments (temperature, wind, and precipitation) experienced at various Air Force bases, there is a need for air mobile (C-130) lightweight, easily erectable shelters. These shelters would allow quick maintenance turn arounds and rapid munitions loading. A shelter must be large enough to cover one aircraft such as the A-10, F-15, and F-16, as well as munitions loading equipment. It must provide protection to ground personnel from temperature extremes (-50° to $+120^{o}$F), precipitation, and wind. Wind loads will be specified by the Air Force before starting Phase I work. The Phase I effort shall provide a review and analysis of existing shelter structures and materials, and mobile heating/cooling systems. Should no existing shelter hardware provide satisfactory performance, the Phase I effort shall also provide preliminary design of new shelter, complete with heating, cooling, and appropriate utilities. Emphasis must be placed on lightweight, mobile shelter systems. While heat must be provided under extreme cold conditions, cooling and/or shade can be provided in a number of ways in high temperature conditions. Phase II work would involve fabrication and testing of the recommended shelter system(s) under actual field conditions.

AF88-058 TITLE: Reactive Protection for Hardened Facilities

OBJECTIVE: To determine the feasibility of adapting reactive armor concepts for protective facility construction.

DESCRIPTION: Substantial work has been accomplished to develop reactive armor technologies for military equipment. As aerial weapon delivery systems become more accurate, conventional munitions can directly impact fixed facilities more readily. Passive defense systems (rock rubble, concrete burster slabs, etc.) will eventually become uneconomical because of the mass required to defeat large munitions. The Phase I effort shall investigate the feasibility of developing reactive protection to defeat general purpose bombs, kinetic energy penetrators, etc. as specified by the Air Force, impacting on fixed facilities. The feasibility study must be thorough, including safety implications, effects on underlying primary structures, and approximate costs of reactive systems. The feasibility study shall result in a matrix of recommended concepts that might be pursued in Phase II effort. The different concepts will address the specified weapons. A possible Phase II effort would involve designing full- and small-scale test prototype for explosives effect testing.

AF88-059 TITLE: Small Crater Bridging Material

OBJECTIVE: Develop an airfield pavement crater repair system that bridges craters and does not require crater fill.

DESCRIPTION: Air Force rapid runway repair procedures must address small bomb craters from 6-10 feet in diameter with little upheaval. Composite material technology may offer a means to develop a repair system that can be used to bridge such small craters. The maximum wheel load would be 325,000 pounds for cargo aircraft and 45,000 pounds for fighter aircraft. The thickness of such bridging cannot exceed ¾ inch. The bridging system shall also incorporate a means to anchor to Portland cement concrete (PCC) and PCC with asphalt overlay. The bridging material shall be able to withstand loading throughout the full range of aircraft operations. The Phase I effort shall address system design and proposed prototype development and test plans.

AF88-060 TITLE: Disposal of Chemotherapeutic Agent – Contaminated Waste

OBJECTIVE: Develop safe, economical methods to dispose of chemotherapeutic wastes.

DESCRIPTION: Air Force regional medical centers world-wide generate annually about 100 50-gallon drums of syringes, tubing, bottles, gowns, and rags contaminated with small quantities of chemotherapeutic agents classified as carcinogenic, mutagenic, or teratogenic drugs. A Phase I engineering feasibility study should result in recommendations to include a prioritized list of disposal methods for implementation either at each site or at a

central disposal site. It should also include recommendations for actual tests for Phase II study. A Phase II study, if approved, will include laboratory bench-scale or pilot testing of recommended methods for the disposal of actual waste. The study should resulting the estimation of environmental quality effects when such methods are implemented. A list of chemotherapeutic agents for study are: metronidazole; nitrofuratoin; isoniazid; furosemide; acetozolamides; 4-aminobiphenyl; chlorambucil; cyclophosphamide; daunomycin; 3 3-dichlorobenzidine; ethylene thiourea; mechlorethamine hydrochloride; alpha-naphthalamine; streptozocin; o-tolidine dihydrochloride.

AF88-061 TITLE: Aromatic Hydrocarbon Optorode Development

OBJECTIVE: To develop a fiber optic optrode to detect aromatic hydrocarbons.

DESCRIPTION: Remote fiber spectroscopy coupled with fiber optic chemical sensors has shown promise for groundwater monitoring. The major advantages of fiber optic methods are that they allow in situ, real time analysis versus "grab sampling" with later laboratory analysis. The current methods rely on costly sampling and analytical procedures. Current sampling methods are subject to mislabeling, sample loss, and other handling, storage, and administrative errors. Sample degradation and correlation of laboratory measurements to actual in-place groundwater contaminant levels presents problems. The Air Force's greatest monitoring requirements will center around fuel storage and conveyance facilities, and past spill sites. This requirement presents the need for an optrode to detect aromatic hydrocarbons such as benzene, toluene, and xylene in the one to ten parts-per-billion range. Cost savings will result because simpler monitoring wells can be utilized, reducing operations and maintenance requirements, and decreased manning and technical expertise for monitoring and analysis.

AF88-062 TITLE: Minimization of NO_x Emissions From Existing Fixed Sources

OBJECTIVE: Develop a method to remove NO_x from gases exhausted by incinerators and jet engine test cells.

DESCRIPTION: Combustion, particularly at high temperatures for extended periods of time, as required to completely destroy refractory organic materials, generates oxides of nitrogen (NO_x). Modifications to the incineration process would be expected to compromise accomplishments of the design purpose. Incinerators and jet engine test cells are stationary sources and are subject to NO_x emissions regulation. Modifications would not be considered to jet engines which are optimized for performance. A second-stage treatment is an obvious possibility, subject to limitations that it may not alter significantly the performance of the fixed source, it must be affordable, and it may not introduce other pollutants. The Phase I product shall be a complete design of the control method(s), and the Phase II product shall be a bench-scale (or larger) working prototype(s).

AF88-063 TITLE: Human Systems/Subsystems Research

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

DESCRIPTION: This topic is intended to provide an opportunity for the proposer to submit ideas directed toward enhancing man's capability to function effectively and safely as an integral part of Air Force systems and military operations with the overall objective of increasing mission success. This general area includes: Human factors engineering, such as methods of improving man/machine interfaces or enhancing human physical or cognitive performance; personnel interfaces or enhancing human physical or cognitive performance; personnel protection/life support, such as life support and crew escape from a transatmospheric vehicle, Chemical warfare defense, such as advanced personal and collective protective equipment; Occupational/Environmental Hazards, such as identification of and protection of toxic materials and electromagnetic or ionizing radiations; and Personnel Training and stimulation, 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. Areas of special interest include computer-based training or training management, automated job performance aids, and applications of biotechnology to solve human-related concerns.

AF88-064 TITLE: Intelligent Tools for Intelligent Tutorial Systems

OBJECTIVE: Design and code an ATN-similar NLP interface for an intelligent tutorial systems.

DESCRIPTION: This effort should consist of the design and implementation of at least one tool that may serve as an intelligent interface for an intelligent tutorial system. Design and implementation may consist of the construction of an augmented transition network suitable for a first pass-parser on a query related system, such as a query on a database using natural language technique. In Phase I, the intelligent interface should be able to handle all types of relative clauses, embedded clauses, adjectives, complementizers, multiple prepositional phrases, pronouns, gerunds, present participles, and auxiliaries. The interface should also possess the capability to handle the following: sentences with an unusual grammatical sequence; adverbs occurring at any point within the sentence; gerundive clauses and gerunds; and extensive verb phrases with multiple clauses, compound adjectives, nouns, verbs, and compound sentences. In Phase I, the intelligent interface tool should be incorporated within an Air Force instructional domain such as fix-to-fix instruction within aerial navigation instruction. English sentences should be passed through a parser, a parse-tree translator, and a CD similar translator in an attempt to develop CD similar forms. Such semantic representations must be susceptible to modification so that they could readily be used in an attempt to construct a tutorial component for this domain.

AF88-065 TITLE: Human-System Interfaces

OBJECTIVE: Develop innovative concepts, principles and mechanisms for effectively integrating crew capabilities into advanced military systems.

DESCRIPTION: The crew station design problem is becoming more complex. With the mergence of digital avionics systems, artificial intelligence echnologies, and advances in sensors, communications and weaponry, crews of military systems can be overwhelmed by massive amounts of data. While advances in virtual display technologies proposed for integration into future systems endorsed by the Air Force's recent planning exercise, Project Forecast II, promise to alleviate the information overload problems, much remains to be done in the human engineering area. Programs in the following areas are of special interest: Situation awareness: Metrics and measurement techniques are needed for assessing the effectiveness of human-machine interface technology. The metrics should be empirically derived and must be appropriate for assessing the adequacy of human-machine coupling alternatives including virtual displays. Information coding principles: There is an interest in human-machine interface design based on the principles of icons and flow fields which convey properties of dynamic activities entailed in relevant environmental vents (external or internal to the system). This requires the application of knowledge and principles of Event Psychology. The challenge is to develop information codes which support a high degree of situation awareness despite momentary shifts in the man-in-the-loop simulations is desirable. Operator state feedback: Digital systems architectures currently permit measurements of hardware states and operator interactions hardware. New interface technologies, such as virtual display systems, will record data on hand, eye and head movements. Technology for non-invasive sensing of physiological signals is progressing. Now there is a need for algorithms, software and hardware to close the loop between system hardware states and human operator states in the operational environment. Automated analysis of physiological data in the presence of artifacts is challenging. Innovative techniques, rugged miniaturized hardware and automated analysis algorithms must be developed. Feasibility demonstrations and prototyping will be required. Hyper-media integration: There is a press for effective integration of multi-media information types in battle management and command-control-communication workstations. The application of virtual display concepts is anticipated. Information media include computer, text, stereo sound, optical-video-discs, etc. The challenge is to link the media via a relational database supportive of efficient extraction of meaningful information, in a timely manner, from a vast amount of data. Design approaches must be developed and demonstrated.

AF88-066 TITLE: Gaseous Oxygen Sensor for On-Board Aircraft Use

OBJECTIVE: Provide a reliable, maintenance-free oxygen breathing gas sensor for on-board oxygen generating systems.

DESCRIPTION: The USAF School of Aerospace Medicine is constantly looking for new and innovative ideas/techniques for biotechnology research and development whose objective is to provide a reliable, maintenance-free oxygen breathing gas sensor for on-board oxygen generating systems. This technology would enhance the current use of on-board oxygen generating systems (OBOGS) by providing an oxygen sensor small in size and power requirements, insensitive to pressure and temperature changes, not affected by acceleration, and yet provide a rapid and accurate analysis for the breathing gas produced by an OBOGS as well as controlling the OBOGS concentration. Phase I research will conclude with the report that specifically addresses the feasibility and merit of the selected approach. Phase II will conclude with a laboratory working breadboard system that will clearly demonstrate the power requirements, sensitivity, linearity, and the effects of temperature, pressure (altitude) and acceleration. These demonstrations will be required in the altitude chambers at Brooks AFB Texas.

AF88-067 TITLE: Flight Instructor Tutor

OBJECTIVE: To develop a computer-based elementary flight instruction tutor.

DESCRIPTION: Most Air Force specialties require the acquisition of complex skills which go beyond the learning of facts and concepts. The acquisition of most complex skills typically proceeds through three stages: a declarative stage in which the learner acquires the basic concepts and principles underlying skilled performance; a procedural stage in which the declarative knowledge becomes compiled into a more easily applied form and errors in the initial understanding of the task are gradually detected and eliminated through practice; and an autonomous stage in which task performance gradually becomes more refined, faster, and less attention-demanding with continued practice. The purpose of this proposed effort would be to develop an elementary flight instruction tutor which would teach some basic flying procedures in the context of a four-hour computer-based instructional lesson. The tutor should teach a subset of the basic concepts and principles of flying (declarative stage) and then provide the opportunity to practice the application of these in the flight simulator component of the tutor (procedural stage). The tutor should be designed to assess the learner's knowledge and skill levels at several points in the learning process. The delivery system for the tutor would be a Zenith 248 (IBM compatible) with an EGA color graphics board monitor, 20 megabyte hard disk, math co-processor, and 640K RAM plus 2 megabyte extended memory. Phase I of this effort would be used to demonstrate the proposed tutor's feasibility through construction of a 30-minute version which would include some instruction at both the declarative and procedural stages of learning. The tutor will be used to generate interim criteria for validating experimental test batteries. Phase II would produce a validated four-hour tutor.

AF88-068 TITLE: Electromagnetic Transient & Pulse Propagation in Complex Media

OBJECTIVE: To calculate how radar pulses more through the human body and other related materials.

DESCRIPTION: Electromagnetic radiation from radar and communication systems may penetrate the living body and deposit electromechanical or thermal energy. Penetration of transient or pulsed fields will be strongly dependent on the electrical properties (dielectric constant and conductivity) of living tissue, and these properties need to be measured over a broad range of field frequencies and field strengths in order to calculate electromagnetic energy deposition. The desired apparatus and analytical approach will measure dielectric constants and conductivities of tissue as functions of field strength and field frequency and shall be able to detect and characterize nonlocal effects (spatial dispersion). Nonlocal effects refer to the case wherein polarization at a point in the medium is determined by the exciting field as it exists in a neighborhood (or area) around the specific point. Phase I of this effort should develop an apparatus design, with complete theoretical treatment. Phase II of this effort should provide construction and use of the apparatus.

AF88-069 TITLE: Biohazards Associated with Biologically-Engineered Polymers

OBJECTIVE: Develop screening methods to assess toxicity of intermediates and final products related to polymer formation.

DESCRIPTION: Many microbial polysaccharides in solution act as viscosity enhancers and may exhibit shear-thinning, pseudoplastic behavior. The properties and range of temperature, pH, and ionic strength over which these are required to be stable will dictate the choice of polymer. The general use of such polymers are as stabilizers, suspending agents, thickeners, film-forming agents, etc. Presently, little is known about the biohazards associated with the making or use of biologically engineered polymers. Phase I of the task is to identify existing examples of biologically engineered polymers and develop a strategy as to how best to assess the biohazard. The second phase is to develop a screening method to ascertain if any acute toxicity may result from handling/inhaling byproducts of the synthesis and/or end product.

AF88-070 TITLE: Mission Reliability Model (MIREM) Engineering Workstation

OBJECTIVE: Integrate/demonstrate MIREM in an engineering workstation which can interactively run other circuit design tools.

DESCRIPTION: The AFHRL/LR developed Mission Reliability Model (MIREM) evaluates the reliability of new fault-tolerant, electronic circuits during the early stages of system development. MIREM accurately reflects the impact of reconfigurable, competing functions on system reliability. As an analytic model, MIREM determines a specific value for mean time between critical failure, mission completion success probability, and failure resiliency. This proposed effort seeks to integrate/host MIREM in an engineering workstation to make MIREM available as a primary reliability tool in the design of advanced, fault-tolerant electronic systems. The desired workstation must allow access not only to MIREM but to other circuit design tools. Each tool must run interactively with their design output directly accessible by MIREM. The design engineer must have both text and graphics displays to allow user friendly input and easy comprehension of calculated and displayed output. The technical challenge is to design a user friendly engineering workstation that supports multiple circuit design tools, provides various graphics displays, and allows interactive calculation of reliability values for various circuit designs and architectures. Phase I should result in a detailed description of workstation functional requirements, existing workstation designs, recommended approach to developing a concept demonstration prototype, and feasibility/risk assessment. Phase II should result in an integrated, functional engineering workstation concept demonstration with supporting software, software code and program documentation.

AF88-071 TITLE: Inflight Physiological Digitization, Processing and Storage System

OBJECTIVE: Develop an on-board, G-hardened device for analog to digital conversion and storage of physiological data.

DESCRIPTION: G-induced loss of consciousness represents a significant safety problem for pilots of high-performance aircraft. Physiological measures such as the EEG have been shown to be useful in the laboratory environment for detecting consciousness. There is a need for on-board, G-hardened device for analog to digital conversion and storage of physiological data. This device should provide for multiple channel, high sampling rates and large data storage capability. On-line data processing would greatly enhance current capabilities although off-line processing is also desired. Phase I will yield engineering specifications and prototype systems. Phase II will result in an operational product for the cockpit of high-performance, ejection seat aircraft.

AF88-072 TITLE: Articulated Total Body (ATB) Biodynamic Modeling

OBJECTIVE: Develop improved models and software integration components as integrated research tools for crewmember ejection analysis.

DESCRIPTION: The ATB model is a large Fortran program for simulation of human-body gross dynamics resulting from such hazardous events as crewmember ejection and crash impacts. The model and its associated programs currently run on a mini-computer. Implementation of the ATB on a PC system and further development of its submodels and associated user interface programs would result in a software package easily accessible throughout the Air Force, aerospace industry, and other agencies. An ATB software system is required that shall:

(1) include preprocessing capabilities for generating manikins or human body descriptive data sets for both males and females from anthropometric data bases, (2) provide an interactive capability for generating and modifying data files, and (3) provide post-processing graphics and statistical analysis capability. Hard tissue models for relating gross mechanical properties to substructure geometry and constitutive properties are needed as submodels within the ATB system. Development of these models require: (1) methodology and capability for generating continuum composite descriptions for stress-strain-strength properties for hard tissues that are suitable for finite element structural analysis based on internal geometry and mechanical properties on constitutive parts, (2) software, together with documentation, and (3) continuum composite descriptions and finite element analysis results for several cases. The models will be utilized to study how the influencing factors (i.e., internal morphology and component mechanical properties) actually vary for hard tissue, from tissue to tissue, from one site to another, or during remodeling due to aging, exercise, or sustained exposure to low-gravity environments.

AF88-073 TITLE: Force Reflection and Tactile Feedback Technology

OBJECTIVE: Develop force-feedback and spatial information algorithms.

DESCRIPTION: In order to develop a bilateral dextrous manipulator for robotic telepresence applications, transformation algorithms to reflect forces and torques acting on the robotic manipulators back to the arms of the human operator must be identified. This force information must be presented to the human in such a way that he can intuitively relate the forces acting on his arms to the forces acting on the robotic manipulators. Efforts are currently underway to develop a dual-arm exoskeleton system that can independently deliver forces and torques to each of the seven degrees-of-freedom (DOF) in the human arm. This system will allow man-in-the-loop control of a dextrous end-effectors attached to six DOF robotic arms. Successful implementation of this exoskeleton controller requires the development of algorithms to transform the vectors measured at the wrist plate of the robotic arm into force vectors that can be applied to the human arm by the actuators on the exoskeleton. The transformation algorithms will receive input in the form of six force and movement vectors Fx, Fy, Fz, Mx, My, Mz. The output will be in the form of seven torque vectors that can be applied to the seven DOF in the human arm: shoulder flexion/extension, forearm pronation/suppination, wrist flexion/extension and wrist abduction/adduction. The forces to be delivered to the human arm should enable the operator to perceive that his arms are experiencing the same forces as the robotic arms. Also of interest are tactile stimulation mechanisms operating in a virtual or telepresence environment that measure and communicates stimulation in three-dimensional space. These mechanisms should be capable of being used within a virtual cockpit where virtual images of discrete cockpit switch locations or control panels are projected and displayed in a helmet-mounted display, and stabilized in space using a helmet-mounted sight. An example would be piezoelectric materials embedded in gloves providing various forms of tactile feedback to the operator indicating switch contact and activation in virtual space. The products resulting from Phase II shall include a standardized test methodology for the simulation, evaluation and validation of cand force-reflection algorithms and a comprehensive report describing the results obtained through application of this methodology to the three algorithms developed in Phase I.

AF88-074 TITLE: Development of Operational Concepts for Chemical Agent Simulant Use

OBJECTIVE: To define an Operational Use Concept for training with chemical warfare agent uptake stimulants.

DESCRIPTION: Chemical warfare agent uptake simulants are agent substitutes that mimic physiochemical properties of the nerve and mustard agents, but are physiological innocuous, non-metabolizable, and easy to measure. The uptake simulants will be used during chemical warfare training exercises to quantify the real physiological consequences of operating in the chemical warfare environment. Uptake simulants will allow the measurement of actual physiological levels of agents that would be expected in personnel by measuring individual simulant levels during chemical warfare exercises. The offeror will be expected to define how uptake simulants can be dispersed to simulate an expected chemical agent attack on an air base, when and how to measure individual physiological levels of the simulant, and how to interpret the measurements of simulant levels. The expected Phase II product is a report that recommends a single-operational concept based on a trade-off analysis. Phase III will entail the fabrication of hardware needed to implement the operational concept and the description of the procedures for the hardware implementation.

AF88-075 TITLE: Fail-Safe Fault-Tolerant Electronics

OBJECTIVE: Investigate and define innovative concepts for allowing aircraft avionics to continue mission operation in spite of hardware and software failures to combat damage.

DESCRIPTION: The Avionics Laboratory is currently developing an advanced avionics architecture, which is functionally divided into separate areas. The resources within each of these areas can be shared for the purpose of functional recovery and reconfiguration. The Laboratory is also the office of primary responsibility for the Project Forecast II initiative entitled PT-13 Fail-Soft Fault-Tolerant Systems Technologies. PT-13 will develop a system fault tolerant architecture and supporting technologies. This effort will investigate revolutionary architecture concepts in order to improve overall system reliability and mean time between critical failure by at least one order of magnitude. Both hardware and software technologies, redundant techniques, and other innovative concepts will be explored. The complete aircraft system electronics will be integrated such that fault tolerance and reconfiguration can be accomplished over the entire electronic system. Phase I activity will include assessment of the aircraft system functional description and identification of high payoff hardware and software technologies, redundant techniques, and other fault tolerant concepts. Phase II activity will be the design of the aircraft system electronics using these new avionics architecture concepts to enable the aircraft to electronically become a completely self-repairing vehicle.

AF88-076 TITLE: Superconductivity Applied to Photonics, Non-Linear Optics or Microwave Devices

OBJECTIVE: Explore and develop new optical devices and applications utilizing high temperature superconductivity materials.

DESCRIPTION: Many Air Force problems can potentially be addressed through the use of photonics and nonlinear optics. Areas impacted by these new devices include computers, communications, radar, data processing, and electronic warfare. Advances in high temperature superconductivity (greater than 77° K) enable the development of realistic devices for use in existing and new applications. For example, use of magnon-photon interactions could be used to achieve energy transfer for such things as switching, detection, amplification, interconnection, and wavelength shifting. Wave coupling by bulk, surface, and evanescent fields can be utilized for new device structures. New proposed devices should have clear utility in associated applications. The basic research activity of Phase I should demonstrate the physical principles required to support the proposed device structure. Phase II exploratory development activity should result in the validation of the device structure fostered in Phase I to the extent that further development and transition to advanced programs could be considered.

AF88-077 TITLE: Variable Sample Rate Forward Looking Infrared (FLIR) Conceptual Design

OBJECTIVE: To develop a conceptual design for a laboratory FLIR sensor that can generate imagery at variable sample rates to verify analytically derived design and performance figures of merit.

DESCRIPTION: Automatic target recognizer (ATR) computers are causing a revolution in the design of FLIR sensors. Historically, FLIRs have undersampled because of the small number of detectors available on the focal plane arrays/FPAs, and the fact that the human brain can compensate for the aliasing artifacts in the imagery. However, FPA detector densities have improved and ATRs are sensitive to alaising. As a result, sampling a rate is now considered to be a critical design parameter. The correct values for various applications are the subject of an industry wide debate that is being discussed at national conventions such as the Infrared Information Symposium (IRIS) and the Automatic Target Recognizer Working Group (ATRWG). New FLIR design and performance figures of merit are being proposed. However, there is no way to verify then since all existing sensors are limited to one sample rate by the detector size and spacing on the FPA and/or scanner limitations. In Phase I of this effort, an innovative design for a variable sample rate laboratory FLIR will be developed. Approaches which may not be practical for operational FLIRs such as combining a staring FPA with a step-stare two axis scanner, are acceptable to achieve the variable sample rate feature. The FLIR must generate non-uniformity corrected, non-interlaced video at 525 TV line rates. High frame rates are desired so that the data can be displayed to an operator iwhtout image tearing artifacts. The detector and aperture sizes should be selected to provide anti-aliasing filters. Modifications to

an existing FLIR should be pursued to reduce costs. Phase II will consist of the final design, FLIR fabrication and the collection of data to verify the figures of merit.

AF88-078 TITLE: Electronic Warfare (EW) Requirements for Hypervelocity Vehicles

OBJECTIVE: To examine and define the electronic warfare requirements for hypervelocity vehicles.

DESCRIPTION: The hypervelocity vehicles under consideration will operate the Mach 6 to Mach 20 speed regime. Representative vehicles can be an airplane, a boost glide vehicle or a launched space vehicle capable of accelerating directly into orbit. This effort shall define the electronic warfare requirements for one or two hypervelocity vehicles given defined mission scenarios for the vehicle(s). Critical technical problems can be imposed by the mission, vehicle dynamics, physical environment, and threat environment. Some of the areas of concern that must be examined before electronic warfare requirements can be defined are: a) Survivability of antennas/sensors, b) Situation assessment and response functions, c) Off-board versus on-board payload space, d) Robustness of selected EW approach, e) On-board payload space, f) Cooling requirements for EW equipment, and g) Usability of Integrated Electronic Warfare System (INEWS) related technology. During Phase I, all areas of concern will be addressed to allow for early identification of critical technology areas. Phase II activity could consist of preparing simple models that describe the operation of the installed EW approach for varying scenarios and environmental conditions. This approach will pave the way for future parametric analyses.

AF88-079 TITLE: Advanced Information Processing Architectures

OBJECTIVE: Develop innovative methods and architectures for real-time processing of knowledge based systems, graphics, computer vision, neural nets, and holographic images in an embedded avionics environment.

DESCRIPTION: Advanced methods and processor architectures are needed to provide real-time processing of the various types of data used in embedded avionics systems. Some specific applications include defining requirements and architectures for: (a) An airborne Artificial Intelligence (AI) processor that is an element of a distributed processor system architecture and is optimized to execute knowledge based system applications. System, hardware, and instruction set level architectures are desired. (b) An airborne graphics generation and image processor capable of simultaneously processing multiple aircraft video sensor images and performing display format generation with 2-D and 3-D, zoom, rotation, windowing, overlay, and color capabilities. Both of the architecture definitions above must be compatible with Advanced Tactical Fighter (ATF)/PAVE PILLAR (the Air Force Standard avionics system architecture) requirements and architectures. Other types of advanced processor requirements include: A performance evaluation processor for training advanced vision systems based on genetic learning or neural network research; computer vision architectures, utilizing the Soar architecture for general intelligence developed by Carnegie Mellon University, capable of integrating the outputs of multiple methods of three-dimensional sensing and interpretation (radar ranging, infrared); and real-time processing of holographic image information using optical modulation and/or parallel processing techniques. Phase I activity encompasses definition of methodology or techniques for the chosen application, and development of a preliminary design architecture. Phase II effort includes detailed architectural design and specification, and prototype breadboard demonstration where feasible.

AF88-080 TITLE: Complex Integrated Circuit Technology

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

DESCRIPTION: Research is needed to advance the state of the art in the area of complex monolithic integrated circuits and take maximum advantage of novel approaches to circuit configuration and point to point interconnect. To accomplish this objective will require dedicated efforts in such areas as: 1) optimized interconnect concepts which achieve high speed through enhanced conductance and controlled parasitics; 2) the use of multilevel metal and/or three dimensional structures to achieve higher functional density; 3) modeling techniques to lower the risk of accurately predicting functionality of devices, interconnect, and packaging in competitive approaches; 4) innovative

packaging concepts which address power distribution and thermal management; 5) fault tolerant and yield improvement approaches to lower final assembly costs. The above description defines a broad area of interest, and proposals addressing individual or combined areas are strongly encouraged as long as they are clearly targeted on the final objective. Phase I activity will identify the limitations of present interconnect or packaging approaches and determine those areas which offer the greatest potential for improvement. Phase II will select one or more interconnect or packaging concepts based on modeling results, demonstrate the improvement in total performance, and identify further development necessary for transition to system applications.

AF88-081 TITLE: Space Time Adaptive Radar Processing

OBJECTIVE: To develop airborne interceptor radar adaptive signal processing techniques to allow the detection of low radar cross section targets in difficult ground clutter interference environments.

DESCRIPTION: Data-adaptive radar processing, in which both the spatial (antenna pattern) and temporal (Doppler filter) responses of the system are controlled adaptively, has been technically investigated for over a decade. In such a radar, a complex weighting is computed from the covariance of the antenna array element outputs to maximize the target-to-interference ratio in a particular space-time direction. The array/filter weights can be described as forming a retrodirective receive beam in the direction of a source of interference. Subtraction of the retrodirective beam pattern from the normal, unadapted pattern will effectively null out the source of interference. Aircraft motion induced clutter Doppler shift is compensated for by incorporating a digital delay line in each of the elements and adaptively employing Displaced Phase Center Antenna (DPCA) techniques in order to make the radar antenna appear stationary. Conventional radar detection processing, consisting of the Fast Fourier Transform(FFT) and Constant False Alarm Rate (CFAR), may follow. Data-adaptive radar processing methods are generally applicable to optimum measurement of environmental parameters, the rejection of correlated interference, and system calibration. Specific tasks include resolving and tracking multiple targets in the antenna main beam, clutter rejection, multipath rejection, jammer rejection, and system calibration. Space-time adaptive radar processing techniques afford optimum performance in particularly applicable to airborne interceptor radars operating at the lower frequencies and, hence, incorporating conformal array antennas with correspondingly few elements but large power-aperture products. The coming of very high throughput digital processors, especially parallel systolic arrays intended for the manipulation of large matrices, makes possible the exploitation of the space-time adaptive radar processing technology. Phase I activity will include feasibility investigation and assessment of space-time adaptive radar processing techniques. This will lead to Phase II simulation and validation of the most practical techniques.

AF88-082 TITLE: Improved White Light Source for Aircraft Applications

OBJECTIVE: Develop a more efficient, durable, continuous wave white light lamp, with minimal output at nonvisible (ultraviolet and infrared) wavelengths, for use on high performance aircraft.

DESCRIPTION: There are a variety of advanced development programs which require the use of very bright (over 300 Watts output) white light sources for aircraft applications. The problem with the sources used at present is that they require too much energy outside the visible spectrum, and they cannot survive the harsh environment (vibration, g-force loading, temperature extremes, etc.) which they must endure on a high performance aircraft. Therefore, the first phase of this effort will be an investigation of lamp technologies and a theoretical analysis showing what improvements can be made in lamp design to eliminate or improve the deficiencies mentioned above. If it can be shown that a significant improvement would be possible, the effort would be expanded to design and build prototype lamps.

AF88-083 TITLE: Learning Systems for Electronic Combat Applications (LSECA)

OBJECTIVE: To develop learning system technologies for use in real-time, adaptive electronic combat avionics.

DESCRIPTION: The operational requirements for next generation electronic combat avionics systems call for performance of extremely complex information processing tasks in real-time with adaptive, fault-tolerant, and

gracefully degrading operation in a dynamic, hostile real world with incomplete or corrupted information, possibly lethal novelties, noise and deception. A key enabling technology for meeting these requirements is leaning systems. Learning systems technology is a recently emerging area of Artificial Intelligence (AI) research and includes three general approaches to real-time adaptation: Neural Learning, Evolutionary Learning, and Distributed Rule-Based Learning. The first two use concepts from neurophysiology and evolutionary biology respectively, the last approach relies on the formal and informal logic based techniques of mainstream AI and incorporates concepts of Distributed AI for real-time potential. In general, electronic combat avionics applications from the point where the aircraft meets its environment with its sensors, emitters, and radars up to the situation assessment module of whatever cockpit management system is in place (e.g. Pilot's Associate) will be explored. This program will thus complement the Pilot's Associate program and other cockpit centered programs. Emphasis will be on the real-time, adaptive system technologies rather than on the specific application. One of the general types of learning systems (Neural Learning, Evolutionary Learning, and Distributed Rule-Based Learning) should be chosen along with the electronic combat application domain (e.g., Electronic Support Measures, Electronic Countermeasures, or Electronic Counter-Countermeasures) the respondent is the most familiar with. The challenge is to mature the chosen learning system research technology for use in next-generation avionics systems by exercising it with an electronic combat application. The Phase I goal will be an initial survey and feasibility study for the proposed work which identifies the specific combination of learning system technology and electronic combat application providing the greatest technological payoff. The Phase II goal will be a working prototype system which simulates a real-time, adaptive electronic combat system using the identified learning system technology for the targeted applications.

AF88-084 TITLE: Microwave/Optical Techniques

OBJECTIVE: Develop gallium arsenide (GaAs) based on intefrated microwave/optical circuit's to provide transmission of analog microwave signal information through optical fibers.

DESCRIPTION: The concept of integrating optical sources and detectors with GaAs based monolithic microwave integrated circuits (MMICs) for wideband analog signal transmission through optical fibers is a new technology with promising potential. Recent advances in GaAs based microwave and optical devices has established the technical feasibility of fabricating integrated microwave/optical transmit and receive functions with multi-gigahertz band-width, and compatibility optical fiber transmission links. Additionally, realizing techniques for analog signal filtering, microsecond signal delay, and versatile routing are also contemplated. Associated technologies should be exploited and expanded to develop GaAs based integrated microwave/optical circuits with the necessary performance that are reproducible and affordable. A variety of feasible approaches shall be explored for realizing GaAs based monolithic integrated microwave and optical devices on a common chip. Standard processes and materials for MMIC and optical devices will be investigated and refined for compatibility. Computer-aided models and designs will be established which simultaneously analyze both MMIC and optical elements.

AF88-085 TITLE: Parallel Processing Applications for Avionics

OBJECTIVE: To determine the design characteristics of parallel processing systems required to effectively support selected real-time avionic applications.

DESCRIPTION: The following programs are of specific interest:

a. Determination of Distributed Object Representation, Prediction and Matching Techniques for Model Based Vision. Current object recognition approaches in vision focus upon the use of massively parallel architectures to extract object features such as edges and homogeneous regions from imagery. The prediction of each object features, the representation of these features, and the matching of these predicted features with image (e.g., infrared, synthetic aperture radar) features is generally performed as a single process on a single CPU. This research will investigate approaches to use massively parallel architectures for: (1) Storing distributed representations of objects; (2) Performing predictions (infrared, radar) from these objects; (3) Storing the predicted object representation (i.e., an object view); and (4) Matching the distributed object view with a distributed feature representation derived from the image (in this context, distributed representations refer to one object, view, etc., being represented on many

processors). Phase I activity will be limited to concept formulation and validation via implementation and testing on Government furnished massively parallel hardware.

b. Determination of Processing Requirements for Expert Systems Using Machine Intelligence. The projected use of expert systems will require orders of magnitude improvement in processing throughput to achieve real time airborne operation. The use of parallel processing in conjunction with the high speed microcircuitry is a potential solution. In order to prepare for the eventual integration of an advanced developmental configuration, design tradeoffs leading to the identification of desired system characteristics need to be accomplished in the near term. Phase I activity will include surveys of available algorithms and available parallel processing machine configurations. The relative merits of each type of hardware/operating system design will be judged in terms of their adequacy in supporting, principally, selected expert system software applications. Design consideration should be given to achieving fault tolerant operation while providing efficient allocation of resources. Insight into the use of Ada- and LISP-based languages will also be provided. Recommendations for additional design characteristics of advanced computer systems will also be made, along with plans for conducting a Phase II demonstration in an Integrated Test Bed environment and the Avionics System Analysis and Integration Laboratory in Building 620, Wright-Patterson AFB, OH.

AF88-086 TITLE: Aircraft Signature Situational Awareness

OBJECTIVE: Analyze and develop the use of "situational awareness," as a tool to increase aircraft survivability in a battlefield environment.

DESCRIPTION: Situational awareness is defined as the use of stored data on threats as well as information gathered by all available onboard sensors to either automatically configure or inform the aircrew on how to best configure or maneuver the aircraft to take advantage of any natural cover or aircraft profile to reduce their signature to the threat. As detection systems, anti-aircraft systems, and interceptor aircraft improve, it will become increasingly difficult for an aircraft to survive a combat mission. One method that may work to increase aircraft survivability would be to use an onboard computer system with real time data gathered from all the onboard detectors/sensors (Forward Looking Infrared, radar, laser warning, solar, etc.) and stored data on threat positions and operational parameters of both the threats and the host aircraft to assist the pilot to configure or maneuver his aircraft in the best possible manner, to survive whatever situation develops. The initial phase of this effort would be to analyze what type of sensors and information would be required to demonstrate the use of situational awareness in the visible portion of the spectrum. This would entail gathering data on the optical signature and performance characteristics of a US aircraft, and the performance of a visually diverted threat anti-aircraft system. A system would then be devised to use this data, with the AFWAL Optical Reduction Image Processing System (ORIPS), to demonstrate the kinds of signature reduction that could be achieved through situational awareness. ORIPS can be used to generate the visual scenes (as would be viewed by the threat) with both a normal flight profile and one modified to take advantage of situational awareness. ORIPS can then be used to evaluate any improvement in visual signature reduction throughout a given mission. If a reasonable improvement is shown, the effort would be expanded to include the entire electro-magnetic spectrum. This would involve measuring and cataloging the threat data and aircraft signatures from the visual through the radar portions of the spectrum and could involve development of the system and software to flight test this concept.

AF88-087 TITLE: Conformal/Imbedded Adaptive/Phased Arrays for Hypervelocity Vehicle Applications

OBJECTIVE: To conduct research in the areas of conformal/imbedded adaptive phased array antenna configurations when conformal to or imbedded within hypervelocity vehicle (HVV) structural or surface materials.

DESCRIPTION: Hypervelocity vehicles will be subject to severe thermal environments during reentry and other various mission phases. This condition will require conformal and/or imbedded adaptive or phased arrays (rather than arrays located above the HVV outer mold line), to service transmit and receive functions expected to be on HVVs. Of interest for this effort are arrays to service communications, navigation, identification, and threat warning/direction finding functions. Operating frequencies of interest range from Ultra-High-Frequency (UHF) through 5 GHz. Technical issues include (a) Trade-offs between antenna performance and whether HVV antennas

should be conformal or imbedded microstrip-type structures, and if imbedded, the depth to which imbedded; (b) The impact of surface waves on overall antenna performance and if surface waves can be used as an aid rather than as a detriment to antenna coverage; and (c) Compatibility with materials which would be used in HVV applications. The Phase I effort will be a study effort to identify candidate configurations which could be developed. Configurations will be developed in and evaluated under Phase II follow-on efforts.

AF88-088 TITLE: Layered Semiconductor Devices

OBJECTIVE: To develop methods for assessing the viability of layered semi-conductor devices.
DESCRIPTION: Semiconductor device structures composed of thin layers separated by atomically sharp interfaces have become the basis of a rapidly expanding technology. The unique physical properties of such ultra-structured material devices have already resulted in significant improvements in performance of a variety of devices and new concepts are constantly being considered. These new structures are necessary for the continued advancement in the state-of-the-art of digital, electro-optical, and micro/millimeter wave technology. Areas which must be considered in assessing the viability of such devices include material growth device processing, physics and device performance. Efforts designed to improve the understanding of the unique physical properties of these structures, especially those which address electro-optical and/or high-speed phenomena are of great interest. Computer or mathematical models of transport or crystal growth are needed and novel device concepts verification is strongly encouraged. Development of the processes that are specific to the fabrication of these structures and associated devices such as ways of selectively contacting specific layers, ways of growing complementary structures on the same substrate or ways of achieving high device density will be given consideration. The Gallium Arsenide-Aluminum Gallium Arsenide system is the one that is presently of the highest interest but other materials combinations that would enhance some aspects of performance are also considered important.

AF88-089 TITLE: Diode Array Laser Radar

OBJECTIVE: To develop a diode array laser radar.

DESCRIPTION: A need exists for laser radar system which are the optical equivalent of microwave radar phased array antennas. The advantage of such a system is that it would be completely electronically steerable and therefore operate without moving parts. Such a laser radar should be compact, light-weight and efficient for use in high-performance applications. To be a true phased array, the size of the aperture subelements must be less than the wave-length of the transmitted energy, which is especially challenging for optical wavelengths. In particular, diode lasers offer potential since they can be fabricated in modules with small dimensions and phased together electro-optically. Critical issues for phased array steering are the field of regard and beam quality, while critical issues for the diode lasers are frequency stability and narrow linewidth for effective heterodyne detection. (Direct detectors can be used if sensitivity is high enough.) The Phase I effort should explore and validate an approach to create a diode laser radar phased array. The Phase II effort should prove the concept with a lab demonstration and plan for a Phase III effort to produce a phased array laser radar which could actually be employed on a weapon platform.

AF88-090 TITLE: Laser Countermeasures

OBJECTIVE: To investigate, develop and test potential countermeasure techniques to negate laser fuzes, trackers, rangefinders, designators, or beamrider directed weapon systems.

DESCRIPTION: With the advances made in laser technology, detectors and optics, laser guided and/or directed weapon systems are now being employed in large numbers on the modern battlefield. Besides the advantage of increased accuracy that lasers provide to weapon systems, they are also immune to conventional electronic countermeasure techniques. Hence, new countermeasure techniques need to be developed to negate these threats in order for U.S. aircraft to accomplish their assigned missions. Of primary concern are countermeasures against laser fuzes, laser trackers, laser rangefinder systems, laser designators and their associated weapon system (i.e., missiles), and laser beamrider missiles. This program shall analytically investigate potential laser countermeasure techniques and their potential effectiveness. The techniques with the greatest potential for success will be developed further via

laboratory tests. The appropriate equipment for the countermeasure and contractor configured threat will be designed, fabricated, and calibrated. Laboratory tests will be conducted and test data analyzed to determine the effectiveness of the different techniques. The goal of Phase I is to identify one or more potential countermeasure techniques which warrant testing. The Phase II goal is to accomplish laboratory countermeasure effectiveness tests on one or more countermeasure techniques. The effort will require access to classified foreign intelligence information; therefore, SECRET facility and personnel clearances will be required.

AF88-091 TITLE: Rapid Two Dimensional Nonmechanical Scanner

OBJECTIVE: To develop a new two dimensional laser scanning technique by the use of passive optical elements.

DESCRIPTION: The Air Force (AF) has a need for optical sources which can be scanned throughout some field of view for tactical airborne applications. Current AF technologies utilize a single wavelength in conjunction with precise mechanical scanning to fulfill mission needs. The development of lasers that can be frequency tuned holds promise for obtaining a scanning source without mechanical means, thereby eliminating one of the major maintenance items in such systems. As the frequency of a laser is changed, one can utilize passive optics (either diffractive optics such as gratings or interference optics such as etalons) to achieve two dimensional (2-D) color maps. One possible method deals with the conversion of the linear sweep normally associated with frequency turning into a unique 2-D sweep. The technique involves the realization that the linear scan can be converted to two dimensions by utilizing each diffraction limited element of the linear scan to address an optical element which can relocated the beam of light in 2-D space. The key technical challenge is to obtain the required 10^8 solution elements in the total scan, with 10 cm aperture output optics. It should be assumed that the total tunable bandwidth will be 100 nm in the 600-900nm region. Methods involving electro-optical or acousto-optical scanning should not be considered. Also, there is a preference for non-birefringent (i.e., polarizers) components to accomplish the total scan. Also since it is anticipated that the device will be subjected to high laser fluence, the optical components must be of low loss and high damage threshold. Phase I activity will be the design and initial testing of the device as a proof of principle experiment only. Then Phase II will be final optimization and complete characterization of the device.

AF88-092 TITLE: Systems Level Technology Assessment Methodology for Short Takeoff and Vertical Landing (STOVL) Type Aircraft

OBJECTIVE: To develop Systems Analysis Technology Assessment methods to determine the military worth of STOVL type aircraft in various warfare environments.

DESCRIPTION: Certain types of advanced technology add weight, drag, fuel consumption, and/or complexity to the aircraft. Although these do not benefit aircraft performance, they can benefit the Air Force from an operational standpoint. The payoff may include enhanced lethality, reliability, maintainability, detectability, sustainability, ground supportability (logistics, civil engineering, maintenance, and basing), and/or combat supportability (tankers, escorts, airborne radar, etc.). These concepts require a broad technology assessment approach to determine their military worth – a systems analysis. The analysis has to weigh the vehicle liabilities against the operational benefits to the Air Force, and must answer questions such as “Which is the better approach?” or “How much of each is appropriate?” To evaluate such issues, we need to understand the real world job including the operational rationale where the aircraft is just one element of the total problem. Phase I activity will include a survey of possible systems level technology assessment approaches including problem flexibility, ease of use, credibility, etc., and a recommended technique. This will lead to Phase II activities consisting of the final development including algorithms, data base, coding, validation, documentation, and transition of the methodology to the Air Force Wright Aeronautical Laboratories.

AF88-093 TITLE: Damage Detection and Active Control Systems for Smart Aerospace Structures

OBJECTIVE: To develop a cradle-to-grave structural health monitoring and active control system for aerospace vehicles and space platforms using sensor arrays and an Artificial Intelligence computer.

DESCRIPTION: A smart aerospace structure is one that has a nervous system which can be used for real-time detection and tracking of damage and active flight control. The nervous system would consist of an array of sensors (nerves) throughout the structure and an Artificial Intelligence computer (brain) to process the sensor data, make decisions concerning structural health, and provide active control capability. Structural integrity applications of the smart structures concept would be to monitor the depot inspection, and help maintenance personnel with required repairs. Active control application would be to monitor and control flow fields, vortex configurations, shear layers (including transition, heat transfer, and circulation). Space applications to space structures would involve vibration detection and suppression, alignment/pointing control, and detection/evaluation of foreign object damage. The first step in the development of the Smart Structures concept is to investigate/define the concept using innovative ideas and approaches. This would involve the identification of the number and type of sensors to be used, definition of real-time data and structural analysis requirements, definition of active control requirements, definition of data storage requirements, definition of Artificial Intelligence computer requirements, and definition of the decision making program architecture. Moreover, the potential structural integrity monitoring and control payoffs of the smart structures concept over current structural integrity monitoring and active control systems needs to be defined. The objectives of the Phase I effort are to fully define the smart structures concept, identify the sensor requirements and deficiencies in current sensor technology, define real-time data acquisition and analysis requirements, define active control requirements, and define the required decision making architecture. If no technology deficiencies are identified, then Phase II would involve the development of a smart structures concept demonstration. Otherwise, Phase II would involve research and development to eliminate identified technology deficiencies.

AF88-094 TITLE: Miniature Angular Transducer Development

OBJECTIVE: To develop a lightweight, high resolution, and wide frequency range angular vibration transducer capable of obtaining low microradian measurements in airborne and space-based environments.

DESCRIPTION: Development of angular vibration transducers will support all flight and space vehicles which incorporate electro-optical systems such as lasers, radars, and infrared tracking systems. Vibration adversely affects the pointing accuracy of these systems, especially in the low microdian angular motion. There is a severe problem in defining vibration design and control requirements for these systems since high resolution transducers that can measure low levels of angular vibrations are not available. Large space structures testing is another area in which angular vibration measurement is required. The combination of low frequency range, highly flexible structure, and large displacements restricts the use of many linear transducers. The available angular transducers have very limited resolution and frequency bandwidth capability, and are massive; furthermore, their angular measurement is also affected by linear motion. An angular vibration transducer that meets the resolution, weight, frequency, sensitivity, and small size requirements needs to be developed. Phase I activity will include the design of a proposed angular vibration transducer that meets the specified requirements. This will lead to Phase II in which fabrication, demonstration, and verification of the prototype transducer will be performed.

AF88-095 TITLE: Application of Ultraefficient Three-Dimensional Reinforced Composites to Airframe Structure

OBJECTIVE: To develop and assess the potential for three dimensional reinforced composites and unique structural concepts that will significantly reduce aircraft structural weight or cost and increase structural durability.

DESCRIPTION: The next generation aircraft and aerospacecraft, including high altitude long endurance aircraft, will extensively incorporate composite materials in their covers and substructure to reduce airframe weight, resulting in increased payloads, ranges, and overall performance. These aircraft will require ultraefficient materials and structural concepts to achieve the required weight reductions. This program will determine and/or explore the feasibility and payoffs of unique design concepts and advanced materials for ultraefficient airframe structural elements where strength, stiffness, and fracture toughness are required in three dimensions. For example, composites of ultrahigh strength graphite with matrices of ordered polymers or molecular composites could offer a particularly high payoff for both structural efficiency and durability. Phase I should include selection of innovative composite concepts, formulation development, assessment of productivity, preliminary determination and design of

structural elements, preliminary study for vehicle application potential, initial feasibility testing, and definition of technology gaps. Phase II would conduct detailed design, fabrication, and structural testing of demonstration materials and representative airframe hardware.

AF88-096 TITLE: Expert Systems Applied to Vulnerability Assessments

OBJECTIVE: To develop approaches which greatly reduce time spent performing vulnerability assessments by utilizing the techniques of expert computer systems.

DESCRIPTION: Present vulnerability assessment computer codes require a tremendous amount of manual preprocessing. Much of this input has to be generated using subjective judgment which is error prone due to differences in perception and experience level. Examples include the building of probability of kill given hit (PK/H) from raw data, analysis of failure modes, effects and criticalities, building of fault trees and assigning of appropriate failure probabilities, ascertaining the threat level and determining the proper percentage mix for aspect ratio. In the hands of a skilled vulnerability analyst, vulnerability assessment computer codes can provide a reasonable assessment; however, results can be disastrous in the hands of a novice. This fact necessitates the development of a technique which will greatly facilitate and standardize the preprocessing associated with vulnerability assessments. A prime candidate would be a computer enhanced expert system. Such a system could perform all the tedious preprocessing needed for vulnerability assessment computer codes, thus allowing a novice to effectively utilize the codes. The Phase I effort would be a feasibility study which addresses the creation of a computer enhanced expert system for performing vulnerability assessments, and Phase II would be the development and verification of the expert vulnerability assessment computer system.

AF88-097 TITLE: Investigation of Unique Thermal Management Techniques for Hypersonic Aerospace Vehicles

OBJECTIVE: To develop concepts for the control and/or redistribution of internal thermal loads which exist in hypersonic aerospace vehicles.

DESCRIPTION: The Air Force has recently begun development of aerospace vehicles capable of reaching altitudes of 500,000 feet and of traveling at speeds up to Mach 25. These vehicles are subjected to severe thermal environments as a result of aerodynamic heating and heat generation by vehicle equipment. Useful ways of utilizing and managing this heat energy is essential to the prolonged, continuous operation of the vehicle. For this reason, advanced innovative methods of controlling the interior thermal environments of a hypersonic aerospace vehicle are needed. Possible concepts include, but are not limited to: thermal control loops, heat sinks, heat redistribution, heat powered cycles, utilization, and rejection, self-adjusting environmental control systems. Phase I activity will include demonstration of feasibility through assessment of the thermal management parameters of a given concept. This will lead to Phase II activities which include the development of equipment and techniques, and performance validation of candidate concepts.

AF88-098 TITLE: Aircraft Tire Inflation/Deflation Systems

OBJECTIVE: To develop concepts for inflation/deflation systems for aircraft tires both internal and external to the rolling stock.

DESCRIPTION: Today's aircraft typically use a pneumatic tire for use in landing gear. With more Air Force aircraft being tasked to be capable of operating from rough/soft fields or runways, the use of an inflation/deflation system for optimal tire/soil interaction will be required for ground operations. Inflation/deflation concepts will be defined/developed, both internal to the wheel and external. A deflation system only should also be developed. Phase I activity will involve conducting a trade study using the developed concepts under defined scenarios. The scenarios include: soft/short field operations, hypervelocity vehicle high speed takeoff, and peacetime operations (useful as a baseline to other scenarios). The trade study categories shall include, but are not limited to, weight, reliability and maintainability, and performance (inflation/deflation time, flow rates, pressure range, etc.). Phase II

of the program would include analysis and fabrication of prototype hardware for proof-of-concept performance resting in a laboratory environment.

AF88-099 TITLE: Vertical/Short Takeoff and Landing (V/STOL) Stability and Control in Ground Effect

OBJECTIVE: To develop a detailed understanding of the flow phenomena encountered by V/STOL aircraft operation in ground effect.

DESCRIPTION: The design and utility of V/STOL and STOVL (Short Takeoff and Vertical Landing) fighter-type configuration can be severely limited as a result of the required operation in ground effect. Large and possibly adverse changes in stability and control characteristics occur on all types of these aircraft operating in ground effect. In addition, hot gas clouds are formed which can seriously degrade engine performance and result in landing (or hover) performance compromises. The basic flow mechanisms that produce the ground effects experienced by these aircraft are known, but there are significant details of the mechanisms which are not adequately understood. New approaches, analytical or experimental, are required for additional insight into these phenomena so that they can be adequately considered during the design process. A better understanding of these flow phenomena would also allow for increased accuracy and confidence in sub-scale testing of these types of configurations. Phase I activity will involve demonstration of the feasibility of the testing concept or analytical model for future analysis in Phase II. Phase II will involve detailed testing and analysis or detailed analytical analysis with an emphasis on comparison to existing experimental data.

AF88-100 TITLE: Feedback Control of Systems with Unknown Parameters

OBJECTIVE: To develop design methodology for flight control systems of hypervelocity vehicles.

DESCRIPTION: The dynamics of future aerospace vehicles cannot be accurately modeled. Parameters are expected to vary in a wide range due to the large flight envelope of these vehicles. It is desirable to have controllers whose algorithms are, in some sense, optimal with respect to on-line data. The proposers should be aware of the drawbacks and pitfalls of the existing adaptive control techniques, and should state in the proposal how these drawbacks might be avoided or resolved in the proposed research. Phase I research includes feasibility study and mathematical development followed by numerical demonstration on a generic aircraft model. Phase II research shall consider the time-varying nature, or nonlinearities, of hypervelocity vehicle dynamics and the effects of external disturbances and measurement noise on the control system. Relaxation of the constraints or limitations imposed on the system in Phase I, if any, shall also be considered. Results of Phase II research shall also be demonstrated by computer simulation on a generic aircraft model. The contractor is to supply the simulation models in both Phase I and Phase II.

AF88-101 TITLE: Robust Control Law Design for Multivariable Systems

OBJECTIVE: To develop robust flight control laws for future aerospace vehicles with uncertain dynamic modeling.

DESCRIPTION: Future aerospace vehicles are expected to be systems with multiple inputs and multiple outputs. The dynamics of these vehicles are not expected to be well known. Uncertainties arise due to variations in parameters (structured uncertainties) that describe the system. Uncertainties also arise due to model truncation at high frequencies (unstructured uncertainties). Phase I research will develop methods to design control laws that guarantee stability and performance robustness in the simultaneous presence of both the structured and unstructured uncertainties. Emphasis will be placed on including both of these uncertainties explicitly in the design process. Phase II activities will extend these design methods to include unstructured uncertainties at multiple points in the feedback loop along with structured uncertainties explicitly. Results of both Phase I and Phase II shall be demonstrated by computer simulations. Simulation models are to be supplied by the contractor.

AF88-102 TITLE: Digital Imaging and Enhancement of Flow Field Visualization

OBJECTIVE: To digitize and enhance visual images of flow field perturbations as captured through nonintrusive optical techniques.

DESCRIPTION: Visual images of flow field phenomena taken using various optical techniques have provided qualitative information of complex interactions. For advanced flight systems incorporating the full range of Short Takeoff and Landing (STOL) to hypervelocity vehicles, quantitive data is needed where experimental techniques are difficult and questionable. A real time digital imaging and processing system is needed to provide flow field parameters from the analog visualizations provided by schlieren, shadowgraph, holographic interferometry and laser light sheet, among others. Phase I activity would identify the range of digital imaging needed to provide quantitative data from identify the range of digital imaging needed to provide quantitative data from interferograms taken in High Reynolds Number facilities. Phase II would involve the development, fabrication, and demonstration of a system to actually perform the digitization and enhancement to provide real time data. This data will have significant impact on the understanding of complex, transient flow field interactions to greatly improve flight vehicle performance.

AF88-103 TITLE: Rarefield Gas Flow Effects on Hypersonic Vehicles at Very High Altitudes

OBJECTIVE: To develop methods, both theoretical and experimental, to determine, on a molecular flow basis, rarefraction effects on aerothermal characteristics of hypersonic vehicles during operation at high altitudes.

DESCRIPTION: Theoretical and computational techniques including innovative test techniques and unique experimental facilities are needed to determine aerothermal characteristics such as forces, moments, and heat transfer including real gas conditions on hypersonic vehicles operating at altitudes in excess of 65Km. In these environments wherein the vehicle experiences slip flow, transitional flow (with characteristic-local Knudsen numbers varying between 0.2 to 5 approximately) and free molecular flow (at altitudes of about 250,000 ft plus), the vehicle performance can only be analyzed by a molecular flow approach. A mathematical model of the rarefied gas flow is the Boltzmann equation which spans the entire spectrum between the continuum gas dynamic equations (i.e., Navier Stokes type) and the free molecular flow equations. Phase I activity should demonstrate a knowledge of the solution methods (as related to the Boltzmann equation) and the concomitant results on simple hypersonic configurations. In this phase, results shall be obtained by using the known analytical and computational techniques for shapes such as swept and blunted plates, hemi-spherical cones and cylinders, ogives etc. Also, outlines of experiments which can be performed for the purpose of validating the theoretical and computational results as well as for obtaining test data on more complex shapes should be discussed. The Phase I studies will lead to Phase II research in which a higher hierarchy of analytical/computational solution methods (which include real gas effects) will be developed. Appropriate experimental studies will also be conducted with a view to validate the prediction techniques and to assist in the design of hypersonic vehicles.

AF88-104 TITLE: Computational Model for Thrust Reversing/Vectoring Jet

OBJECTIVE: To develop a time dependent, compressible, three-dimensional, Navier-Stokes computational model(s) for thrust vectoring/reversing jets for Vertical/Short Takeoff and Landing (V/STOL) fighter aircraft.

DESCRIPTION: An advanced computational model is needed to predict the complex flow field around V/STOL fighter aircraft with thrust vectoring/reversing nozzles to enhance the current engineering design practice which is highly experimental in character. Because of the complex turbulent character of the jet flow associated with thrust vectoring and reversing near the ground, significant attention must be given to the basic understanding and development of a jet model before it can be successfully integrated into a numerical aerodynamic method. Phase I is directed at investigating the most efficient means of modeling generic flow problems such as an impinging jet in crossflow with and without a boundary layer, inclined jets in crossflow, the jet fountain, and jet flow near a control surface. Since this is not a research effort to develop a computer code, it is expected that the proposer will have available an existing computer code capable of solving the time dependent, compressible, three-dimensional Navier-Stokes equations and that this code will be used to investigate these generic problems. The Phase II activity will

focus on improvements to the turbulence model, computational grid density, further refinement and validation of the computational jet model(s).

AF88-105 TITLE: User-Friendly Interface for Attaching Dynamic Attributes to Graphic Objects

OBJECTIVE: To develop a user-friendly interface for defining and attaching dynamic attributed to objects in graphic cockpit displays.

DESCRIPTION: This effort supports laboratory research to develop the technology for a Rapidly Reconfigurable Crewstation (RRC) program which will create the capability to design and evaluate cockpits and displays in one day. As a part of this program, a graphics workstation will be used by personnel without programming experience to create cockpit display formats with objects (target aircraft, weapons, etc.) that have dynamic attributes which will vary as a function of the output of aerodynamic models, control system models, discrete cockpit switch inputs, etc. In Phase I the contractor will review user-interface methods/technologies; identify and analyze RRC requirements for dynamic attributes; evaluate methods versus RRC requirements; and generate three alternative user-interface concepts for RRC. In Phase II the contractor will develop working representations of the three alternate concepts; evaluate them to converge on a preferred design (for a subset of attributes), and develop prototype software compatible with government furnished equipment to demonstrate/prove the selected concept (for all attributes).

AF88-106 TITLE: Leading Edge Structural Concepts for Reusable Hypervelocity Vehicles

OBJECTIVE: To develop and assess hot and cooled leading edge concepts suitable for reusable, hypervelocity vehicles.

DESCRIPTION: The Air Force is currently studying many different hypersonic flight systems – both single and multi-mission. A critical element for both types of systems is the wing leading edge which must survive and maintain structural integrity in an aeroheating environment capable of generating radiation equilibrium temperatures on the order of thousands of degrees F. Of the two types of systems, however, the reusable mission vehicle imposes the greater technical challenge in the sense of having to maintain leading edge moldline contours and structural integrity under severe repetitive thermal and mechanical loading. The emphasis of this effort will be on the development of multi-mission leading edge concepts capable of sustaining maximum radiation equilibrium temperatures of between 4000° F and 5000° F. Cooling techniques may be employed, but only to the minimum extent required to enable maintenance of structural and material system integrity for a given concept. The philosophical approach is thus that less cooling is preferable to more cooling, whereas no cooling (active), if possible, would be most desirable for system simplicity (and hence reliability) and ease of maintenance. Stated equivalently, the goal should be to push to the limits of materials technology and then actively cool. Phase I should include the selection and justification of a vehicle and its attendant leading edge characteristics, or alternatively, the establishment of generic, representative leading edge elemental testing to assess feasibility of innovative concepts, and definition of technology gaps. Subsequently, a Phase II program would develop detailed designs including methods of integration into adjacent structure, fabrication development, and thermal/structural/flow testing of demonstration hardware.

AF88-107 TITLE: High Energy Braking System

OBJECTIVE: To develop new High Energy Braking (HEB) concepts and innovations for application to Hypervelocity vehicles (HVV).

DESCRIPTION: Future HVV's will have lower atmosphere operational characteristics similar to conventional aircraft as well as the capability to accelerate directly into orbit. Envisioned as single-stage-to-orbit vehicles, they will employ conventional horizontal launch and alighting techniques. Total weight at launch will be in the range of a half million to a million pounds plus. Takeoff speeds of approximately 340 knots are expected. Utilization of existing B-52 class runways is anticipated for both takeoff and landings. To maintain an adequate crew, vehicle and/or payload safety margin during horizontal runway launches, the HVV must have full Refused Takeoff (RTO)

stop capability. This program addresses only the self-contained on-aircraft braking system, however, the aircraft system should be compatible with ground based deceleration assist concepts. Ground based systems may be employed if full RTO capability cannot be assured by the aircraft system alone. The percentage split of aircraft versus ground-based braking will be determined, if necessary, as a part of this program. Integration of the latest in HEB technology and application of new design concepts suitable for incorporation in a flight research vehicle are sought. A Phase I program should define conceptual materials, design approaches, system architecture, and performance specifications. The major technical risks should be identified along with an assessment of the probability of success. Phase II of the program would include analysis and fabrication of prototype hardware for proof-of-concept performance testing in a laboratory environment.

AF88-108 TITLE: Structural Organic Composite Processing and Properties

OBJECTIVE: Improved material concepts and processing of structural organic composite components.

DESCRIPTION: Development of one or more of the following technologies is needed in the area of aerospace materials processing and design: (a) Innovative and improved methodology for processing structural composites (including molecular composites) components. Such activities can include new means of processing; fundamental research that can lead to improved quality and reliability of components; and computer aided systems for processing control. (b) Improved material concepts and systems (fiber, matrix, prepreg systems, or other material forms that can provide ultralight weight materials, with high specific strength and modulus, for structural application. (c) Improved mathematical modeling and experimental confirmation of emerging composite materials in the area of failure, processing, and design. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-109 TITLE: Biotechnology for Aerospace Materials Applications

OBJECTIVE: To apply biotechnology to aerospace materials requirements to achieve lower cost processes for advanced materials or improved materials designs not otherwise obtainable.

DESCRIPTION: This activity can include the following areas: (a) Biosynthetic methods to provide state-of-the-art materials for Air Force applications utilizing resources that can be domestically produced. The biosynthetic methods may provide unique precursors which can be converted by conventional chemical methods to materials such as organic matrix resins for lightweight structural composites; carbonizable matrix resins for carbon matrix composites, lubricants, elastomers, electro-optic materials, ceramic or ceramic precursors, and pure metals for structural or electronic applications. (b) Novel materials obtained from biological sources with properties that may satisfy current or future Air Force needs in areas such as those listed above. Examples would include carbonizable matrix resins with high theoretical char yield, modified ceramic exoskeletons which could be grown into a carbon matrix composite for oxidation protection, or materials with very rapid response to changes in light intensity. (c) Biodegradation techniques appropriate to applications such as polyurethane paint stripping or integrated circuit etching. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts. Either process or design concepts should lead to a marketable product for Phase III.

AF88-110 TITLE: New High Performance Polymers

OBJECTIVE: To investigate the synthesis, characterization and processing of new polymer systems in order to discover and tailor molecular structures which can provide performance advantages over state-of-the-art materials.

DESCRIPTION: Research and exploratory development is sought to discover new polymeric materials with potential for the development of improved structural materials, nonlinear optical/materials or conductive materials. Polymer systems with exceptionally high use temperatures and reasonably low energy requirements for curing and

processing will be considered. Areas of current high interest included investigation of (a) synthesis routes and methods to improve processing of rigid rod polymer molecular composites entailing the preparation of very thermally stable (600°-700°F use temperatures) high polymer systems under reasonable processing conditions and without the evolution of impractical quantities of volatiles, (b) theoretical chemistry to provide fundamental understanding of the molecular requirements for achieving nonlinear optical or conductive properties in organic and semiorganic polymer systems, (c) processing and morphology of rigid rod-like polymers to discover approaches for achieving superior compressive strengths, and (d) polymer structure-property correlations to elucidate processing options for achieving desired morphologies and mechanical properties. Phase I conducts research to discover, establish, and/or verify the potential of the specific approach being investigated (e.g., (a) synthesis routes and methods… (b)theoretical chemistry…, (c) processing and morphology…, or (d) polymer structure – property correlations…). Phase II pursues a high potential Phase I approach to bring it to a stage for follow-on development.

AF88-111 TITLE: High Temperature Engine Oil Base Stocks and Additives, and High Temperature Hydraulic Fluids

OBJECTIVE: To investigate and develop for use over the temperature range of –54° to 370°C. (a) Base stocks and boundary lubrication additives for high temperature gas turbine engine oils and, (b) High temperature hydraulic fluids.

DESCRIPTION: Research and development is required in the following two areas related to high temperature fluids and lubricants:

a. The Air Force is initiating a program to develop a –54° to 370°C advanced gas turbine engine oil for high performance engine technology (HPTET) engines. Perfluoropolyalkylethers (PFPE) are the most promising candidates known at this time. Two distinct technical programs requiring research in two different technical areas are required. Some of the work to be conducted consists of research and development of other chemical classes of base stock candidates as alternatives to the perfluoropolyalkylether candidates. Candidates shall be selected for further screening based on factors including, but not limited to: viscosity-temperature range, oxidative stability, toxicity, density, additive susceptibility and commercial feasibility of manufacturing. The candidates selected shall be further evaluated for high temperature (–54° to 370°C) capability. In the second program, boundary lubrication additive development for perfluoropolyalkylether base fluids, the effort consists of synthesizing and determining the effectiveness of candidate boundary lunrication additives for perfluoropolyalkylether (e.g., Krytox 143, Fomblin A, Demnum) candidate high temperature engine oils. These additives must be completely soluble in PFPE fluids at concentrations up to 5% by weight and must withstand a minimum of a 72-hour cold soak at –54°C without precipitating or otherwise coming out of solution. The effectiveness of candidate additives shall be determined using a standard four ball wear test (ASTM D4172) using high load conditions (40Kg load) or some other equivalent test method. The lubricity tests must be conducted at 75°C and up to 370°C. In addition to lubricity tests, the stability (oxidative and thermal) and metal compatibility characteristics of the formulations containing the candidate additives must be determined up to 370°C.

b. The effort consists of synthesizing and determining the suitability of selected classes of base fluids for use as hydraulic fluids over the temperature range of –54° to 370°C for long periods of time. Classes of base fluids which are expected to be the most promising candidates are the silahydrocarbons, perfluoropolyalkylethers and tri-n-alkylbenzenes. The optimum base fluids must be formulated with the reqisite performance improving properties and evaluated over a –54° to 370°C temperature range.

The Phase I goal for the above described programs is to demonstrate the technical feasibility of the technical approaches taken by the contractor. The Phase II goal for the above programs is to synthesize and characterize large quantities (?-5 Kg for program a.; 2 Kg for program b.) and demonstrate through experimental data their ability to achieve the goals of the respective program.

AF88-112 TITLE: High Temperature Materials for Advanced Systems

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

DESCRIPTION: New approaches to the development and characterization of advanced high temperature (2500-4000°F) structural ceramic and carbon matrix composites, and advanced high temperature (2000-3000°F) structural intermatallic materials and composites, are needed for potential Air Force applications in advanced gas turbine engines and advanced transatmospheric flight vehicles. New, unique high temperature matrix/reinforcement materials, configurations and oxidation protection systems must be developed, and evaluations conducted to determine matrix/reinforcement interactions during manufacture and during application of the composites. Test systems must be developed and applied for use with small samples to determine mechanical and physical behavior, such as failure modes, crack and void growth, oxidation, stress strain and cyclic stress-strain of behavior as a function of temperature and loading histories. Modeling mechanical and physical behavior in terms of composite constituent materials must be implemented, and applied to predication of mechanical behavior, failure characteristics, and response to environmental exposure of structural concepts for potential application in future advanced system designs. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-113 TITLE: Determination of Mechanical Properties of Materials Subjected to Severe Environments

OBJECTIVE: To develop methods to determine fracture, fatigue, creep and constitutive characteristics of newly developed materials for high performance turbine engines and advanced structures for aeronautical and space applications.

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

AF88-114 TITLE: High Performance Light Metal Alloys and Metal Matrix Composites

OBJECTIVE: To develop new and improved light metal alloys based on the Aluminum, Beryllium, Titanium, and Magnesium systems for use in high performance turbine engines and advanced structures for aeronautical and space applications.

DESCRIPTION: Unique approaches to result in new rapidly solidified aluminum, beryllium (Be), magnesium (Mg) and titanium alloys are required. These materials are needed to support the NASP, SDI and requirements identified in the Air Force Systems Command Forecast II study. Incorporated are ultra high temperature aluminum alloys to replace titanium for applications to 900°F and ultra high temperature titanium alloys to replace superalloy applications to 1800°F. Utilizing Rapid Solidification (RS) technology environmentally stable, ultra light magnesium alloys and beryllium alloyed to alter the normally hexagonal close-packed structure, are desired. Included is the response of these alloys to secondary processing. Rapid Solidification Technology (RST) Titanium alloy requirements are directed for improvements in three areas: temperature stability to 1800°F, strength to 210ksi, and higher modulus/density ratio. Because of good specific strength and stiffness, magnesium alloys are potentially attractive for many aerospace applications. Research is now needed to explore property improvements, especially in

the corrosion resistance of these alloys. Improvements in strength, stiffness, and a reduction in density may be possible using novel alloying additions. Approaches are needed in the following areas: development of an RS process for Mg and Be alloys development; low cost consolidation techniques, and characterization of microstructure/mechanical property interaction. Magnesium/graphite (Mg/Gr) metal matrix composites offer considerable promise for space applications because of their strength to density ration and zero coefficient of thermal expansion. Low cost scaleable approaches are needed for fiber wetting, composite compaction and assembly. Matrix materials considered should be rapidly solidified to take advantage of unique property improvements available. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-115 TITLE: Ultrastructured Materials

OBJECTIVE: Development of improved processes to fabricate ultrastructured materials for opto-electronic applications.

DESCRIPTION: Ultrastructured materials describes a broad technology area where the unifying theme is control of chemical composition or spatial order at nearly the atomic level in the range of 10 nanometers or less, thereby obtaining dramatic improvements in desirable materials properties. Development of improved processes to fabricate ultrastructures is within the program scope. Possible processes include, atomic layer epitaxy, ion cluster beam deposition, laser assisted deposition, metal organic chemical vapor deposition, molecular beam epitaxy, non-acid routes to polymer synthesis, bio-processing, and electroless and electrolytic deposition techniques. Processes for fabricating improved opto-electronic materials for applications such as solid state high frequency microwave, for infrared detection, optical signal processing, and artificially structured magnetic materials are of high interest. Robust process modeling and development of robust artificial intelligence (AI) sytems oriented toward smart processing and the ultra-high vacuum electronics shop floor are considered appropriate topics for the program area. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-116 TITLE: Nonlinear Optical Materials

OBJECTIVE: To demonstrate approaches for obtaining materials with large nonlinear coefficients in useful configurations for application in optical switching and in optical data processing.

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

AF88-117 TITLE: High Temperature Superconducting Materials

OBJECTIVE: Development of materials that demonstrate superconductivity at 77K or higher which can be incorporated into electronic circuitry both as passive and active elements.

DESCRIPTION: The recent dramatic increases in the transition temperatures for certain classes of superconducting materials (layered Perovakites containing La, Cu, O, and Ba or another Group IIA metal) makes their potential application to a broad range of Air Force systems far more feasible. For example, power requirements would be decreased if superconducting interconnections were used between active devices in cooled high-speed electronic

circuits. Speed could be increased by using superconducting materials for switching devices. Potentially sensitive bolometers may be practical at 77K for infrared detection. Work including modeling of the superconducting mechanisms, phase diagram studies of these compounds, development of unique processing methods and models, thermal conductivity and heat capacity analyses, and electrical and magnetic measurements are examples of topics considered appropriate for this program area. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-118 TITLE: Field Surface Preparation for Adhesive Bonded Repair of Aluminum Alloys

OBJECTIVE: To demonstrate the feasibility of the use of non-hazardous bonding pretreatments for aircraft aluminum alloys.

DESCRIPTION: The effort shall focus on the development, test and evaluation of non-toxic non-hazardous pre-bond surface preparations for aircraft aluminum alloys. Candidate surface treatments shall be characterized using surface analytical tools such as Fourier Transform Infrared Spectroscopy (FTIR).

Scanning Electron Microscopy (SEM), Auger Spectroscopy (AUGUER), etc., and evaluated mechanically using the double cantelever wedge opening test. Adhesive materials to be utilized shall include two-part as well as one-part film type adhesives. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-119 TITLE: Unified Life-Cycle Engineering Design Aid

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

DESCRIPTION: The design of most real-life (in lieu of idealized academic problems) engineering systems is characterized by the following descriptive sentences: (a) The problems are multi-leveled, multi-dimensional and multi-disciplinary in nature. (b) Most of the problems are loosely defined, open-ended, virtually none of which has singular, unique solution, but all of which must be solved. The solutions are less than optimal and are called satisfying solutions. (c) There are multiple measures of merit for judging the “goodness” of the design, all of which may not be equally important. (d) All information required may not be available. (e) Some information may be hard, that is, based on scientific principles and some information may be soft, being based on the designer’s judgement and experience. The ultimate engineering scheme must be based on life-cycle considerations to include both the “process-of-design: and the many “disciplines” which must be invoked during the process. The goal of life-cycle engineering is to design “optimum” or near-optimum” systems. Optimum is defined as a design that is feasible and also superior to a number of other feasible alternative designs. A superior design can be obtained in two ways: 1) by an iterative process, or 2) by solving an optimization problem. In the first way the design is improved through repeated modification and the values of the design variables are changed or made firm sequentially. The process relies heavily on interaction with the designer who has to use his experience-based insight to guide the solution process. In the later, all the design variables are determined simultaneously so as to satisfy a set of constraints and optimize a set of objectives. External intervention by the designer is necessary only if the problem formulation or the input data are to be altered. The preferred process is the later because it frees the designer of tedious data gathering and forces more objective solutions. In addition, the autonomous behavior of such a design aid may extent to adaptive or self-improving performances, real-time interaction with distributed databases and expert systems, and automatic generation/translation of design variables into mathematical expressions for algorithmic computation. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-120 TITLE: Common Data Semantics Modeling Processor and Resolver Tool

OBJECTIVE: To capture user views and definitions and automatically resolve and process required data to applications regardless of the data source with the conceptual schema of the enterprise.

DESCRIPTION: The Air Force developed the Integrated Computer Aided Manufacturing Definition (IDEF) methodologies for a broad base of users. The languages of IDEF are crystallizing and maturing. This process is pointing out the need for research to augment the languages making it more simple to capture specifically how the user views his environment; operates within his environment; to capture how he activates the mechanisms to perform his functional tasks; how he asserts, triggers, and constrains the processes and data under his control; and to capture the user value system for and demand storage and retrieval from data management systems. Data base management machines have increased the users ability to store and retrieve data faster. This advancement in technology has not solved the inherent data management problems of accuracy, quality and uncontrolled duplication of data. This effort should explore the use of data base machines for processing "common data" and the administration of common data. The state management of data as it is processed through the business enterprise is not well understood and requires this research. The developer should demonstrate the common data processor technology using parallel processing technology attached to an Office of Standard International (OSI) network to provide the independence and widest possible application support for engineering and manufacturing users. The User Semantics Modeling and Resolver Tool should demonstrate the ability to capture and represent user characteristics and criteria, and support the resolution of user views into the Enterprise Conceptual Schema (ECS). The User Semantics Modeling and Resolver Tool should support the ECS administrator in the resolution of system data conflicts. This technology should support life cycle discipline from product requirement and conceptualization through product logistical support. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-121 TITLE: Space Power Technology

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

DESCRIPTION: Development of one or more of the following technologies is needed in the area of space power including thermal management, power conditioning, energy conversion and energy storage: (a) fault tolerant, lightweight power distribution; (b) high frequency (greater than 400 hertz) power distribution: (c) high voltage (100-1000 volts) direct current distribution; (d) insulations and dielectrics; (e) high efficiency (greater than 30%), hardened, solar photovoltaic energy conversion; (f) high temperature (600 centigrade) photovoltaics; (g) autonomous power system operation; (h) high energy density (greater than 50 watt hours per round) electrochemical energy storage; (i) thermal energy storage; (j) low area lightweight, survivable 100° centigrade radiators; (k) high efficiency heat transport (heat pipes); (l) thermionic energy conversion technology for nuclear based systems; (m) high efficiency solar thermal concentrating technology; (n) heat receivers; and (o) heat to electric conversion technologies.

AF88-122 TITLE: Power Technology for High-Performance Aircraft

OBJECTIVE: To develop electrical, mechanical, fluid and energy storage system and component power technologies for high performance manned and unmanned aircraft.

DESCRIPTION: Development of one or more of the following advanced power technologies is required for future aircraft: (a) high temperature (greater than 500 centigrade) components, fluids and seals for hydraulic systems; (b) energy efficient hydraulic technology; (c) cold weather (-55 centigrade) energy storage technology (batteries, hydraulic accumulators, capacitators); (d) fault tolerant power technology; (e) solid state power controllers; (f) high temperature (200-1000 centigrade) wire, cable, connectors, power semiconductors and filter capacitators; (g) high temperature (300 centigrade) 30 million Gauss-Oersted permanent magnets; (h) innovatie converter/inverter capabilities for producing high quality three-phase 400 hertz power; (i) lightweight shafts, gearing clutches,

housings and gearboxes with special emphasis on advanced materials; (j) high performance small turbine technology; (k) electromagnetic actuator and other electrically driven systems such as fuel pumps; (l) cooling techniques for power componentry and hot aircraft surfaces.

AF88-123 TITLE: Pulsed Power for Airborne/Spaceborne Applications

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

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

AF88-124 TITLE: Missile Electrical, Thermal and Mechanical Power (Nonpropulsion)

OBJECTIVE: To develop advanced sources of onboard and ground support power for strategic intercontinental ballistic missiles (ICBM) cruise missiles, and/or tactical air intercept (AIM) and/or air to ground (AGM) missiles.

DESCRIPTION: Innovative nonpropulsion, power technology advances are sought that offer revolutionary reductions of life cycle cost, weight and/or volume and/or increases of active and/or inactive operational lifetimes. The power technologies of interest are: hydraulics, actuators; auxiliary power units, ram air turbines; airborne generators and/or electric power systems; thermal control; batteries; fuel cells. The application areas of interest are: onboard sources of power and/or power generation technology, as well as, hydraulics and actuation for ICBM, AIM, AGM and cruise missiles; ground support power for missile silos and/or transporters. The power source goals/desired characteristics are listed below: (a) ICBM, AIM & AGM onboard power: peak power 22 kw/kg in a pulsed mode, active lifetimes from 1-60 minutes; shelf life of 25 years without maintenance; 1 second delay or less from initiation to full load; operation over altitude range from sea level to 1500 km; operation over temperature range from -54° C to $+74^{o}$ C without power from an external heat source; granimetric energy density from 25 wh/kg for 1-minute lifetimes to over 220 wh/kg for 60 minute lifetimes; volumetric energy densities from 0.1 wh/cc for 1-minute lifetimes to over 1 wh/cc for 60-minute lifetimes; size average power range from .1 to 10kw; (b) ICBM support/silo power source; 15 years' inactive lifetime; active lifetimes up to 10,000 hours; 900 wh/kg or greater., 1.5 wh/cc or greater; thermal efficiency of 90%; 500 kg or greater modules; (c) ICBM support/silo energy storage: 15 years' lifetime; round trip energy efficiency 80%; 220 wh/kg; 1 kw/kg peak power capability; 1000 discharges/charges; 0.6 wh/cc; minimum self discharge rate of 10,000 hours; size, 50 kwh or larger, (d) Cruise Missiles: dynamic power sources up to 5000 watt eith energy densities approaching 0.6 kw/kg and lifetimes of 10's of hours, electrical actuator systems in the integral horsepower arena.

AF88-125 TITLE: Weaving and Braiding Techniques for Turbine Engine Composite Components

OBJECTIVE: To investigate the automation of the fabrication of continuous fiber reinforced composite components for future advanced gas turbine engines.

DESCRIPTION: Continuous fiber reinforced composite materials offer properties which enable the designers of gas turbine engines the ability to develop lightweight, high performance engine components. The purpose of this effort is to investigate the application of special weaving or braiding techniques to the automation of the fabrication of composite components for advanced engines. Current fabrication methods, other than filament winding, rely heavily on hand layup techniques. This leads not only to high fabrication costs, but also to problems with repeatability and quality assurance. Future, highly structurally efficient components will make very high demands on fiber orientation accuracy and integrity. This Phase I effort will investigate the feasibility of automating the fabrication of near net shape components, while allowing total freedom of fiber orientation and geometry. These latter qualities will allow the true tailoring of the material's and hence, the component's mechanical properties. A follow-on Phase II effort will build and test the automated fabrication technique designed during Phase I activities.

AF88-126 TITLE: Turbine Engine Test Instrumentation Techniques

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

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 gage 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 temperatures and strains typical of turbine engines for extended periods of 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.

AF88-127 TITLE: High Temperature Electronics for Aircraft Engines

OBJECTIVE: To develop innovative technology to provide electronic and electro-optical devices that can tolerate long-time exposure to temperatures above 300°C without fuel cooling.

DESCRIPTION: Considerable effort is being expended to advance microprocessor performance through increased levels of integration and miniaturization. Little of this effort is being devoted toward improving the operating temperature capability of integrated circuits. Some of the approaches employed are contrary to high-temperature operation. Various semiconductor materials and design and fabrication techniques are known to enhance the operating temperature capability of circuits and show promise for further development. This effort should be directed toward devices with modest computational capability to perform ancilliary functions at remote locations, such as on sensors and actuators, and not for a central processor. Electro-optical interfaces for optical data bases may be considered. Phase I will result in feasibility demonstrations. Phase II will include breadboard testing of fabricated devices and will lead to a Phase III system demonstration.

AF88-128 TITLE: Support Technology for the Integrated High Performance Turbine Engine Technologies (IHPTET) Initiative

OBJECTIVE: To provide basic, or generic, supporting technologies required for the achievement for the year 2000 goal of the IHPTET Initiative – to double turbopropulsion capability.

DESCRIPTION: The IHPTET Initiative is an integrated DOD/NASA effort to double turbopropulsion capability by the turn of the century for a wide range of future military and civilian aerospace systems. The IHPTET technical approach includes the development and application of high temperature lightweight materials, advanced aerothermodynamics and innovative engine structural concepts. These technologies will be integrated into advanced engine components which will then be assessed and verified in Advanced Technology Development demonstrator engines. In the supporting base technologies, innovative research and development is needed in many areas – including, but not limited to, new techniques for the fabrication and application of composite materials (metal-matrix, ceramic, and carbon-carbon) to turbine engine components having complex shapes, computational fluid dynamics models for 3-D viscous flows with improved accuracy and computational efficiency, efficient new techniques for engine hot section cooking, development of lightweight engine control components and accessories, and new high temperature bearings and lubrication concepts. This topic is intended to provide latitude to a proposal to submit innovative IHPTET related concepts not addressed by other more specific IHPTET topics.

AF88-129 TITLE: High Temperature Tribological Assessment

OBJECTIVE: Design, construct, demonstrate and deliver a tribometer capable of assessing critical tribological properties of advanced liquid and solid lubricants at temperatures from 400 to 1000°C under controlled atmospheric conditions.

DESCRIPTION: Advanced candidate liquid and solid lubricant materials which may be available in subgram quantities require basic tribological characterization under conditions of potential use in advanced turbine engines. A tribometer is required to be designed and built such that specimen and test configurations will be adaptable for different materials and conditions. Test cost and evaluation time should be minimum. Design should include capability for real time presentation and permanent record of friction and wear data. Phase I activity will include conceptual design and selection of materials enabling high temperature operation. Phase II will include final design and construction of the machine, selection of wear substrate materials which may be potentially useful in advanced turbines and demonstration and delivery of the tribometer.

AF88-130 TITLE: Air/Oil Seal Concepts for High Speed Applications in Advanced Turbine Engines

OBJECTIVE: To develop innovative concepts for air/oil seals in advanced turbine engines which would be capable of operating at very high rubbing velocities, high temperatures and high differential pressures.

DESCRIPTION: In order to meet the thrust-to-weight ratio goals of advanced engines, it is predicted that rotor speeds will need to increase on the order of 20% over current state-of-the-art production military engines. The temperature environment in which the seal must operate will also increase. In addition, counter-rotating shafts are being used in these engines, which also increases the rubbing velocities of seals used in the intershaft locations. Innovative approaches are needed for the design of air/oil seals capable of operating at rubbing velocities up to 1200 ft/sec and at temperatures of 1500°F. Maximum air leakage rate must not exceed 50 lb/hr at differential pressures as high as 100 psi. Phase I activity would include design and analysis of innovative seal concepts. This will lead to Phase II activities of fabrication and testing of the most promising concepts.

AF88-131 TITLE: Fuel Combustion Technology

OBJECTIVE: To demonstrate significant advances in combustion technology.

DESCRIPTION: Renewed interest in hypersonic flight and continued emphasis on improving the performance of conventional aircraft require significant advances in fuel combustion technology. Specific topics of interest include: (1) combustion enhancement concepts for use with conventional and advanced fuels in subsonic and supersonic combustors wherein the ignitability and flame propagation speed of the fuel is inadequate under some flight conditions; (2) new fuel/air mixing concepts for potential use in subsonic and supersonic combustors to increase combustion efficiency, reduce pressure losses and permit the development of smaller, lighter combustors; (3) new or

improved mathematical models that accurately calculate fuel/air mixing in the presence of large-scale turbulent structures, including simplified but accurate fuel pyrolysis and oxidation kinetics and include two-phase flow capabilities for handling liquid fuel injection, automazation and evaporation; and (4) advances in non-intrusive diagnostics that can measure temperatures, pressures, species concentration and other parameters of interest in turbulent, reacting flows and with data rates exceeding 10kHz.

AF88-132 TITLE: Organic Compound Data Base for Fuel Selection and Optimization

OBJECTIVE: To develop a searchable computer data base with calculational structure permitting the evaluation of organic compounds as fuels.

DESCRIPTION: Selection of promising fuels and evaluation of representative fuels rely on the use of thermodynamic properties reported primarily in printed tables. The data are often unverified, with selection between conflicting values dependent upon a critical assessment or confirmatory evaluation. In other cases, properties can be obtained only by calculation from other thermodynamic data. Referred data available in a readily searched format permitting calculation of missing values would allow better selection of organic compounds/fuels for a variety of Air Force missions. A data base incorporating referred data on organic substances, including thermodynamic, physical and chemical properties, will be constructed. The data base will be structured to permit the evaluation and incorporation of new referred data, and will permit determination of compound properties at specific conditions, as well as review and interpolation or extrapolation of existing data. Referred calculation routines permitting property evaluation and optimum selection will also be included. Language, format, and computer system selection will be negotiated at the time of contract award. Phase I activity will include survey, selection and evaluation of data and equations and outline of the data base structure. Phase II will include incorporation of data and equations into the data base, development of software and manuals for user friendly operation, and operation of the data base on a local system.

AF88-133 TITLE: Advanced Aviation Fuels

OBJECTIVE: To investigate high energy-density fuels and those advanced fuels and fuel system concepts which will permit aircraft fuels to be used as a coolant during high velocity flight.

DESCRIPTION: Conventional aircraft fuels do not have sufficient heat sink capacity to cool air vehicle and propulsion system components during high velocity flight. For the least demanding case, the fuel can be a high boiling liquid which is thermally stable to its vaporization temperature at fuel system pressure (non-vaporizing case). If further heat sink capacity is necessary, such fuel could then be vaporized to absorb additional heat. To minimize the heat absorption capability of the fuel, the vapor may then undergo a thermally and/or catalytically induced endothermic reaction. Liquid fuels which undergo various combinations of heating, vaporization, and catalyzed dehydrogenation reactions to provide acceptable heat absorption are being studied. Furthermore, new approaches to high energy-density fuels are always of interest. New, innovative fuel concepts are needed to provide adequate heat sink, high gravimetric and volumetric heating values, excellent high temperature stability and good combustion characteristics. Proposed fuels must have good storage stability and low-cost, large-volume production capability. Phase II will involve bench-scale test and evaluation of fuel concepts explored in Phase I.

AF88-134 TITLE: Advanced Air Separation Concepts

OBJECTIVE: To develop techniques for in-flight collection of air by hypersonic, suborbital, and orbital vehicles for the purpose of separating oxygen and storing it for use in a rocket.

DESCRIPTION: Promising concepts are sought for in-flight collection of air by hypersonic, suborbital, and orbital vehicles for the purpose of separating oxygen and storing it for use as in a rocket. Numerous studies conducted in the 1960's indicate that systems capable of handling air flow rates of 2,000 lb/sec and producing 90% pure oxygen are required for a practical space vehicle; thus, these are the minimum performance requirements for any proposed oxygen separation/enrichment concept for use in flight. Emphasis also must be placed on lightweight and small

volume devices and/or processes. Methods considered previously have included distillation, cyclic oxidation reduction, and membrane processes. New materials and new processes available since 1965 should be examined for potential application. Responses should include preliminary volume and weight estimates for a 2,000 lb/sec air handling capacity system. Phase I goal: Preliminary demonstration of concept feasibility. Phase II goals: Preliminary design of full scale system and demonstration of a small-scale prototype.

AF88-135 TITLE: Prevention of Freezing in Cryogenic Heat Exchangers

OBJECTIVE: To develop techniques by which flow blockage can be minimized in cryogenic heat exchangers.

DESCRIPTION: Promising concepts are sought to alleviate atmospheric constituents fouling in air liquefaction based propulsion systems. Atmospheric air, when cooled to very low temperatures by heat exchange with cryogenic fluids, will deposit water and carbon dioxide on the heat transfer surfaces, reducing heat transfer efficiency and causing blockage of airflow passages. Techniques are sought by which flow blockage can be minimized. The water and carbon dioxide may be actively removed or accommodated by features of the design. Active removal means should avoid great complexity as well as large weight and volume. Means of accommodating ice and carbon dioxide also should be light and as small as possible. Methods previously considered have included glycol injection, cyclic de-icing, tube coatings, thermal/pressure distortion, ultrasonic vibration, liquid air injection, and liquid condensation combined with glycol injection. New materials and processes available since the mid-1960's should be examined for potential application. Phase I goal: Preliminary demonstration of concept feasibility. Phase II goals: Preliminary design of full-scale system and demonstration of a small-scale prototype.

AF88-136 TITLE: Combined Cycle Propulsion Technology

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

DESCRIPTION: New and novel concepts and approaches are sought for combined cycle propulsion systems which involve the elements of ramjets, scramjets, rockets, turbojets, turbofans, and ejectors in various combinations. Such propulsion systems would be capable of operating over a wide range of flight Mach numbers from 0 to 8 or above. Both manned and unmanned vehicles are involved. The aim of combined cycle propulsion systems is to maximize the over-all system efficiency by exploiting the attributes of the various elements in their respective best operating speed regimes. In addition to maximum efficiency, emphasis is also placed on low weight, volume, and cost.

AF88-137 TITLE: Improved Analytical Capabilities for Air Bearings

OBJECTIVE: To develop advanced analytical techniques for design and analysis of compliant foil air bearings for gas turbine engines up to 1,000 pounds thrust.

DESCRIPTION: Advanced analytical methods are needed for the design and testing of compliant foil air bearings for advanced gas turbine machinery. Emphasis will be placed on developing improved analytical tools needed for rotor dynamic studies in the design of the engine rotors for journal and thrust air bearings and in interpreting results, including failure modes of component bench test rigs and engine simulator testing. Also, improved methods for predicting bearings performance and critical parameters such as sway space and journal and structure distortion are needed for determining thermal effects on the rotor group and on thrust and journal bearing carriers. Phase I activity will include development of improved analytical methods for rotor dynamic studies and for thermal effect studies. Phase II activities will apply these improved techniques to testing journal and thrust compliant foil air bearings in component bench test rigs and in engine simulators.

AF88-138 TITLE: Department of Defense (DOD) Anthropometrics

OBJECTIVE: To establish procedures for obtaining the range, numbers, and selected bodily characteristic measurements of the DOD personnel population.

DESCRIPTION: Many types of equipment are developed, purchased, and issued to DOD personnel. Specific databases used in determining the numbers, sizes, and sizings characteristics themselves are derived from estimates and statistical analysis of population profiles. However, DOD subpopulations have specific characteristics relatively unique to the DOD. What constitutes "fit" and how "fit" relates to the development, storage, and issue of garb to DOD personnel is currently undefined. For example, no criteria currently exists for the issue of chemical protection masks that guarantee full protection of the 10 to the fourth power protection factor. This project would (1) establish criteria needed to determine what body characteristics to measure and to what extent, (2) obtain these data for current DOD personnel, or (3) suggest procedures to be used to get the data. In addition, the project would establish procedures to obtain and maintain this database for all new DOD personnel on a continuing basis. The database would be used to provide baseline population data in the acquisition and issue of equipment for various segments of the DOD.

AF88-139 TITLE: Standardized Recording Test and Measuring Equipment (T&ME)\

OBJECTIVE: To identify and/or develop a full range of efficient Test and Measuring Equipment possessing standardized electronic readouts.

DESCRIPTION: Currently, many field failures and errors are traceable to product nonconformances that were undetected during project inspection and test. Some reasons for this are (1) that the manual inspection and test methods used are prone to human error, (2) the equipment does not incorporate the newest technology available, and (3) lack of standardized automated development/manufacturing methods. This project would (1) identify the range of the most common T&ME equipment product characteristics, (2) develop a standardized format for T&ME output displays to verify the chemical, physical, electronic, mechanical and other characteristics, and (3) identify and/or develop a full range of standardized, real-time digital output instrumentation. One suggested T&ME development approach would include selection of input/output data formats; selection/development of a full range of electrical, thermal, pressure, and other sensors that could be used to build automatic sensing and standardization of digital readout capabilities. Project benefits could be measured in terms of how well new generation T&ME equipment keeps pace with the current technology and newly developed automated techniques. Additional savings are achieved through reduced manpower required to perform inspection/test, fewer undetected failures, and more productivity.

AF88-140 TITLE: Low Temperature Curing Resins for Composites Repairs

OBJECTIVE: To demonstrate the feasibility of the rapid structural repair of thermosetting composites via the use of strong acid catalysts.

DESCRIPTION: One approach that show promise for the rapid low temperature cure of conventional heat curing epoxy resins is the use of strong acid catalysts. This effort will focus on the cure of conventional aerospace epoxy resins using strong acids as catalysts. Resin theological performance as well as cured mechanical properties shall be evaluated to demonstrate feasibility. Dynamic mechanical spectroscopy and differential scanning caloremetry shall be used to develop the necessary data. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-141 TITLE: Low Cost Molding Process for Composite Components for Aircraft

OBJECTIVE: To demonstrate the feasibility of the use of low cost – high rate production technology for the fabrication of high performance components for aircraft.

DESCRIPTION: High rate, low cost production process including RIM (resin injection molding) and RTM (resin transfer molding) will be modified and evaluated for feasibility demonstrations of their use in the production of high performance aerospace composite materials. Epoxy, BMI polymide and PBI resins shall be utilized in combination with graphite reinforcements and RIM and RTM processes 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 aircraft structures. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-142 TITLE: Ultrasonic Repair of Thermoplastic Matrix Composites

OBJECTIVE: To demonstrate the feasibility of rapid structural repair of carbon fiber reinforced thermoplastic resin matrix composites.

DESCRIPTION: Thermoplastic matrix carbon finer composites have strong potential for good survivability in the maintenance environment and for low cost production routes. These composites are presently the subject of intense research and development to develop the enabling technology for their introduction into the inventory. Crucial to the application of these materials are rapid and effective repair procedures. This effort is to demonstrate the feasibility of the use of ultrasonic welding and bonding technology to perform structural repair of damage thermoplastic matrix composites. Thermoplastic matrix composites including Polyether Ether Ketone (PEEK), Amid-Imid Polymer (Torlon), Langley Research Center-Thermal Plastic Polymide (Larc-TPI) and other will be selected for repair studies. Effort shall be concentrated on the demonstration of rapid and complete bonding and welding of step-lap, scarf and doubler type repairs. Specimens shall be inspected via nondestructive methods, cross sectional and examined under optical and Scanning Electron Microscopy (SEM) as well as tested for mechanical properties. Phase I of this program would address requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-143 TITLE: High Performance Carbon-Carbon Composites for Advanced Application

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

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

AF88-144 TITLE: Controlled Emissivity Materials and Techniques

OBJECTIVE: To investigate innovative approaches for controlling the spectral emissivity of materials.

DESCRIPTION: The Air Force is interested in conducting basic research into the science of selecting and controlling the emissive nature of materials. Materials to be investigated may be in either bulk form or as a combination of constituent materials in some unique construction. Research shall include controlling both high emissivity and low emissivity over select frequency bands through the visual/infrared electromagnetic spectrum at room temperature up through select elevated temperatures. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-145 TITLE: Improved Nondestructive Evaluation

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

DESCRIPTION: Advanced, innovative approaches are needed for the development of improved nondestructive inspection and evaluation (NDI/E) techniques for the detection and characterization of flaws in airframe and engine materials including metals, composite, and ceramics, and for use in real-time monitoring or aircraft structure manufacturing processes. In particular, innovative technical approaches are needed for the detection and characterization of bulk and surface defects in both metallic and non-metallic structures, for the evaluation of the integrity of bondlines in bonded structures, for the determination of the condition of the matrix and reinforcing substructures in advanced composite structures, for the quality of high-temperature material coatings, and for the inspection and evaluation of electronic device materials and components. Technical approaches proposed must either achieve clearly significant improvements in the standard techniques currently being used in factory and field inspections or must identify new inspection and evaluation techniques which have capabilities far superior to those currently used and which have the potential for ultimate use in realistic manufacturing or in-service environments. Proposals addressing significant technical advances in all phases of the inspection procedures are solicited, from new sensors for the collection of inspection data to advanced NDE signal processing concepts and methods. Phase I of this program would address application requirements and goals as well as initial formulation, fabrication, and evaluation of specific subjects for proof of concept. Phase II would perform enhanced development for optimization followed by trade and design studies for future efforts.

AF88-146 TITLE: New Concepts and Innovations for Aeronautical Systems/Subsystems

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

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

AF88-147 TITLE: New Concepts and Innovations for Logistics Support

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

DESCRIPTION: This category of innovative concepts is intended to cover all facets of logistics support research, acquisition and management. It is also intended to provide latitude to the innovator to include areas not specifically addressed by other specific topics. This general area covers the full spectrum of Air Force logistics (i.e.. design interface, maintenance planning, supply support, technical data, etc.). Emphasis is placed on potential long term planning concepts. Topics as diverse as new technology impacts on traditional logistics planning and improved

software life cycle cost modeling can be submitted. Some other areas of interest are impacts of new operational concepts and logistics organizations, models to assess the effectiveness of logistics planning in wartime situations, etc. This topic is structured to provide a maximum of innovative flexibility to prospective participants.

AF88-148 TITLE: Location and Recovery of Downed Air Crews in Wartime Environment

OBJECTIVE: To investigate new innovative approaches to locate and recover downed air crews.

DESCRIPTION: Investigate new and innovative methods to locate and recover downed air crews in a wartime environment in smoke, fog, and haze. One such method might be to equip air crews with a portable handheld radar system similar to automobile traffic control units. Actuation of the device would register on a rescue aircraft radar screen with a computer to establish map coordinates and information as to whether the crash is fresh or not. Currently, helicopters hover overhead and are vulnerable to enemy ground action during recovery. If a suitable recovery kit was provided to air crews, it might be possible for the helicopter to avoid hover and increase survivability on the first pass over the crash site. It might be possible to use a faster fixed wing aircraft, instead of a helicopter. The Phase I effort should concentrate on various optional techniques and their analysis to determine the most effective approach(es). The Phase II effort would examine the specific technique(s) identified in Phase I and develop the technique into specific implementations and their projected operational utility.

AF88-149 TITLE: Artificial Intelligence Applied to Aeronautical Systems

OBJECTIVE: To develop Artificial Intelligence applied to all aspects of the Air Force mission related to aeronautical systems.

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

AF88-150 TITLE: Aeronautical/Space Operational Interface Requirements

OBJECTIVE: To access the operational utility and interface requirements between aeronautical and space assets generated data.

DESCRIPTION: The strategic and tactical operational use of space assets generated data requires the examination of a number of interface concepts and the development plans for verification of the utility of these interface concepts. This effort will review and update current verification methodologies to include current and planned aircraft and space systems as well as develop specific simulation methodologies to assess the operational utility of the interface concepts. Phase I of this program should outline the scope and develop the approach for a methodology which can simulate the mission environment to determine operational utility of the specific interface. Phase II will do the detailed assessment and interface requirements definition for a number of current aircraft and space systems relative to their potential contribution to mission effectiveness. Work will require access to, storage and creation of classified data, and personnel security clearances.

AF88-151 TITLE: Tactical Theatre Air Warfare Methodologies/FY88

OBJECTIVE: To improve the current tactical methodologies used for submission area evaluation by building an integrated-interdependent modeling approach for assessment of mission requirements.

DESCRIPTION: Vanguard is a development planning tool. The Vanguard methodology includes offensive counterair, defensive counterair, the suppression of enemy air defenses, and tactical air-to-surface components. Each submodel stands alone and is not evaluated in concept with the other components. In addition to the lack of model integration, many conceptual systems are difficult to or cannot be analyzed with current methodologies. For example, the disruptive effects of jamming drones, mine warfare weapons cannot be evaluated in the current methodology. The tactical air-to-surface methodology includes only destruction of targets (i.e., percentage of required target set killed) as a measure of merit and ignores the remaining air interdiction mission components of delay, disruption, and diversion. In general, Vanguard as well as the tactical analytic community would benefit from an integrated modeling tool which evaluates the previously mentioned submission areas with the ability to include a host of conceptual systems as well as traditional weapon/airframe/avionics contributions. A Phase I effort would consist of the development of a matrix and supporting data base of existing/proposed methodologies which addresses each of the submission areas. Because cost for the development and integration of the various submission areas methodologies is a prime consideration, this matrix should consist primarily of Government owned models. This data bank should, at a minimum, include the inputs, sources for inputs, hardware and software requirements, current users, the developer, analytic purpose and the outputs for each model. This data bank should then be analyzed for recommendations on the best course of action for integrating the submission area models into a single model. The proposal should also include steps necessary and the requirements necessary to integrate the final product into the tactical Vanguard process. The matrix and data bank should include "best weapons," the current Vanguard modeling tool, as a standard of comparison. The Phase I effort is intended to identify methodologies and prepare a top-level design of a recommended integrated solution. Phase I should address the prerequisites of detailed system design, implementation and control in a Phase II effort.

AF88-152 TITLE: Remote Detection of Fuel Vapors and Exhaust Fumes

OBJECTIVE: To investigate the feasibility of infrared differential absorption techniques using Laser Detection and Ranging (LADAR) sensors in the detection of fuel vapors and exhaust fumes.

DESCRIPTION: Investigations are needed to determine the spectral line signatures for fuel vapors and exhaust fumes by the use of a Differential Absorption LADAR (DIAL) sensor in the near infrared. In the Phase I effort, as a minimum, the remote detection investigation of techniques should include: the selection of spectral lines emitted by a multiwavelength agile laser, the degree of propagation of these lines through various slant ranges up to five miles, and the necessary concentration of fuel vapor or exhaust fumes to provide detectability from a DIAL sensor. The Phase II effort will provide validation and demonstration of the techniques developed in Phase I.

AF88-153 TITLE: Development of Interactive Threats for Combat Mission Simulations

OBJECTIVE: To develop a capability for converting available data on manned and man controlled threats into software suitable for use in training engagement and follow-on tactics and criteria in future combat simulation applications.

DESCRIPTION: Current methodologies in using simulation to accomplish tactical combat mission training are limited to the identification and early positioning tasks of the mission due to the limited ability and fidelity of threats to present realistic, complex flyouts of combat scenarios required in today's training environments. This is mainly due to the inability of such simulations to present follow on interactive events without using costly and often nonoptimum manpower to control the actions of the required threat. Since most tactical combat scenarios require large numbers of man interactive threats to achieve realism and combat training objectives, a possible solution is to automate these threats by using current computer capability and technology. The initial task required is to conduct a literature search and then define threat performance parameter standards, algorithms, and rule based performance options based on perceived cueing and mission objectives. The contractor must then create a generic software product which will integrate all of these factors into a rule based, real time interactive program compatible with current simulator technology. The generic model should include ground based and airborne threats and replicate the search, acquisition, sort, engage, flyout and disengage profiles applicable to the threat envelopes. The outcome of this effort will be a reproducible software program that can be selectively applied to specific programs and needs within combat training systems throughout the Air Force. The program will be adjustable and manageable by the

Air Force to account for specific threat characteristics, specific weapons employment criteria and effects, and able to simulate team or joint threat activity as needed.

AF88-154 TITLE: Technology Modernization (Tech Mod) for Small Businesses Supplying Propulsion Products

OBJECTIVE: To involve small businesses in the propulsion sector's efforts to reduce cost, increase quality, reduce lead times, and reduce use of critical raw materials in the production of aircraft engine components.

DESCRIPTION: The Tech Mod program addresses development, integration, and implementation of new manufacturing technologies that can be applied to the propulsion sector. Small businesses that are presently supplying machine tools, processing equipment, parts, or hardware to the propulsion sector are encouraged to submit proposals. The proposals may either relate to improvements that are or will be offered to the propulsion sector, or those that will be implemented within the company offering the proposal and that will significantly reduce the cost of propulsion systems to the United States Government. The types of work included in Tech Mod are study, development, and implementation efforts relating to:

a. Enabling technology
a. Design of in-plant material handling, storage, and movement systems
b. Design of special tools, test equipment, and inspection equipment
c. Design and integration of factory layout and work cells
d. Qualification of new processes, cells, and work centers
e. Qualification of hardware produced by new processes
f. Integration of new technology into production systems
g. Management information systems (internal to the company only)

AF88-155 TITLE: High Dynamic Range Mixers

OBJECTIVE: Develop a high dynamic range millimeter wave mixer and demonstrate its preliminary performance.

DESCRIPTION: Communication receivers for space based applications can potentially be subjected to high power jammers that can saturate the receiver front-end mixer. When the mixer is saturated, spurious lines or intermodulations appear thereby decreasing the detection signal/noise ratio, and the signal detection gain. It is very difficult to suppress the jamming signals with the receiver electronics since they are in the same band as the signal. However, if the mixer has a large dynamic range so that it will not be saturated by the jammer, then techniques exist in the receiver to suppress the jamming.

Mixer analyses use the principle that the second-order term is responsible for intermediate frequency conversion for the desired signals. Higher even-ordered terms contribute to intermodulation and cross-modulation terms. The odd-order terms can be effectively eliminated by filtering. High dynamic mixer performance is dependent on the diode non-linear characteristics which are affected by the diode design, the bias conditions, and the external circuit.

AF88-156 TITLE: Novel Millimeter Wave Sources for Phased Array Applications

OBJECTIVE: Develop a compact and lightweight millimeter phased array structure.

DESCRIPTION: Many advanced communications and radar systems require phased array structures with increasing scanning and resolution capabilities. Conventional beam steering is done by shifting the pulse of individual amplifier/antenna module. Improved methods are needed for efficient millimeter wave generation and phase control. In order to accomplish these goals, advanced technologies must be extensively employed. These techniques include but are not limited to: electro-optics, phase conjugation, intense modulated electron beam generation, novel millimeter wave phased array structures, advanced interferometric and modulation techniques.

Phase I products: Perform trade-off studies to identify needed approaches and current phased array antenna problems and provide detailed analyses of proposed approach. Define detail specifications and tasks for Phase II.

Phase II products: Provide proof-of-the-principle and design a phased array structure to meet the performance specifications.

AF88-157 TITLE: 60 GHz IMPATT Diodes

OBJECTIVE: Develop a 60 GHz high efficiency and output power IMPATT diode design and doping profile growth.

DESCRIPTION: High power and high DC-to-RF conversion efficiency low noise GaAs IMPATT diodes are needed for space communications. It is fundamentally important to use high power solid state transmitters for space based communications to achieve large bandwidth and long distance links. The use of high power and high efficiency diodes reduces the number of diodes required for power combining hence enhancing reliability and reducing prime power dissipation in the system.

Phase I products: Perform trade studies of high efficiency and output power IMPATT diode designs. Present detail performance analyses. Draft preliminary specifications for the IMPATT diode and amplifier performance. Define tasks for Phase II.

Phase II products: Design, fabricate, and test high efficiency and output power IMPATT diodes and demonstrate IMPATT diode power amplifier performance to meet specifications.

AF88-158 TITLE: Laser Disk Digital Bulk Memory (LDDBM)

OBJECTIVE: Identify the applications, feasibility, and cost of implementing a LDDBM system in the space environment.

DESCRIPTION: Currently laser and video disk recording technologies have produced a rugged yet simple data storage system processing long bulk storage life. A digital optical disk memory resembles a magnetic disk drive and its read-write interface electronics except for using a laser to write on a preformatted disk. Digital programs so recorded would be invulnerable to wipe-out from nuclear radiation effects. That property makes them of exceptional value for bulk storage, for satellite configuration control and autonomy. General satellite communications and data processing require units capable of ten-year on orbit life, a memory capacity of about one gigabyte, and potential for both read and write.

In this task the contractor shall complete the following tasks:

1. Identify applications for bulk digital data storage.
2. Determine feasibility of space qualifying a LDDMB.
3. Compare the proposed LDDMB technology with other candidate space-flight bulk digital data memories as to size, weight, power, and input/output speeds. Consider implementation of the subject LDDBM in a 1995 technology hardware embodiment, with a one gigabyte capacity.
4. Identify shortcomings of using the proposed LDDBM in military space (or related) service.
5. Identify cost and reliability projections for such LDDBM equipment in late 1990's service.

Phase I Products: Identify application of bulk digital data storage, and perform trade studies of bulk digital data memories vs. proposed LDDBM in terms of size, weight, costs, and reliability.

Phase II Products: Implement prototype LDDBM and demonstrate performance.

AF88-159 TITLE: Production of Spacecraft Grade Nitrogen Tetroxide (N_2O_4)

OBJECTIVE: validate bench production of N_2O_4 by catalytic combustion of ammonia.

DESCRIPTION: Problem: N_2O_4, along with Monomethyl Hydrazine, is used in bipropellant rocket engines. Current and planned space systems project the increased use of bipropellant systems, replacing the older hydrazine engines. A bipropellant system provides more energy per unit of propellant mass than a monopropellant system. This makes N_2O_4 an attractive alternative but it can cause clogging of filters and valves in the propulsion system. This clogging can render propulsion subsystems useless, resulting in the loss of the spacecraft.

The reduction of dissolved iron, water, chlorides, and non-volatile particulates can essentially eliminate this clogging problem. Yet, current production methods yield N_2O_4 with undesirably high levels of these impurities. Catalytic combustion of ammonia, however, yields inherently pure N_2O_4. This process has been demonstrated in the laboratory, so the technical challenge lies in scaling-up the process for production. This scaling-up can be divided into two steps which nearly fit the division between Phase I and Phase II of the SBIR Program.

The end product of Phase I should be a flow diagram which describes the process for producing N_2O_4 by catalytic combustion of ammonia. It should include pressures, temperatures, and flow rates for all steps in the process. This flow diagram, which represents the correct process, must be generated by analysis and experimentation, then tested and validated by setting up a bench process that duplicates the production process.

The flow diagram validated by Phase I is then used to design and construct a pilot plant which would check out full scale production of N_2O_4.

AF88-160 TITLE: Algorithm for Slow Moving Targets

OBJECTIVE: To define and develop techniques for detecting and tracking slow-moving targets with a Space-Based Radar (SBR).

DESCRIPTION: The primary mission of most proposed Space-Based Radar (SBR) systems is the detection and tracking of atmospheric threats, principally aircraft. The radar hardware designs and the detection algorithms considered for these SBR concepts have therefore been chosen for this mission and use Moving Target Indicator (MTI) technology that is effective for high-speed targets. A secondary SBR mission that is nonetheless of high importance is the detection and tracking of larger, slow-moving targets (5-50kt) on the ground, e.g., relocatable missile launchers. In Phase I define approaches by which an SBR designed for aircraft detection could be used to detect such slow-moving ground targets by switching to a different operation mode, with a different algorithm, but without significant changes in hardware design. In Phase II, develop an approach from Phase I to produce the software/hardware to detect and track slow-moving ground targets.

AF88-161 TITLE: Optical Signal Distribution In Large Phased Arrays

OBJECTIVE: To investigate innovative optically-based techniques for controlling signal phase at each element of a large space based phase array.

DESCRIPTION: Large aperture phased arrays require each array element to be phased according to its position and the desired array beam direction. Precise phasing element-to-element will result in low sidelobes in the array far field radiation pattern and will improve the ability to place nulls in the direction of jammers.

Large phased arrays for space-based applications will have elements whose positions vary with time as a result of thermally and mechanically induced strains. Current concepts for phasing these elements include techniques to use stored element position information and translate that into phase commands.

Recently developed optical components (e.g. fiber-optic transmission lines and optical-RF transducers) offer the possibility of distributing the necessary phase information rapidly, efficiently, with enhanced radiation survivability,

and very high effective bandwidths. In Phase I define methods to apply these new optical technologies in controlling the phases of the many elements with appropriate compensation for the relative motions of the elements. In Phase II, develop the device and prepare a ground-based demonstration.

AF88-162 TITLE: 3D Analysis Software of Near Earth Space

OBJECTIVE: To acquire a PC based software package which will animate the positions of satellites and earth boundaries from selected orbits and fields of view.

DESCRIPTION: The rapid advancement of desk top computer power provides an opportunity to construct software tools useful for space system concept generation and analysis. In particular, animated computer graphics offers the capability to work with physically correct time scaling by running simulations of orbital dynamics on the order of 10 times faster or slower than real time. Space system architecture analysis requires tools which handle four dimensional space-time in a manner consistent with basic physical laws.

There is some PC based, menu drive software that shows the earth disk from different viewpoints in space. None is capable of time-scaled animation to show how the scene in a given viewport pointed toward the earth or toward other satellites in orbit would vary as a function of time. Specific solutions of time scaling and intervals between animation scenes is left to the contractor. For first cut analysis, time precision on the order of a minute and spatial precision on the order of 10 km should be sufficient.

In order to promote widespread use, it is desirable that the Phase I product be compatible with an AT class machine running MS DOS with a graphics board and a math to-processor. Image display need not be more elaborate than that necessary to show continental boundaries on earth and bright points for satellites or stars. The Phase I product should indicate the terminator on the earth, positions of the sun, moon, planets and at least 10 satellites. The model should be constructed to allow potential upgrades and enhancements for Phase II such as major political boundaries, star field with galactic plane indicator, database of greater than 100 satellites, ability to change the viewport size and direction while the simulation is running, and the capability to form population histograms according to the criteria as fraction of orbit illuminated by the sun and nearest neighbor over a given period of time. Phase II will be contingent upon Phase I showing potential for Phase II upgrades.

AF88-163 TITLE: Space Application of Superconductivity

OBJECTIVE: To develop concepts and applications of superconductivity for space systems.

DESCRIPTIONS: Superconducting technology is not presently used in space systems because of the cryogenic requirements. Recently a new class of superconducting materials was discovered that operates at significantly higher temperatures. The Air Force is seeking applications of this new technology for space systems. These applications may include but are not limited to energy storage, high power microwave generation, high energy circuit breakers, high speed computing, memory, communication receivers, radiometers, clocks, frequency systhesizers, and sensors. In Phase I, define the application and requirements to develop, construct and validate the concept. In Phase II, develop, construct and validate the concept. Either a physical device or proof-of-concept feasibility is the product of Phase II.

AF88-164 TITLE: Innovative Concepts to Reduce Space Launch Costs

OBJECTIVE: To develop innovative concepts to reduce cost of access to space.

DESCRIPTION: The life cycle costs of space launch systems is too high. The Air Force is looking for innovative concepts which hold the promise of reducing costs in launch processing, launch operations, and launch vehicle production and procurement. Phase I will define the concept and establish the technology and methodology requirements to validate the concept. The contractor shall provide a rough estimate of the cost savings between the

proposed concept and current space launch systems. Phase II will develop, validate, and demonstrate the Phase I proposal. Proof-of-concept feasibility is the product of Phase II.

AF88-165 TITLE: Innovative Concepts to Reduce Space Systems Cost

OBJECTIVE: To develop innovative concepts to reduce cost of on-orbit space systems and their ground stations.

DESCRIPTION: The life cycle cost of space systems is too high. The Air Force is looking for innovative concepts which hold the promise of reducing costs in designing, manufacturing, production, and operation of spacecraft and ground control stations. Phase I will define the concepts and establish the technology and methodology requirements to validate the concept. The contractor shall provide a rough estimate of the cost savings between the proposal and the current space system. Phase II will develop, validate, and demonstrate the Phase I proposal. Proof-of-concept feasibility is the product of Phase II.

AF88-166 TITLE: Sidelobe Reduction and Clutter Suppression for a Distributed Sparse Array (DSA) Radar System

OBJECTIVE: To identify and develop innovative methods to reduce sidelobe emissions and to suppress clutter returns arising from sidelobes of a Distributed Sparse Array Radar System.

DESCRIPTION: DSA radar is a space-based, thinned phased array radar system in which each array element is a separate spacecraft. These spacecraft, called mini-radars, cooperate to form a single coherent radar beam. DSA radar has a number of desirable characteristics, which include very fine angular resolution, Anti Satellite (ASAT) survivability, mainlobe jammer nulling, and possible lower total system cost than a monolithic space-based radar. These systems, however, have the inherent disadvantage of high close-in sidelobes which can greatly increase both clutter and susceptibility to jamming. In Phase I define innovative approaches to reducing these sidelobes and for suppressing the clutter returns arising from the residual sidelobe level. In Phase II, develop one or more of these approaches for a ground-based demonstration.

AF88-167 TITLE: Design and Development of a K-Band Monolithic GaAs Low Phase Noise Frequency Source

OBJECTIVE: Develop an optimized design for a low phase noise GaAs monolithic frequency source at K-band and fabricate and characterize the source.

DESCRIPTION: Advanced communication satellite systems require ultra-stable phase coherent low noise frequency sources for optimum utilization of bandwidth and immunity to intentional or unintentional interference. Elaborate multiplier chains in conjunction with highly stabilized low frequency sources are traditionally used. These schemes have serious drawbacks since close-in phase noise increases 6 dB with each octave of multiplication. However, fundamental microwave frequency sources utilizing GaAs MESFETs, which currently dominate both hybrid and Monolithic Microwave Integrated Circuit (MMIC) technology, have considerable shortcomings as well. Although these devices exhibit high gain and low noise figure at microwave frequencies and are readily integrated into monolithic circuits, GaAs MESFET oscillators traditionally exhibit substantially higher FM noise than comparable Si bipolar transistor or Gunn diode components. This has been attributed to the higher l/f noise of the FET devices. The latter elements are, unfortunately, not suitable for monolithic integration. A monolithic low noise fundamental frequency phase lockable oscillator based on a low l/f noise monolithic compatible microwave device technology is therefore necessary to satisfy the requirements for advanced military communications systems at 20 and 44 GHz such as MILSTAR and advanced DSCS.

Phase I Products: Feasibility of the low l/f noise source will be demonstrated by the detailed design and analysis of a 20 GHz monolithic source.

Phase II Products: The photomask tooling will be designed and fabricated with subsequent GaAs fabrication, characterization, design optimization, and any necessary redesign and fabrication to achieve a 20 GHz source.

AF88-168 TITLE: Thin Film Coatings for Infrared Detectors

OBJECTIVE: To develop processes for deposition of thin film anti-reflection or bandpass filters directly onto detectors.

DESCRIPTION: The performance of long wavelength infrared detectors could be significantly enhanced if it were possible to deposit anti-reflective coatings directly upon the surface of detectors. This technique, if developed, could be extended to permit direct deposition of multiplayer interference filters upon the detectors to tailor spectral responses for specific requirements. These layers must adhere over repeated temperature cycles from room temperature to cryogenic temperatures as low as 10°K. Also, these coatings must be compatible with infrared detector materials such as mercury cadmium telluride, indium antimonide, and arsenic or cadmium doped silicon. The index of refraction and optical transmittance of the filter materials must be appropriate for the spectral regions and detectors of interest. Phase I includes the feasibility study of developing such processes within material compatibility and temperature constraints. Phase II is to develop processes for the deposition of the thin films or bandpass filters directly onto the detectors.

AF88-169 TITLE: Shape, Vibration Control, and Identification Techniques for Large Space Systems

OBJECTIVE: Develop non-orbit identification techniques, shape and vibration control algorithms, and smart structures for space systems.

DESCRIPTION: Future Air Force space missions will involve large, precision space structures that will be lightweight and flexible. Predicting structural modes accurately using ground testing techniques will be difficult; therefore, on-orbit system identification methods are needed. Mission requirements dictate that many future space systems need to point accurately and maintain specific shapes. Two approaches are available to address this problem: innovative control techniques and “smart” structures.

The Air Force is interested in developing both innovative on-orbit system identification and shape/vibration control techniques for large space systems. There is a need to develop system identification methods which can adequately identify large flexible space structures on orbit in real-time or near real-time. The method should use optimally a minimum set of sensors and actuators with a minimum amount of computational and data handling capability. The control techniques should be designed to use practical or conceived actuators and/or sensors. The control system must have a bandwidth capable of suppressing vibration modes that influence the particular parameter of interest. For example, line-of-sight-error for space-based laser type systems or RMS shape error for space-based radar type systems. Finally, the control and identification techniques must have the capability to be implemented in the space environment. Phase I efforts will develop the particular control or identification algorithms and Phase II will develop the software and implement the techniques on a simple experimental structure.

The Air Force is also interested in investigating concepts for “smart” structural components. “Smart” components are components which contain all of the essential sensing, actuating, and processing capabilities to autonomously perform active vibration control. In Phase I, the offeror will define, design and analyze a “smart” structure. In Phase II, the offeror will fabricate and test a representative structural component.

An offeror may submit more than one proposal in response to this topic, but each proposal should cover only one of these areas: system identification, advance controls, “smart” structures.

AF88-170 TITLE: Novel Concepts for Spacecraft Heat Rejection

OBJECTIVE: Develop novel, heat exchanger and fluid collection concepts to minimize spacecraft thermal control system weight.

DESCRIPTION: One of the primary technical issues in future space power systems I sthe excessive mass of the thermal management subsystems. The Air Force is interested in concepts that would lead to lighter spacecraft thermal management systems. One concept is the Direct Contact Heat Exchanger (DCHX) which eliminates interior hardware in the heat exchanger and brings the two heat exchange media into direct contact. Another concept is the open system space radiators, such as the Liquid Droplet Radiator (LDR), which eliminates hardware by spraying the heat transport fluid across space in the form of controlled streams of tiny droplets.

For the heat exchanger the primary technical issue is the separation of the heat exchange media in the absence of gravity. The target space power systems for the novel heat exchanger range from 100kWe to 1Mwe with Brayton, Recuperated Brayton or Rankine power conversion subsystems. For an open system space radiator, one of the primary technical issues is the efficient collection of the working fluid from space after the fluid has radiated its waste heat. Typical test parameters that a fluid collection concept must meet are flow velocities of 5 to 20 meters per second and volume flow rates of approximately 0.5 gallons per minute. For each concept, Phase I should be a complete analysis of the feasibility and predicted performance characteristics of the proposed concept; in Phase II, a bench-scale model of the concept will be designed, built and tested in both ambient and vacuum conditions. All experiments will be designed to reduce the effect of gravity on the experimental results.

An offeror may submit more than one proposal in response to this topic, but each proposal should cover only one area: heat exchangers or fluid collection.

AF88-171 TITLE: Biocatalytic Production of Hydrogen and Oxygen Propellant for Spacecraft

OBJECTIVE: To demonstrate biocatalytic production of H_2 and O_2 propellant by splitting water in coated organelles.

DESCRIPTION: Hydrogen and oxygen propellant for spacecraft can be produced by biocatalytically splitting water in organelles coated with a catalyst. Bioactalytic fuel production can result in significant power savings since the process requires no external power supply. Mechanical simplicity and fuel handling safety are increased. Proposed ideas should address the technology challenges of assuring organelle survival outside of living cells and large-scale coating of organelles with a catalyst. Phase I will consist of a thorough review of recent work involving coated organelle technology and a small-scale laboratory experiment that demonstrates organelle extraction from living cells, organelle coating with a colloidal catalyst, and H_2/O_2 production by the coated organelle. Phase II will consist of a larger-scale laboratory feasibility demonstration of H_2/O_2 production and a design and study effort. The larger-scale laboratory feasibility demonstration will involve deposition of a colloidal catalyst on organelles outside of living cells, measurement of H_2 and O_2 production rates for splitting water in coated organelles, and measurement of any resulting electric currents. The study will assess economic payoffs of biocatalytic production of H_2 and O_2 for space propulsions based on extrapolations of results from the larger-scale feasibility demonstration. It should specifically address the economics of on-board production for small space engines, production for LOX/H_2 engines used on orbital transfer vehicles (OTVs), and large-scale preliminary design of full-scale systems for biocatalytic fuel production and for a follow-on zero-gravity feasibility demonstration of the key technologies for application to small space engines and OTV engines. Proposed concepts may include, but need not be limited to, biocatalytic splitting of water with sunlight in platinized chloroplasts.

AF88-172 TITLE: CT Inter/Intra Pixel Mensuration and Imaging of Non-Destructive Evaluation Data

OBJECTIVE: Develop improved software analysis tools for the NDE inspection of CT data on solid rocket nozzle components.

DESCRIPTION: Current work in CT software analysis imaging and data manipulation has been limited to the routine technology of image enhancement through subtraction, beam hardening and simple contrast discrimination techniques. The human eye does not have the ability coupled with current image display technology to adequately distinguish anomalies that are present within the existing data. A rocket nozzle, for example, has bondlines that may have separations on the order of 1 to 2 mils that could be detrimental to the survivability of the vehicle that the

nozzle is attached to. This also holds true for the solid rocket motor propellant/insulator/case bondlines. With current display monitors we can only see a separation if it lies within a whole pixel, so there is a distinct difference visible to the human eye. The data that is being taken, however, has considerably more resolution than can be seen visually. What is desired in this program is the ability to computationally be able to resolve this data and tell an engineer that, indeed, a flaw is present in the inspected hardware. In Phase I of this program the contractor will examine existing data sets taken from the Advanced Rocket Nozzle Inspection System (ARNIS) and determine a technology that is suitable for the intra- and inter- pixel imaging at menuration levels less than pixel size. The CT data will be supplied to the contractor by the Air Force Astronautics Laboratory (AFAL). Due to the rapid advances in work in this area the contractor is to assess the current state-of-the-art in image analysis software. A review of the CT data will then be undertaken to understand its inherent resolution and a method for the display of this data shall be generated. A program plan will be developed and presented to the AF for Phase II approval. Phase II will be used to develop this technology, deliver it to the AF, and install it on the two ARNIS systems located at carbon-carbon fabrication facilities and the remote data workstation located at the AFAL. Phase I deliverables will include an assessment of the most current CT analysis imaging software, a recommendation of the best technologies to pursue a program plan for Phase II work. Phase II work will deliver the software and documentation necessary to accomplish the objective of the program.

AF88-173 TITLE: Protective, Absorptive Polymeric Coating for Rocket Motor Case/Insulation Manufacture

OBJECTIVE: Provide a protective coating that will eliminate problems of volatiles encountered in solid rocket motors.

DESCRIPTION: There are a number of ways to insulate a solid rocket motor case. In each manufacturing process, there is the problem of vulcanization by-products, which exude from the insulation into the chemically sensitive solid propellant grain. Insulation ingredients which have been found to be detrimental to the integrity of the propellant/insulation bondline include thiourams (sulfur activators), chlorowax and other processing aids, alcohol by-products from peroxide cures, residue from solvent wipes, and the ever-present water in the rubber layers. It is important to extract all unreacted, migratable species and vulcanization by-products from the insulation prior to the propellant casting step. One method would be to apply a soft, absorptive polymer coating to the insulation to extract undesirable species from the insulation and prevent contamination and human error during process. Development of this protective coating is expected to dramatically improve system reliability through reduced bondline ingredient variability and post-processing reactions. This manufacturing approach would certainly eliminate numerous quality control errors in the handling and surface preparation of production motor insulations, such as problems identified during the investigation of Titan segment manufacturing. Phase I: Identify potential polymer coating materials that can be applied to case insulation and have the following features: 1) highly absorptive fillers for ingredient extraction; 2) permeable polymer for rapid migration of reactive species; 3) good wetting of insulation surface; 4) mastic sling or spray applicable; 5) quick curing to a soft, pliable state at room temperature; 6) weak (associative) bonding to insulation for ease of removal prior to liner or propellant processing. Phase II: Develop a test matrix to evaluate potential coating materials identified in Phase I. The tests shall include ingredients commonly found in both class 1.3 and class 1.1 solid rocket propellant motor manufacture. Rank the materials, select the most promising, and evaluate in an analog motor design, using both steel and composite case materials.

AF88-174 TITLE: Organic Matrix Composite Materials for Cryogenic Service

OBJECTIVE: Develop an understanding of fundamental mechanisms affecting performance of organic composite materials at cryogenic temperatures.

DESCRIPTION: Organic composite materials are of significant current interest for reducing the weight of cryogenic liquid rocket propulsion systems. Components of which have been identified for applicability of these composites include propellant feed lines, pressure vessels, housings for pumps and valves, and structural reinforcement for propellant-cooled thrust chambers and nozzles. These materials are also of interest for spacecraft structures which will be exposed to very low temperatures and possibly thermal cycling on orbit. The typical composite material consists of high strength, intermediate modulus graphite fibers in a resin matrix. Maintaining ductility of the resin after repeated cycling to cryogenic temperatures, especially to liquid hydrogen temperature, is

an area requiring improvement in fundamental understanding to allow optimization of composition for rocket propulsion and spacecraft service. Phase I of this program shall investigate formulations of resins with graphite composite materials to evaluate their physical and chemical behavior at cryogenic temperatures and after repeated thermal cycling. The goal shall be a preliminary assessment of chemical and physical effects, including interactions with the fiber, so as to provide directions for optimization of resin composition for cryogenic service. In Phase II, selected resin and fiber combinations shall be optimized in terms of chemical composition and their applicability to a propulsion component demonstrated. Property characterizations should be based on standard ASTM (American Society of Testing and Materials) test methods as applicable.

AF88-175 TITLE: The Global Positioning System (GPS) and Inertially Instrumented Satellite for Global Gravity Field Mapping

OBJECTIVE: Develop GPS-based techniques to determine gravitational field parameters, inter-satellite state vectors and satellite orientation.

DESCRIPTION: The Air Force has a continuing requirement to improve the earth's global gravity model which determines a major part of the motion of any vehicle either in a free-flight trajectory or orbit, or under the guidance of an inertial navigation system. Also, with Project Forecast II, the Air Force has identified several requirements for very precise absolute and relative positioning of satellites, as well as precise satellite navigation and orientation. Similar precision surveillance capabilities to track cooperative targets are required by the Strategic Defense Initiative (SDI). The Global Positioning System (GPS) of satellites, in concert with a variety of satellite-borne instrumentations, has the potential to satisfy all of these requirements.

The technical challenges associated with the use of GPS for Air Force applications in space include deriving the maximum accuracy from a system that provides a given, but diverse, set of data (code and phase measurement); combining GPS receiver measurements with measurements from other ancillary instruments, such as multiple-axis accelerometers, gyroscopes, and star trackers; and developing computer software that exploits and enhances this synergism to meet Air Force needs. Applications relying on solutions to these challenges include gravitational field determinations, precise inter-satellite distance, velocity, and acceleration determinations, and precise relative orientation of satellites in distributed arrays.

Phase I of the project involves the delineation of (1) enhancements to existing GPS-based techniques to determine the earth's gravitational field, as well as very precise absolute and relative positions, velocities, and accelerations of lower earth-orbiting satellites; (2) the synergism of GPS and ancillary instrumentation required to satisfy the position and orientation requirements of Air Force systems in space; and (3) all error sources of the various instrumentations under consideration with proposals to reduce major errors.

Phase II of the project builds on the foundations laid during Phase I by developing comprehensive error models for specific GPS receiver and ancillary instrumentations, devising optimal techniques for combing the data from these instruments, and producing computer software that implements these techniques to arrive at the desired satellite parameters. Based on existing Air Force studies, new techniques and software are to be developed to analyze data obtained by a satellite specifically tracked by GPS for the purpose of determining the earth's gravitation vector at altitude.

AF88-176 TITLE: Application of Adaptive Systems Techniques to DMSP Remote Temperature Sensing

OBJECTIVE: Advances in temperature retrieval methods make possible stand-alone adaptive processing with readout on ground interrogation.

DESCRIPTION: The polar-orbiting DMSP (Defense Meteorological Satellite Program) vehicles have on-board both infrared and microwave sounder packages capable in principle of determining the atmospheric vertical temperature distribution. These thermal profiles are needed for AF tactical operations and as drivers for the AFGWC (Air Force Global Weather Central) numerical prediction models. The reduction of the satellite radiance data to temperature profiles involves both difficult mathematical inversion analysis as well as complicated data

processing. The technical challenge is to extract in real-time readout mode all the information on the thermal state of the atmosphere resident in the radiance data.

This potential only became realizable with the development of physical retrieval methods such as the differential inversion technique which provide in a progressive algorithm the problem solution free from the need of externally-imposed constraints. The processing of the satellite observations into a radiance profile compatible for the data ingest into the inversion algorithm is extremely tedious. Fortunately, this problem lends itself to an adaptive systems approach both in the calibration of the data and the processing of the radiance profile. It is expected that the MIT AI "MACSYMA" programs will be helpful here for the purpose of aiding the symbolic manipulation of complex mathematical expressions. This program has in it a sense of "where to go" by following a complexity gradient in the direction toward simpler expressions.

Phase I will consist of a "black-box" systems analysis beginning with the ingest of satellite radiance data with the atmospheric thermal structure as output. The problems of acquisition, calibration, AI processing, radiance profile construction, retrieval algorithm application, and thermal data output will be addressed. The follow-on Phase II will consist of the bread-board engineering implementation of Phase I research. The component parts in the systems analysis string will be developed pointing toward the goal of operational application to real satellite-intercepted data.

AF88-177 TITLE: High Energy Electron Beam Source for Ionoshperic Modification Experiments

OBJECTIVE: Design an electron beam source for use on space platforms in ionospheric modification programs.

DESCRIPTION: Electron guns have been used in ionospheric modification and space plasma experiments. However, the penetration depth of the electrons into the atmosphere was limited by the relatively low energy of the electron beam. An entirely new range of ionospheric modification phenomena could be investigated with much higher energy electron sources.

Projected requirements for the pulsed, high energy electron source are: electron energy. 3 to 5 MeV; peak current, 40 to 100 mA; peak power, 140 to 500 kW; pulse length, 3 to 10 microseconds; pulse repetition rate, 5 to 10 Hz. The electron source must be designed and packaged so that it can be flown on space platforms. It must be able to withstand the rigors of operation in the upper atmosphere and space environments.
In Phase I, we expect that the feasibility of building such an electron source will be assessed and that a preliminary design will be prepared. In Phase II, a prototype electron source will be constructed and tested. If the tests are successful, the prototype will be considered for actual field experiment.

AF88-178 TITLE: Code-Free, Dual Frequency Global Positioning System (GPS) Ionospheric Receiver

OBJECTIVE: Design a dual frequency, code-free GPS receiver for making ionospheric measurements.

DESCRIPTION: The earth's ionosphere can limit the capability of many Air Force space systems, including those currently operating as well as systems in advanced planning and development. A simple method is required to make continuous measurements of the ionospheric time delay parameter, by measuring the differential time of arrival of the dual frequency signals transmitted from the constellation of GPS satellites, without requiring access to the potentially limited availability GPS precise "P" code. Receivers developed in this effort would be used in a system to provide needed data for updating ionospheric models, which will then be able to provide real time prediction s of ionospheric time delay effects on various Air Force systems. A study of the potential of using the code-free GPS concept for making differential carrier phase and signal amplitude scintillation predictions is also required.

The Phase I effort would include developing a receiving system concept, including block diagrams, calculations of integration time required to obtain various group delay accuracies for nominal gain antennas, and trade-offs of required antenna gain versus integration time versus accuracy of differential carrier phase and carrier amplitude measurement capability. Full scale development would be based on satisfactory results in Phase I.

AF88-179 TITLE: Miniature Imaging Photometer for Aurora and Airglow

OBJECTIVE: Design a miniature imaging photometer to perform high sensitivity, spectral measurements of low-brightness aurora and airglow.

DESCRIPTION: Optical measurements of aurora and airglow, produced by natural or artificial sources, can yield important information on ionospheric structure, dynamics and interaction processes. A need exists for a miniature, easily portable imaging photometer to perform high sensitivity, spectral measurements of low-brightness auroral and airglow emissions. Real time viewing is critical to insure correct aiming and sensitivity adjustment for high quality images. One possible application is sensing ionospheric modification by chemical releases or high power radio wave heating. Opportunities may exist to conduct measurements from the Space Shuttle which dictate the requirement for a miniature, portable system. Ground based measurements are also planned. Important instrument characteristics would include high sensitivity to measure light intensities of a few Rayleighs, high spatial resolution, variable field of view, variable wavelengths in the visible region, small size, near real time operation and a permanent record of the images. Phase I would include system conceptual development with key hardware components and system specifications identified. Full scale development would be based on results from Phase I.

AF88-180 TITLE: Coherent Semiconductor Laser Arrays

OBJECTIVE: Develop a coherent light source based on semiconductor laser diodes, fiber optics, and optical isolators.

DESCRIPTION: Recent technological developments have allowed for the fabrication of large numbers of semiconductor lasers on a single chip. This abstract addresses two components which may be used in creating and maintaining stable coherence between individual lasers in an array.

Injection locking individual lasers to master laser that is frequency stabilized has been demonstrated experimentally with large gas lasers and more recently on semiconductor lasers by Morgensen et al (830 nanometers CSP, and 1.3 micrometers BH lasers). Experiments have shown it necessary to optically isolate the master laser from the slave laser to prevent unwanted feedback. Faraday rotators, which alter the polarization of light, have been used as optical isolators but are generally too large to be used conveniently in an integrated package with semiconductor lasers. To efficiently injection lock many diode lasers, a small scale optical isolator must either be designed to be incorporated into an optical fiber carrying the injection signal or fabricated directly onto a semiconductor substrate in conjunction with the fabrication of slave laser diodes.

Another technique for coupling a number of diodes is to use single mode optical fibers bundled to form a common external cavity. This second project would explore the possibilities of coupling injection pumped semiconductor material, including quantum well hetrostructures, using fiber optics technology that has been extensively developed. Additionally, it is desirable to design a system to couple selectively so that a single bad diode on a chip would not compromise the whole device.

Phase I of this effort will be concerned with the analysis and design of either an optical isolator or fiber optical couplers. Phase II will be the fabrication of a proof-of-principle device, incorporating several slave lasers injection locked to a master laser or coherently coupled using fibers. It is also desirable to show how this optical isolator could be incorporated into a monolithic device.

AF88-181 TITLE: A Quantitative Description of Soil Microstructure Using Fractals

OBJECTIVE: To determine if soil microstructure characteristics can be described by fractal data.

DESCRIPTION: The approach to constitutive modeling of soils has been phenomenological rather than structural. In this approach, the interaction between the fundamental constitutive units of the systems are not accounted for. Hence, is not suitable for understanding the initiating and evolution mechanism governing soil deformation. If this is to be achieved, an understanding of and mathematical description for the physics at the microstructural level must

be developed. Research in soil microstructure has followed two paths; a mechanistic approach investigating purely granular material, and an experimental approach using microscopy techniques for investigating cohesive soil. Although these studies have provided valuable information on the response mechanisms at the micro level, they do not address the behavior of real soils. Real soils are a complex composite of solids, air, and liquid with response characteristics greatly dependent on stress history. To date, no mathematical model based on microstructural features has been developed to predict the response of this complex system.

In recent years fractal geometry has been successfully used to recreate natural features. Because fractal geometry can describe shape and potential sequence development in a noncontinuous process it may be able to describe the soil deformation process from a microstructural perspective. This will be a new area for fractal analysis.

The Civil Engineering Research Division of the Air Force Weapons Laboratory (AFWL/NTE) has a long term responsibility to develop methods of estimating geologic material response in blast and shock environments. The response of survivability and vulnerability of land based systems. Fractal analysis can contribute to the understanding of geologic material response by a) identifying how internal state variables affect response, b) identifying initiating damage mechanisms, and c) establishing the ability to track damage evolution during deformation. This knowledge will allow material models to be developed from a physical rather than a phenomenological basis.

Phase I will investigate if soil microstructure characteristics can be described by fractal sets. If the approach proves to be feasible, Phase II will establish how the theory of fractals can be used to distinguish the mechanism governing the deformation of real soil. This will lead to the development of a three-dimensional quantitative description of soil microstructure based on the theory of fractals. The theoretical framework will then be validated against existing experimental data.

AF88-182 TITLE: Novel Material and Technique Improvements for Four Wave Mixing

OBJECTIVE: Develop innovative nonlinear optical materials with improved sensitivity and innovative techniques to do Four Wave Mixing without pump-probe coherence.

DESCRIPTION: Current nonlinear optical media appear to be grouped into two categories: low power, slowly responding medial such as photorefractives and dye-doped glass saturable absorbers, and high power, fast responding media such as Kerr-like Four Wave Mixing materials like Carbon Disulfide. The first thrust of this program is to survey and obtain or develop nonlinear materials with millisecond to microsecond response times, and with watts to milliwatts of pump power. The second thrust is to model the theory, propose new techniques, and perform experiments on Four Wave Mixing without pump-probe coherence. Proposals may include theoretical models and small-scale experiments. Phase II efforts will include a comprehensive set of experiments to characterize the new materials and techniques.

AF88-183 TITLE: Microwave Coupling Simulation Code

OBJECTIVE: Develop a code which can use computer aided design (CAD) files when predicting the microwave fields coupled into a weapon system.

DESCRIPTION: A need exists to better understand coupling phenomenology of microwave radiation into weapon systems. To accomplish this, a coupling simulator code capable of reading CAD structural files shall be developed. It is desired that the simulator code run on IBM/AT compatible computers.

The following approach is suggested: Modify an existing CAD system to allow input of structural and electrical parameters for any given weapon system. Then develop a means for microwave coupling codes to use the above CAD files. Finally, apply the above developed software to model an actual weapon system and predict the electrical fields inside it.

A second phase effort, if awarded, would apply the simulator developed in the above effort to predict the fields radiated into numerous DOD weapon systems. Predicted results would then be compared to actual measurements in order to further refine and improve the code.

AF88-184 TITLE: Optical Sensor with High Directional Resolution

OBJECTIVE: Develop a sensor with no moving parts with high directional resolution.

DESCRIPTION: The Air Force has a need for a lightweight sensor that can resolve the direction of incident photons (visible and IR). An optical system modeled on the compound eye (ommatidium) of an insect using fiber optics, detectors, and signal processing could be designed to detect and determine the phase-effort. In Phase I the contractor shall provide a functional description of an optical sensor that can detect and determine the position and separation of point light sources relative to the sensor and a report defining requirements of this sensor for use aboard future Air Force spacecraft. Phase II, the contractor shall develop a sensor that is lightweight, has a potential total solid angle coverage of 2 Pi steradians, has redundance in that the adjunct optical fiber/detector units provide overlapping coverage, can detect and locate multiple light sources. Phase II also should consider (but not limited to): multiple wave length fiber optic/detector interfaces, and an approach defining a high speed motion detector using this technology. Challenges to solving this problem are: selecting an optical fiber(s), connecting fiber(s) to detector(s), determining the number of fiber/detector units to provide 2 Pi steradians of coverage, and a signal processing routine that can accurately correlate detected events to their relative positions.

AF88-185 TITLE: Integral Blast Pressure Amplifier

OBJECTIVE: A miniature, high performance, environment hardened amplifier packaged for use with a sensor measuring blast pressures.

DESCRIPTION: A basic requirement for the success of all Air Force field test programs involving high explosives (HE) is the ability to accurately measure the blast pressure. Such measurements at the HE-earth interface must necessarily be made remotely with sensors in the hostile environment the data signals are conducted through long underground electrical cables to a recording location. Shock-induced effects and inherent cable characteristics invariably alter the data signals. Consequently, the recorded signals may be significantly different from the signals which actually occurred at the sensor. It is known that installing an electronic signal amplifier with the sensor will significantly reduce signal alteration enabling the recorded data to more accurately reflect the actual signal.

This topic is for investigation of integrated circuit, hybrid, and/or other circuit design, fabrication, and packaging technologies to result in a miniature, high performance, hardened, conditioner/amplifier. The technical challenge is to produce a “see-and-forget” unit to be installed with resistance bridge blast pressure transducers at the sensing location. Specifically, the unit in a 10 cubic inch cylindrical package would provide settable excitation, gain, zero, and single-step calibration. A minimum 3 db bandwidth of 100 kHz with minimum slew rate of 100 volts/microsecond, maximum settling time to 0.1% of 100 nanoseconds and at least two-port isolation is required when driving a load of 10kOhm in parallel with 0.98 mfd. Operating ambient environment includes temperatures 30° to 130°F, dust, and moisture. Transient environment at the sensor includes 100k psi, intense thermal flash, vertical shock acceleration to 100 kg, 0.5 msec duration, and will occur up to 30 days after installation. Operation with a single 4-cond shielded cable is desired.

Phase I products of this effort are electro/mechanical performance specification and descriptions, complete design drawings, and one operating prototype package for proof-testing. Phase II products will be three operational test units, definition and execution of a comprehensive static and dynamic test program, a modification and retest program as required, and ten finalized field operational units with all supporting documentation.

AF88-186 TITLE: Damage Measurement System for Reinforced Concrete Structures

OBJECTIVE: To develop a means of measuring the amount of damage in reinforced concrete structures which have been dynamically loaded.

DESCRIPTION: The Civil Engineering Research Division of the Air Force Weapon Laboratory (AFWL/NTE) is extensively involved in the testing of various reinforced concrete structures to determine their effectiveness in protecting their contents from both conventional and nuclear weapons effects. When evaluating the results of these tests, the engineer has two primary sources of information; actively recorded instrumentation, such as strain sources and accelerometers; and visible damage, such as the presence of cracking, spalling, and permanent deformations. Much more information could be obtained if there were a way to determine the extent of damage mechanisms which are not readily apparent during a visual inspection. Damage, such as microcracking, debonding of the steel and the cement-aggregate matric, are important but are not measured with existing technology.

Phase I of this effort would be the theoretical evaluation of appropriate measurement systems. A strong knowledge of material science and instrumentation systems will be required for this portion. The system selected for Phase II development will have to be portable, non-destructive and be capable of being deployed on only one side of a cross-section since the other side will frequently be inaccessible. Phase I will also involve the development of a test plan for validation of the measuring technique.

Phase II will involve the final hardware design and testing of a prototype unit.

Should this effort prove successful, it has potential commercial applications in assessing the extent of damage to concrete structures resulting from fires and earthquakes.

AF88-187 TITLE: Development of Free Field Time-of-Arrival Gages for Low Overpressures

OBJECTIVE: Develop and demonstrate several simple Time-of-Arrival (TOA) gages, and their data recording systems, for use in the 30 to 1 psi overpressure range.

DESCRIPTION: Currently the explosive diagnostic community can measure TOA data internal to the charge using piezoelectric crystals that emit a voltage spike when crushed by a detonation or shock wave. We can also determine TOA at high pressures using existing pressure gages. However, due to cost and technical limitations, these methods are of little use in the free field environments we typically monitor for shock tubes and other explosions. WE need a simple, inexpensive, and self-contained gage (device) and recorder to accurately record the charge initiation and the TOA of the pressure front. It must be stressed that devices measuring dynamic pressure (flapper switches, etc.) are unacceptable since a dynamic pressure threshold would be exceeded much later than desired. The gages themselves can be single use while the recorders should be designed for multiple uses. Recorder protection would typically consist of burial near the gage with retrieval one to four hours after the explosion. Consideration should also be given to designing a single recorder that can accommodate several gages spaced hundreds of feet apart. In all cases, these gages and recorders should be designed for placement by 2-man crews 2 to 48 hours before the explosion.

Phase I: Identify potential gage solutions and candidate recorder systems. Examine recorder systems used by the Air Force Weapons Laboratory (AFWL), the University of New Mexico Civil Engineering Research Facility (CERF), and others to determine their compatibility with potential TOA gage systems. Conduct limited proof-of-concept testing in laboratory experiments. Conduct at least one concept demonstration as a non-interference add-on experiment to a scheduled field test conducted by or participated in by AFWL/NTE (Civil Engineering Research Division of AFWL). Document results in letter reports to AFWL/NTEDA of sufficient detail to allow the evaluation of the technical progress. Desired accuracy for TOA data is one to three (1 to 3) microseconds.

Phase II: Refine viable concepts identified under Phase I and conduct additional laboratory and field testing of the TOA gages and recorders. Field testing shall include, but is not limited to, non-interference experimentation on scheduled field tests conducted by or participated in by AWFL/NTE. Conduct analysis of TOA data and derive estimates of the peak overpressures resulting in the specific tests. Analyze gage performance and recommend improvements in activities, progress, and results in letter reports to AWFL/NTEDA and in papers for appropriate

symposiums on instrumentation, airblast, and other related subjects. A final technical report shall be written and submitted for publication by AWFL.

AF88-188 TITLE: Miniaturized Global Positioning System (GPS) Receivers and Translators for Space Test and Evaluation

OBJECTIVE: Develop new techniques to reduce airborne GPS instrumentation physical parameters and input power requirements for SDI technology demonstrations.

DESCRIPTION: New technologies and techniques are necessary for on-board GPS instrumentation to meet low volume, weight, and power consumption requirements for SDI tests such as the space based kinetic energy weapon.

Phase I studies should include research of electronic technologies and instrumentation configurations applicable to significant reduction of on-board GPS instrumentation power, weight and volume. The studies should include but not be limited to current programs and ground system compatibility requirements. Preliminary risk, cost and advantage comparisons should be provided.

The use of GPS to support global test arenas and numbers of participants limited only by data link constraints is necessary for future test and evaluation of SDI proposed weapons. Current on-board, GPS instrumentation imposes unrealistic performance impacts due to excessive volume and weight and lack of overall system engineering. Innovative antenna, electronic, and power supply design advances are needed.

Promising Phase I candidates will be selected for further studies, development, and feasibility demonstrations.

AF88-189 TITLE: Chirp Waveform Compatible Coherent C-Band Pulsed Radar Transponder

OBJECTIVE: To develop coherent radar transponders compatible with both pulsed CW and chirp waveforms.

DESCRIPTION: Current C-band transponders for missile, space, and aeronautical vehicles are not compatible with the chirp waveform mode of the Western Space and Missile Center (WSMS) ground based tracking radar network. The chirp mode provides enhanced range measurement precision and tracking range at greatly reduced peak power. It uses 12.5 microsecond pulses with linear frequency modulation over 8 MHz. Coherence is required for pulse compression. It should also accommodate 0.5 microsecond unmodulated coherent pulses. Chirp compatibility provides the opportunity for greatly reduced miniturization.

In Phase I of the effort, one or more system concepts for a chirp compatible transponder will be developed. A systems level description of the transponder concepts and transponder block diagrams will be developed. They will then be mathematically modeled or simulated and potential system performance and design tradeoffs analyzed. Since the transponders are to be used on vehicles, minimum size, minimum weight, minimum power, and minimum environmental constraints are required. Phase I should conclude with a summary of projected performance and characteristics, conceptual transponder design, technical risks, identification of components or subsystems requiring new development, a tradeoff study of the concepts explored, and a proposed development approach. In Phase II, one or more of the approaches defined in Phase I will be chosen and developed into prototype transponders. The prototypes will be tested and evaluated. The technology developed will be made available for production of new transponders for operational use.

AF88-190 TITLE: Noise Source Application

OBJECTIVE: Investigate the application of adding noise sources to existing Reentry Vehicle's (RV's) and Penetration-Aids.

DESCRIPTION: Investigate the application of adding a noise source to existing and future RV's and penetration aids. Specify the electronics, battery and antennas required to provide this noise capability. Evaluate degradation in

the threat radar signal to noise parametrically with the jammer to signal possible to achieve from these systems. Emphasis should be on minimizing the impact on the penetration aid or RV and maintaining the size and weight.

AF88-191 TITLE: Ballistic Reentry Slowdown Techniques

OBJECTIVE: Develop innovative techniques to slowdown vehicles on a ballistic missile trajectory from hypersonic velocities to subsonic velocities during reentry.

DESCRIPTION: The capability to slowdown a ballistically re-entering object has several applications to ballistic missile missions. Different types of ballistically delivered sensors need to slowdown to avoid the different problems associated with reentry such as plasma effects. In addition there is the possibility of the offense wanting to slow down to velocities where an object or flight vehicle can be deployed from a re-entering object. Innovative techniques to accomplish this are currently needed.

AF88-192 TITLE: Intentional Destruction of Missile Components

OBJECTIVE: Develop methods for the intentional fractionation of missile components during flight.

DESCRIPTION: The ability to intentionally fractionate ballistic missile components during flight has the potential to hamper the effectiveness of a ballistic missile defense. The components need to be fractionated into an optimum size and number to have any effect on a defense. Once this optimum is determined, then the techniques to accomplish this fractionation need to be developed.

AF88-193 TITLE: Miniature Battery

OBJECTIVE: Design a miniature battery to improve peak power, voltage, capacity and shelf life while reducing weight and volume.

DESCRIPTION: Design, build and test a miniature battery to be used in an ICBM reentry vehicle environment. The goals are to improve power, operating life and shelf-life while reducing weight, size and volume. The following minimum requirements will be met:

200 watt peak power
10% duty cycle
20 seconds operating life
10 year shelf life
Meet range safety requirements

Investigate innovative battery configurations that still meet the above requirements. Include for example the cylinder should be no larger than 1.1”

AF88-194 TITLE: 40 Watt Power Amplifier

OBJECTIVE: Design a 20 watt per polarization c-band, miniaturized power amplifier utilizing GaAs MMDC technology.

DESCRIPTION: Design, build and test a 40 watt C-Band power amplifier, 20 watts per polarization. The amplifier must have sufficient bandwidth to match the threat and a flat response across those frequencies. The unit should have greater than 20% efficiency and operate at a 20% bandwidth. The design should utilize GaAs MMDC technology, minimizing size to approximately 1.12” x 1.12.” Identify potential cooling problems.

AF88-195 TITLE: Miniature Environmentally Protected Antennas

OBJECTIVE: Design antenna concepts that have dual polarization, 20% band width and are protected from severe aerothermal environments.

DESCRIPTION: Design, build and test a dual polarization antenna that operates in C-band frequencies and can cover approximately 15% bandwidth and is environmentally protected. The antenna will be subject to severe aero-thermal loads and must be protected with a heatshield.

AF88-196 TITLE: Wideband Electronics

OBJECTIVE: Develop wideband electronics that can address multiple threat frequencies.

DESCRIPTION: Investigate application of wideband electronics for application to electronic countermeasure reentry vehicle penetration aid concepts. Build and test feasible concepts. Include power amplifiers, phase shifters, noise generators, A/D converters and frequency discriminators. Apply GaAs MMDC technology where applicable. Minimize weight and size to ICBM penetration aid constraints.

AF88-197 TITLE: Barrage Jammer

OBJECTIVE: Design a jammer that survives reentry and barrage jams threat radars throughout the endo-atmosphere.

DESCRIPTION: Design a jammer concept that will barrage jam threat radars of over their entire operating frequency. The concept must survive reentry and operate throughout the endo atmosphere. The size and weight may be up to 30” and 40lbs, but minimizing size and weight is advantageous.

AF88-198 TITLE: Exoatmospheric Jammer Concept

OBJECTIVE: Design a jammer concept that will jam threat radars as the reentry vehicles are deployed from the post-boost vehicle.

DESCRIPTION: Design a jammer concept that will jam threat radars as the reentry vehicles are deployed from the post boost vehicle down to reentry. Define require power level, number of jammers required and their spacing, the deployment method and weight and size. Maximizing power and minimizing weight and size are advantageous. Investigate low frequency (UHF, VHF) and C-band jammers. Identify technology risks and long lead items.

AF88-199 TITLE: Methodology for Evaluation of New Guidance & Control Technology

OBJECTIVE: Develop a methodology and corresponding software for evaluating current and future guidance and control technology.

DESCRIPTION: In Phase I the contractor will review available industry simulations capable of evaluating current and future ICBM mission profiles. The simulation(s) should be able to determine applicable guidance and control (G&C) technology combinations which meet the mission requirements. Determine if available industry simulations can evaluate new and innovative G&C technologies. Examples include; hemispheric resonating gyros, vibrating beam accelerometers, etc. If no industry simulation or combination thereof appear to completely cover technology combinations, the contractor will identify the requirements for a new simulation (or changes to available simulations) to meet all analysis needs.

The Phase II effort will generate a deliverable software capability and all documentation necessary for the user to evaluate current and future ICBM guidance and control technology combinations.

AF88-200 TITLE: Insertable Nuclear Components (INC) for Mobile ICBM System

OBJECTIVE: Determine ICBM modifications necessary for incorporating INCs and the operational impacts thereof.

DESCRIPTION: INC technology is a means for significantly enhancing the safety and security of nuclear warheads. The move to mobile basing modes for the Peacekeeper and Small ICBM (SICBM) indicate potential advantages for using IN technology in future versions of these systems. The Phase I effort should identify and evaluate INC technologies which has application to a mobile missile mission. The Phase II effort should then take these applicable INC technologies and develop a system concept and identify the associated operational impacts.

AF88-201 TITLE: Weapon Targeting/Routing Algorithms

OBJECTIVE: Develop and code targeting and routing strategies for autonomous piloted vehicles.

DESCRIPTION: A weapon such as Maneuverable Reentry Vehicles (MaRV) or Boost Glide Vehicles (BGVs) can visit multiple areas designated by reconnaissance possible Strategic Relocatable Target (SRT) locations. If the weapon doesn't find and confirm a target in one area it can go in another. A routing algorithm is needed to determine how this capability can be exploited to then maximize the effectiveness of a given weapon force. The algorithm should take into account the weapon footprint, target area locations, SRT movement probabilities, reconnaissance false alarm probability, and weapon sensor capabilities.

AF88-202 TITLE: Shielding Designs/Effectiveness to Particle Beams

OBJECTIVE: Provide shielding designs for sensitive missile parts to particle beams.

DESCRIPTION: Evaluate current ICBM susceptible elements to a particle beam environment and determine design approaches which will provide balanced system hardness throughout the missile system. Examples of susceptible ICBM elements include; missile electronics, squibs and propellants.

The Phase I effort will identify designs, software and simulation tools necessary to evaluate current and future ICBM systems to identify key missile susceptible parts. Conduct susceptibility analysis to determine candidate missile components to be evaluated for hardening approaches to Phase II. Use of the SDI Lethality and Target Hardening assessments is recommended. All available documentation on previous susceptibility analyses will be provided.

The Phase II effort will analyze those susceptible missile components identified in Phase I to determine hardening approaches which will provide balanced hardness and survivability throughout the candidate missile system mission profile. Consideration of in-flight radiation environments, particle beam environments and reentry system environments will be used to determine the balanced hardness designs.

AF88-203 TITLE: Hardened Critical Missile Electronic Technology to Particle Beams

OBJECTIVE: Investigate missile electronic technologies for hardness improvements to particle beams.

DESCRIPTION: Identify new and innovative approaches in missile radiation hardened electronic device technology which could improve missile in-flight survivability when exposed to a space based particle beam environment. Order of magnitude improvements in the levels of radiation that missile electronics could survive is sought. Technologies which represent a high risk in either survivability margin or performance should not be precluded from consideration.

The Phase I effort will identify innovative approaches to missile electrons design. Through simulation and any available test determine the proposed level of increased survivability provided by these approaches. Determine

design and performance requirements for use of this technology in current and future ICBM systems and subsystems.

The Phase II effort will design, develop and test those device technologies to the requirements identified in Phase I.

AF88-204 TITLE: One Kilowatt Reentry Vehicle Power Amplifier

OBJECTIVE: Design a 1KW power amplifier for use in reentry vehicle radar maskers.

DESCRIPTION: The amplifier must perform in the C-band and have a bandwidth of 0.5 MHz. The amplifier must use an on board battery supply of 10 volts plus or minus one volt and fit within a total area of 10 inches in length and two inches in diameter (31.4 cubic inches total volume).

AF88-205 TITLE: Manufacturing Method for Metal Coated Glass Fibers

OBJECTIVE: Develop an economical method of manufacturing large quantities of metal coated glass fiber.

DESCRIPTION: Methods of producing 2 to 10 micron aluminum coatings on 0.001 inch diameter glass fibers need to be studied an devaluated in Phase I to determine economical methods of high speed manufacture. Production rates of 60,000 feet per day are required with minimum 2000 foot runs. Phase II will demonstrate the production method on a small scale.

AF88-206 TITLE: Miniaturized Telemetry Systems

OBJECTIVE: Develop miniaturized telemetry systems for use in ballistic missile testing.

DESCRIPTION: During the past 10 years some payloads tested by the Advanced Strategic Missile Systems (ASMS) program have been flown with telemetry (TLM) systems designed in the early 1970's. The microminiaturization of electronics has advanced significantly since the 1970's and offers potential opportunities to perform telemetry functions in smaller packages. Therefore, it is desirable to examine the current TLM package design a flying in reentry vehicles and from these design propose new microminiature electronic designs to either meet the technical requirements of the old designs in smaller volumes and weights or attain expanded technical capabilities within the old design volumes and weights.

The Phase I effort will examine the existing TLM package designs and recommend possible TLM packages. These designs should show either a significant increase in capability or a significant savings in weight.

The Phase II effort will Build prototype TLM and perform ground test.

AF88-207 TITLE: Fuel Cell Power System Technology

OBJECTIVE: Demonstrate a fuel cell power system for an extended endurance period of at least one month.

DESCRIPTION: Fuel cells are attractive power sources because of their high thermal efficiency. Unfortunately, fuel cells require consumables that are highly reactive and hazardous. Materials which can endure the caustic effects of fuel cell reactants are prerequisites to the operation of a fuel cell power supply. The need exists to develop a safe and reliable fuel cell system which minimizes the amount of storage and deleterious effects of hazardous fuel cell reactants and their by-products.

The design goal for a full scale fuel cell is 40 KW and its useful life is 6 months of steady state operation. There will also be numerous start up and shut downs required during a preoperation period to assess the availability prior to the six month power generation period. This preoperation period may last as long as 15 years.

A subscale (i.e. “building block”) prototype fuel cell developed during the course of this work should be capable of being scaled up, produce power at a consistent rate and require little or no repair during the one month of testing. The object of the Phase I effort should be to identify a candidate fuel cell system and to recommend materials and methods by which to achieve the subscale test.

Phase II will include work with component testing, verification of materials properties under simulated operational conditions leading up to at least one month of uninterrupted fuel cell testing. The fuel cell will be tested outside the design envelope (higher operating temperatures, transient load conditions, effects of contaminants).

AF88-208 TITLE: Closed Cycle Diesel Power System Technology

OBJECTIVE: Demonstrate a closed cycle diesel power system for a variety of power performance requirements.

DESCRIPTION: Closed cycle systems must limit or eliminate combustion products released to the local environment. If a diesel power system is to be a viable source of power, a closed cycle system will be necessary.

Engine characteristics common in industrial diesels will require optimization to qualify as an endurable and isolated power source. Of particular importance are the thermal efficiency, the reliability after long idle periods and thermal loading of the surroundings. A closed cycle will depart from convention in order to achieve higher thermal efficiency and eliminate contamination of the local atmosphere by completely recycling the combustion gases. Carbon dioxide in the exhaust stream is chemically absorbed, (or used as a diluent), the gases are cooled and the input stream then replenished with oxygen from stores.

Issues to be addressed include the choice of the best fuel working fluid combination, the method of oxygen storage, organic scrubber technology, fuel purity, engine blowby and soot contamination, system control, waste heat recovery, and the method of control of the working fluid to prevent participation in the combustion and to minimize extraneous stores. Some examples of oxidants are compressed oxygen, liquid oxygen, or hydrogen peroxide. Sensing elements which act to control the oxygen levels and flow stream temperatures will have a direct bearing on the cycle efficiency. The design goals for full scale diesel applications include: 1) 100 KW endurance diesel, and 2) 5 MW high power/short time diesel.

The Phase I effort will identify the critical unknowns which will affect the selection of a full scale closed cycle diesel system design. Parametric studies will be necessary to optimize performance and efficiency. The Phase II subscale test equipment power plant (as well as the generating equipment to which it is matched) will be selected based on these Phase I studies.

Phase II will include the fabrication, assembly, and testing of system chosen. The test should include numerous startups and shut downs, extended endurance operation (at least 500 hours), performance under varying loads, and effects of differing working diluent fluid compositions. Computer models should be developed to perform closed cycle diesel system analysis.

AF88-209 TITLE: Communications Through Intervening Media

OBJECTIVE: Develop and test a communication system through rock/soil.

DESCRIPTION: Several promising concepts have been investigated for propagating and receiving electromagnetic signals through a variety of intervening media. The perceived payoff here is in removing conventional links (hardwire, coaxial cable, etc.) from the network. Traditionally, through the earth signal propagation and reception was thought ill suited for the high data rate, low bit error rate requirements for launch control communications and C^3I. However, recent works would indicate that data transfer rates or the order of a few kilobits per second can be achieved with relatively low bit error rates. There is also the possibility that data transfer rates can be attained when nonlinear signal processing techniques are incorporated in the scheme.

The technical challenge is to define mobile multi-band transceiver concepts that could provide post-attack connectivity via signal propagation/reception through rock/soil. Such a system should be compatible with existing WWMCCS platforms and should be capable of maintaining launch control communications with mobile launcher assets deployed on the surface.

Phase I should define and characterize mobile multi-band transceiver concepts. The characterization should address the complete mechanical and electrical (communications) performance assessment and estimates. A credible system design and general test plan should be used to determine Phase II award. The second phase should consist of proof of concept test(s).

AF88-210 TITLE: Underground Chemical Storage Technology

OBJECTIVE: Demonstrate inherently reliable, underground storage facilities for large quantities of various chemicals, reactants and oxidants.

DESCRIPTION: An underground facility presents unique requirements for the safe storage and use of large quantities of industrial chemicals. Such chemicals may include liquid oxygen (LOX), liquid chlorine, hydrocarbon fuels (methane, diesel), and hydrochloric acid. The leakage of any of these would present a severe hazard to the environment.
Storage facilities should be capable of reducing or eliminating vaporization, hydrogen embrittlement, contamination of the stored chemical, and boil off. The transport of chemicals into underground storage is another hazardous situation that requires a solution.

Development and testing of chemical storage alternatives is also of extreme interest and it is acceptable for the Phase I and II efforts to be devoted entirely to addressing this area of technology rather than storage facility technology. One other alternative is to generate hazardous chemicals at the point of need from relatively innocuous chemicals. Of particular interest is to develop and test a method of: 1) hydrogen generation/reformation (possibly using hydrochloric acid and iron pellets), and 2) oxygen generation (utilizing hydrogen peroxide, perchlorate candles, etc.).

Phase I efforts would be directed at reviewing and updating past Air Force efforts which identify current industrial practices for handling and storing these chemicals. Preparation and planning should begin for meaningful Phase II laboratory and subscale testing.

Phase II work would seek to improve on the body of information derived from the Phase I study based on results from Phase II laboratory and subscale testing. Recommendations for technological advances should include spill detection, improved handling and transport, inherently reliable methods of storage and alternatives to storage.

AF88-211 TITLE: Hygroscopic Effects on Reentry Vehicle Antenna Windows

OBJECTIVE: Develop techniques to lessen the impact of hygroscopic effects on reentry vehicles (RV) antenna windows.

DESCRIPTION: A few candidate reentry vehicle antenna window materials that currently exist or are in production can be hygroscopic to a certain degree. Hygroscopic effects on antenna windows may impact accuracies of future MaRVs. These systems will employ advanced guidance systems that can be impacted by this effect. Methods are sought which would eliminate or lessen the absorption of water vapor from these surfaces. Any method which has potential to eliminate or lessen this effect must not produce a char layer on the window during reentry and must not degrade the electromagnetic performance of the window. Phase I will look at the extent of the problem and identify candidate solutions. Phase II will develop and ground test possible solutions.

AF88-212 TITLE: Reentry Vehicle Window System Design

OBJECTIVE: Investigate material and design options available for advanced reentry vehicle antenna window systems.

DESCRIPTION: Phase I: Investigate current system requirements for antenna window (A/W) performance. Conduct trade-off and comparison of a variety of design concepts and materials for current and future RV systems. Outline what ground test effort would help to define requirements for current reentry scenarios. Investigate prediction capabilities for A/W recession available in the defense community and outline a program for upgrading such prediction resources. Phase II: Conduct ground tests to support current and future RV systems. Conducts testing of new candidate advanced materials for current and future systems. Develop modifications to existing prediction capabilities for A/W recession.

AF88-213 TITLE: Efficient Fans and Blowers

OBJECTIVE: Investigate and recommend new blower designs to increase air flow at lower power requirements.

DESCRIPTION: The problem of air pollution from dust and gases in underground excavations has required large fans and blowers to be used to provide a safe environment for personnel and equipment. Low cost, highly efficient air moving equipment covering a wide range of quantities and pressures is required to provide safe construction and operating conditions in underground openings. Efficiency greater than 80 percent is a goal to be achieved by innovative air handling equipment. Repair and maintenance, downtime, and life cycle costs are important considerations as well as operating efficiency. Air handling systems composed of several modules should be capable of ventilating underground space of up to 30 million cubic feet at depths up to 6000 feet and at velocities which are normal underground practice. The power source, blade design, and distribution system should be coordinated to provide overall maximum efficiency. The Phase I effort should provide written descriptions of equipment which meet the requirements stated and provide a description of innovative methods and design which lower operating costs through improved efficiency. The Phase II effort should provide design concept drawings, the planning necessary for proving the concept feasibility including scale laboratory testing within the Phase II budget constraints. Fully documented reports are required for both phases with emphasis on new and innovative techniques.

AF88-214 TITLE: Flow Control Devices

OBJECTIVE: Develop miniaturized flow control devices for controlling high pressure liquids used in the transpiration cooling of reentry vehicle nosetips.

DESCRIPTION: Phase I: Investigate available technology which could be used in transpiration cooled RV nosetips to control fluid coolant flow during reentry. Conduct trade studies and recommend design options. Phase II: Design and fabricate flow control system and ground test system.

AF88-215 TITLE: Transpiration Cooled Nosetip (TCNT) Design Techniques

OBJECTIVE: Develop new and innovative manufacturing and design techniques for TCNT reentry vehicles.

DESCRIPTION: Phase I: Investigate TCNT design alternatives and conduct feasibility and producibility studies. Demonstrate a proposed design and designs in simulated reentry environments.

AF88-216 TITLE: Laser Cutting Development

OBJECTIVE: Develop an advanced LASER cutting method to form platelet holes.

DESCRIPTION: Current methods to produce small holes in metal is to chemically etch them. It is desirable to use advanced laser techniques to produce these holes. It is desirable to increase speed and accuracy of cut for all metals, including those that do not respond to chemical etching. Phase I will prove feasibility and Phase II will demonstrate method.

AF88-217 TITLE: Active Cooling Nosetips for Decoys

OBJECTIVE: Develop hardware for active cooling nosetip which can be used for decoy design.

DESCRIPTION: Phase I: Investigate TCNT design alternatives for RV decoy systems and conduct feasibility and producibility studies. Demonstrate proposed TCNT design and manufacturing approach. Phase II: Manufacture and ground test alternate TCNT designs in a variety of potential RV decoy environments.

AF88-218 TITLE: Soft Rock/Broken Ground Tunneling System

OBJECTIVE: To develop a near-surface tunneling system to excavate through soft and broken rock, and intermittent soils.

DESCRIPTION: Construction of near-surface, soft ground tunnels will be a major cost driver for certain advanced basing concepts. Each tunnel would be 20-40 feet deep, have an inside diameter of about 20 feet, and be up to 9 miles in length. Individual tunnels would run parallel to others at spacings of about ½ mile apart. Contemporary cut and cover methods are relatively expensive as well as environmentally damaging. The SBIR contractor shall develop at a low cost, near-surface, soft ground tunnel excavation system that minimizes the disturbance to the environment and provides for a lined tunnel capable of supporting a missile transporter/launcher and subsequent launcher break-through for missile launch. The tunnel excavation system should be conceptualized for cemented sands and gravels but also take into account variations in soil conditions. Phase II should provide a detailed conceptual system that covers all aspects of the tunneling including tunnel site preparation, equipment assembly, excavation, power, ventilation, temporary and permanent lining, muck removal and disposal, manpower, maintenance and repair, and demobilization. A detailed cost estimate should also be provided. It can be assumed that roads, power and water are already at the site. It can also be assumed that within the 20-40 ft depth requirement, a deeper tunnel will potentially increase the hardness and thus require a shorter, overall length. Trades should be provided showing the relationship of depth/length vs total tunnel cost for the particular tunneling system.

AF88-219 TITLE: Twenty-First Century Propulsion Concepts

OBJECTIVE: To develop new, non-conventional propulsion concepts for launching and maneuvering payloads in space.

DESCRIPTION: Bold, new non-conventional propulsion concepts are solicited for launching and maneuvering payloads in space. This includes all propulsion concepts other than conventional chemical rocket propulsion which is presently used by DOD and NASA. More specifically, revolutionary concepts are sought in each of the following categories: (1) solar propulsion, (2) electric propulsion, and (3) nuclear propulsion including both fission and fusion. Particular attention will be given to revolutionary concepts based on sound scientific principles offering quantum increases in performance and mission capability.

AF88-220 TITLE: Ballistic Missile Life Cycle Cost (LCC) Data Base Structure

OBJECTIVE: Develop a flexible database of strategic missile LCC information for rapid, accurate, preliminary LCC estimate computation.

DESCRIPTION: BMO Comptroller currently tracks weapons system lifetime costs by requiring LCC management plans and data reports from contractors. To integrate the data reports for use in parametric and analogy cost

estimates Comptroller requires a data base. That data base must accept input from many contractors, must be internally coherent, and must be relevant to classes of missile weapons systems. The goal is to create a data base that can be easily updated and can produce specific estimates for weapons systems and subsystems.

To accomplish will require knowledge of parametrics commonly used for missile system estimation, knowledge of reference sources containing missile system characteristics, and experience in meaningful integration of similar data reported in dissimilar formats. First Unit Production Cost (FUPC) and Average Unit Production Costs (AUPC) are required for each weapons system.

Phase I: The first use of the two phases will be a presentation of the proposed data base uses, needs, and structure. The uses would include applications to cost analyses already preformed to demonstrate that cost data from the data base, coupled with standard parametric techniques, will generate rapid, accurate estimates. The needs of the data base will include additional required inputs from contractor, if any, and outside references necessary to generalize one set of data to a class of missile systems. Data base structure will be displayed indicating proposed fields and field relationships. Internal coherence mechanisms for data reduction and consistency should also be described.

Phase II: Upon approval of Phase I, the second phase would begin with data gathering and input. At intermediate points of input, trial validations of the predictive values of the data will be performed, and the final data base structure refinements made. Upon completion of data entry, checks should be made to ensure data consistency. Data type and data value checks will then be imposed field-by-field. Acceptance of Phase II will be based on a final briefing that acquaints user personnel with the value of the data base resource.

AF88-221 TITLE: Design Producibility Assessment

OBJECTIVE: Develop a computer program to objectively assess the producibility of any hardware design.

DESCRIPTION: Current design producibility engineering relies on the use of checklists and the experience of the designer and the manufacturing engineer to integrate manufacturing requirements into the overall design of an item. Apart form the use of very generalized checklists, however, there exists no established set of criteria or design standards across the defense industry which the designer can follow to ensure the producibility of a given design while the concepts are first being developed. Most producibility engineering, if it is done up front, is based on the subjective assessment of the design engineer.

Theoretically, at least, it should be possible to examine a given design concept and, by understanding the performance requirements, the processes available to manufacture the item, the materials required for fabrication, and the labor effort and skills involved in producing it, to derive an index or measure of producibility for that design. Producibility criteria that are developed should be capable of being applied to all designs, e.g., electronics items, forgings, sheet metal assemblies, solid propulsion motors, precision instruments, etc. It would be ideal if this process were computerized so as to automate the design producibility analysis.

The end product of this research project will be a set of criteria or standards which can be objectively applied to the specific aspects of all types of hardware designs. These criteria will be capable of being assigned quantitative ratings which can be weighted based on program needs. These weighted ratings can then be totaled to arrive at a quantitative measure for the producibility of a given design. Different design approaches can then be compared, and where performance is comparable, alternatives with higher producibility ratings can be selected. The finalized set of criteria should be capable of being drafted in the form of a MIL-Standard and placed on an automated data processing system.

AF88-222 TITLE: Advanced Battery Power System Technology

OBJECTIVE: Demonstrate a rechargeable battery power system with an endurance period of at least one month.

DESCRIPTION: Advanced basing systems require high efficiency and high energy density survivable power supply systems. These power supply systems must have the flexibility to operate in fixed or mobile basing

elements. The power range of interest is several kilowatts to 1 MW Battery power systems offer some of these characteristics but are heavy or are limited in operational flexibility, such as in the ability of recharge and multiple starts and stops. Development is needed on battery systems that will provide high efficiency energy density as well as operational flexibility.

A battery power system will spend most of its life in stand-by or on charge, perhaps 15 years. When required, it must be available, respond to the start-up transients and continue to delver power throughout its design life. The battery system will be required to remain in standby for long periods of time with minimal maintenance requirements and local environment contamination. The system must have a high availability so that when called upon to provide power, there is no decrease in capability. During steady state discharge, the system must deliver the required power.

Phase I of this effort would identify promising battery systems which could meet the technical requirements. Components of the system would be selected for reliability, energy density and availability.

Phase II would test the components of design, the overall power system, and create a test program leading up to an endurance operation of at least one month.

AF88-223 TITLE: Radiation Hardened Optical Mass Storage Devices for Missile System Applications

OBJECTIVE: To develop a radiation hardened optical mass storage device for missile systems.

DESCRIPTION: Select candidate optical mass storage devices with capabilities consistent with U.S. ICBM performance requirements. Take current and future ICBM radiation, vibration, and temperature environment specifications and validate the survivability of the candidate devices in these environments. Provide preliminary designs which implements these final radiation hardened devices into candidate ICBM systems and subsystems.

The Phase I effort will identify candidate optical mass storage devices currently available from industry to determine the performance and hardness requirements needed to implement these devices into current and future ICBM systems and subsystems.

The Phase II effort will design, develop and test candidate devices to the requirements identified in Phase I.

AF88-224 TITLE: Advanced Estimation Theory and Algorithms

OBJECTIVE: Develop and code algorithms for effectiveness/estimation analysis/

DESCRIPTION: The capability to accurately estimate and/or control the state of a reentry vehicle is central to several ASMS development programs. This capability affects the measurement limits in flight test and discrimination and bounds control accuracy for maneuvering vehicles.

The Phase I effort should identify the constraints that limit the performance of filter and guidance algorithms and develop the means to overcome these constraints. A test simulation will be developed to demonstrate the efficiency of the new algorithms.

If the results of Phase I are promising a follow on effort would extend the limited phase I capability to a general case. This will include a documented package that can be applied to the solution of BMO estimation problems.

AF88-225 TITLE: 3-D Graphite Nozzles Using Advanced Control Techniques

OBJECTIVE: Design, and test methods for fabricating 3-D graphite nozzles and the control systems used by these nozzles.

DESCRIPTION: There is a need to determine the method(s) by which nozzles of large size can be constructed of 3-D carbon and the manner they can be used to control missile motion. Large scale nozzles made from 3-D carbon have never been successfully constructed. After the techniques for nozzle fabrication have been determined, sub-scale design and test need to be performed to fully analyze the technique. The design should be subject to very rapid responses and aerodynamic heating as would be experienced in an advanced missile system.

Advanced methods of controlling these nozzles is to be integrated into this effort for two reasons. The first is to adequately analyze the structural integrity of the nozzle designs. And the second is to determine the most effective means of controlling the missile equipped with these nozzles. Once an effective nozzle design and manufacturing technique, and an effective control system designed, the nozzles and control systems are to be integrated and tested as a unit.

AF88-226 TITLE: Fast Deployment Post Boost Vehicle (PBV)

OBJECTIVE: Develop techniques to decrease PBV deployment time.

DESCRIPTION: The need to design and test hardware to evaluate techniques for reentry vehicle (RV) ejection has arisen. It has become important to deploy all objects off the PBV rapidly to eliminate the DAG movement now necessary for RV placement and to avoid detection and discrimination. Two important factors should be considered in the design; first the PBV should be able to maintain control authority after ejection, and second, the CEP (the error in targeting) should not be degraded.

AF88-227 TITLE: Advanced Basing Elements

OBJECTIVE: Identify/evaluate innovative, critical basing element concepts to enhance survivability, cost effectiveness, and performance.

DESCRIPTION: United States strategic systems (e.g., aircraft, submarines, intercontinental ballistic missiles/ICBMs, command, control, communication, intelligence/C^3I, or defense) continuously face military and political reactive "threats." Interaction between US strategic systems (BLUE with BLUE) and with potential opponents (BLUE versus RED) occurs in the technology arena and on the political scene. Strategic system effectiveness is measured in terms of survivability, military effectiveness, fiscal expenditure (development, acquisition, and operation), personnel limitations, and public interface, strategic arms limitation, and arms verification constraints. The various strategic systems' elements (subsystems) operate in different media, operational modes, and locations. Our submarine force uses hardened surface C^3, mobile C^3, "garrison basing" (boats in port), and mobile basing (boats on patrol). Our strategic defense system uses satellites, deeply buried facilities, and dispersed facilities.

Our ICBM force, current and in development, relies on airborne mobility (Airborne Launch Control Centers), hardened facilities (Minutemen and Peacekeeper Launch Control Centers and Launch Facilities), surface mobility (new small ICBM hard mobile launchers and Peacekeeper rail garrison launchers), and alert garrisons (Peacekeeper rail garrison). Future developments in technology and political relationships can significantly affect the contribution of ICBM systems to US strategic posture. Elements of ICBM systems can be adapted to support of other strategic system operations – viz., boosters to reconstitute satellite links or command centers to supplement C^3I. This study should be directed primarily at the technology and architecture of "in-place" deployment and operation of ICBM assets (subsystems or elements) and the effectiveness of the integrated ICBM system(s) in concert with other US strategic systems in relation to the capabilities, limitations, and intent of potential adversaries.

Phase I will provide the identification and evaluation of innovative, critical basing element designs. Synthesis of feasible ICBM system architecture and function must be examined. The evaluation should include: interaction with other strategic elements and strategic force modernization (C^3I, offense, or defense); functional performance under constraints of enhanced enemy threats (nuclear directed energy, and "conventional; " offensive and defensive); altered international arms policies (limitation or build-down and verification); increased resource constraints (fiscal and manpower); altered national or international political posture. ICBM system elements (C^3, boosters, warheads,

and support equipment) might be located in the atmosphere, on the surface, or buried below the surface (shallow or deep). ICBM system element functions may be collocated or dispersed (even booster/warhead elements), redundant (e.g., parallel communication links), relocatable ("shell game" multiple protective structures), or replicative (multi-launch but redundant portals from a buried "arsenal").

Phase II will analyze system payoffs and effectiveness "cliffs, both within the synthesized ICBM basing systems and between other strategic systems and top-level constraints. Special outputs from the studies will include recommendation of technology programs which would move the ICBM configurations past cost or performance cliff while improving overall strategic system effectiveness.

AF88-228 TITLE: Antenna System for Advanced Mobile Systems

OBJECTIVE: Define multi-band antenna concepts for post-attack communication by booster launcher units in silos, tunnels, or shelters.

DESCRIPTION: Several promising basing concepts combine missile mobility with large number of long hardened facilities (such as multiple protective structures, tunnels, etc.) to enhance system survivability. In the post-attack environment, the missile launcher must be able to sustain uplink and downlink communication with survivable command and control elements (such as ALCC, GMLCC, satellite, etc.) as well as with the other launchers to evaluate their status. A large number of hardened, fixed antennas installed at the protective facilities become costly and can lose connectivity with the launcher after attack. Cost and post-attack connectivity may be enhanced by installing antennas on the launcher vehicles.

The technical challenge is to define such mobile multi-band antenna concepts that could provide post-attack connectivity and provide two-way communications post-attack with launcher inside the protective structure (in silos, garages, underwater, tunnels, etc.).

Phase I should define and characterize mobile multi-band antenna concepts. The characterization should address the complete mechanical and electrical (communications) performance assessment and estimates. A credible system design and general test plan should be used to determine Phase II award. The second phase should consist of proof of concept test(s).

AF88-229 TITLE: Operational Equipment Seismic Imitator

OBJECTIVE: Develop requirements for seismic signal generators for use in masking basing operational activity.

DESCRIPTION: Several system concepts related to ICBM basing rely on or benefit greatly from the locations uncertainty of underground assets. The tunnel bori machine (TBM) is a major tool used for the excavation of these underground assets. Due to the high energy in the seismic signal emitted from these machines it is possible to determine with some accuracy the location of these machines form an array of seismic sensors, and thus loosing the location uncertainty during construction. A possible solution on this problem is to utilize seismic signal generators that imitate a TBM and mask real tunnel boring activity. The SBIR contractor shall develop and prove a concept of a seismic generator that would imitate a TBM, including but not limited to determining size, power requirements, and efficiency.

AF88-230 TITLE: Research Instrumentation

OBJECTIVE: To stimulate the development of new scientific instruments for laboratory and industrial applications.

DESCRIPTION: Progress in fundamental research often depends on use or invention of new diagnostic techniques which can provide better insight into the fundamental processes or phenomena under study. Development of improved and novel scientific instrumentation will enable researchers to make more useful measurements per unit of time, to make measurements to a greater degree of accuracy, and to make measurements in places and under

conditions not now possible. It may also permit quality instruments to cost less and be more reliable. This effort seeks to improve the basic function of scientific instruments, and to reduce the cost and improve the reliability of instruments which would enhance the scientific productivity of this country. Areas of interest include, but are not limited to, laser combustion diagnostic testing, vision testing equipment, advanced biogenetic tests for toxicity, new mathematical algorithms allowing improved computer program performance, optical information processing, accelerator mass spectroscopy, aerodynamic flow measurement devices, and improved material and process diagnostic systems. The Phase I effort should provide a review of various concepts and design options for the proposed type of instrumentation. The Phase II effort would then develop a prototype or prototypes of the best concept/design alternatives, leading to Phase III commercialization of the instrument. Evaluation of proposals will include the following factors: (a) Potential value to the Air Force Research program. (b) Potential for transition to Air Force Laboratories. (c) Potential to aid the scientific community.

AF88-231 TITLE: Fluid Mechanics

OBJECTIVE: Improve understanding of flow to improve performance of Aerospace Systems.

DESCRIPTION: Areas of interest include computational fluid mechanics, viscous and separated flows, and hypersonic aerothermodynamics. Research in computational fluid dynamics is needed to predict flow past complex, three-dimensional shapes more efficiently and accurately. Procedures for exploiting new supercomputer architectures and solution adaptive grids are examples of current interest.

Research in viscous and separated flows includes such topics as interactions of strong shock waves with turbulent boundary layers; methods for analytically examining higher order, inviscid flow coupling; and the nature of large-scale organized separations that frequently occur on low-aspect-ratio aerodynamic shapes at high incidence. Research issues associated with fluid dynamics and controls coupling are included. Research in hypersonic aerothermodynamics should improve understanding of strong viscous interactions with and without real gas effects.

For Internal Flow Dynamics, the main focus is on the mechanisms limiting the performance of axial flow compressor, axial flow turbines and diffusers. Better flow prediction methods for modeling the effects of viscosity, turbulence, compressibility, unsteadiness and temperature variations are sought. New concepts for active flow control in the turbomachine environment are encouraged.

Unsteady flow research addresses the scientific basis for exploiting unsteady flow driven by time-dependent boundary conditions to improve aerodynamic performance, especially maneuverability. Current research centers on unsteady flow separation and dynamic stall with emphasis on the mechanisms of vorticity production, accumulation and shedding. The effects of motion history, multiple degrees-of-freedom, and Reynolds and Mach numbers are of interest.

Collaborative, interdisciplinary approaches involving fluid dynamics and control theory are desired to provide new approaches for controlling turbulent and unsteady flows.

AF88-232 TITLE: Structures

OBJECTIVE: Improve structural efficiency and durability.

DESCRIPTION: We are particularly interested in the role of nonlinearity in structural response and in the ability to control the behavior by active and passive means. The dynamic response to external stimuli such as aerodynamics, gust and impact loads and complex interactions with fluids and control subsystems are of major interest. We seek the capability for accurate modeling of thermal diffusion through multiplayer actively-cooled structures including consideration of aerothermodynamic heating and surface reactions in hypersonic flight.

We support development of advanced constitutive theories capable of modeling the behavior of advanced materials such as polymeric, ceramic, metal matrix and carbon-carbon composites. Consistency between micro- and macro-structural viewpoints and accommodation of progressive damage are desirable attributes in this regard.

Special emphasis is placed on innovative interdisciplinary approaches combining materials science and solid mechanics and aimed at bridging the gap between the microstructure and the macro-mechanical material behavior.

Emphasis is also placed on damage growth predictions and physically identifiable and measurable damage metrics. Probability aspects of damage growth and failure are pursued by considering the development of damage states as a stochastic process.

A significant portion of this research addresses composite materials for propulsion and hypervelocity flight structures, including airframe composite laminates; solid rocket fuel particulate composites; and very high temperature ceramic and carbon-carbon composites.

Research areas include micromechanically based, constitutive modeling of soil, concrete and rock; identification and in situ measurement of properties of soils; identification of the mechanics of soil stabilization; investigation of blast-induced soil liquefication; study of the strength and fracture characteristics of geological materials; modeling of the response of jointed and monolithic rock formations; identification of damage mechanisms in concrete materials; investigation of structural systems for expedient facilities; study of the nonlinear structural response to high frequency dynamic loading; and investigation of structure-media interaction.

AF88-233 TITLE: Propulsion

OBJECTIVE: Improve the efficiency and stability of propulsion systems.

DESCRIPTION: Fundamental understanding of the physics and chemistry of multiphase turbulent reacting flows is essential for improving the performance of airbreathing propulsion and chemical laser systems.

We are interested in original and innovative research proposals using simplified configurations for experimental and theoretical investigations. Proposals to develop near-term, empirical, comprehensive models are not desired.

We shall assign highest priority to research relevant to studying supersonic combustion, boron fuels, atomization and spray behavior of slurries and liquids, and understanding the chemistry of fuel combustion. Other topics of interest include, but are not limited to: turbulent combustion, soot formation and combustion instability.

Topics of interest in electro propulsion include pulsed and steady-state plasmas; equilibrium and nonequilibrium flowing plasma, characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface, -electrode, -magnetic and –electric fields; losses to inert parts; plasmas in high magnetic fields and pressures; and plasma diagnostics (new and unique noninterference measuring techniques).

Our objectives are to predict and to suppress combustion instability in solid and liquid rocket systems, to control the complex roles of advanced energetic ingredients in solid propellant burning, to use metal fuels and to improve the service life of solid motors.

We are interested in new diagnostic techniques for analyzing surface reactions and flames of propellants, and in controlling the state of combustion products in plumes. Emphasis is on synthesizing and using advanced propellant ingredients to increase propulsion efficiency and to satisfy specific burning rate requirements.

Research is directed at new techniques for sensing temperature, concentrations, and velocities in energy conversion systems without interfering with the operation of the systems. The emphasis is on diagnostics of laboratory systems that simulate the hostile environments of high performance combustion plasma systems.

AF88-234 TITLE: Multifunctional Nonmetallic Materials Processing and Characterization

OBJECTIVE: To develop new nonmetallic material concepts for unique combinations of optical, electromagnetic and structural properties.

DESCRIPTION: Advances in ceramics, glasses and polymers are expected to come from the control of features at the 10-50 A to 1000-10,000 A level (ultrastructure) via chemical synthesis and processing methods. These materials may take the form of ultrastructural level composites which will perform a combination of active and passive functions. Processing includes new and improved materials based on the methods of organic, inorganic and organometallic chemistry as well as sol-gel, graphite-template chemistry, micromorphology processing, transformation processing, intercalation chemistry, emulsion chemistry and other innovative processes. Imaginative combinations of these processes are of interest for materials with nonlinear optical, magnetic, superconducting and/or semiconducting properties and phenomena and structural integrity. Subpicosecond, nonresonant or near-resonant low power optical polymers, organics and inorganics or combinations thereof or unique materials concepts for high critical temperature superconduction are specifically required. Molecular composites, which would include the analogs of macroscopic composites, biological and natural systems as well as new synthetic combinations, are of interest. Device applications should be considered, particularly where the ultrastructured material will serve as a self-contained functional entity. New organic and inorganic polymers as well as oxides and non-oxide nonmetallics are needed for these multifunctional ultrastructures. New mechanisms and reactions are considered important components of nonmetallic materials processing and synthesis.

AF88-235 TITLE: Atmospheric Science Modeling Technology

OBJECTIVE: To stimulate the development of new experimental and/or numerical methods for modeling atmospheric processes.

DESCRIPTION: Advances in capabilities for more accurate specification and prediction of the state of the atmosphere depend to a large extent on the fundamental understanding of underlying physical processes. There are so many variables in the real atmosphere that isolating various causes/effects of these physical processes often becomes difficult to nearly impossible in the natural environment. Development of physical laboratory models and/or computer models will enable controlled simulation of individual processes to uncover the mysteries of their basic evolution. An improved knowledge and larger-scale numerical modeling efforts, which could aid both the research and operational communities. This efforts seeks to enhance scientific research activities in the area of simulating lesser understood atmospheric processes. Areas of interest include, but are not limited to, gravity waves, lee waves, turbulence, convection, latent heating/cooling, and boundary layer fluxes. The Phase I effort should provide a review of various concepts and design the options for the proposed model(s). The Phase II effort would then involve development of a prototype or prototypes of the model(s) and use in atmospheric simulations. Phase III would be the commercialization of the technology. Evaluation criteria for proposals will include the following factors:

a. Relevance to the Air Force Research Program.
b. Potential value for transition to Air Force Laboratories.
c. Longer-term potential to address major operational support shortfalls.

AF88-236 TITLE: Heterostructures

OBJECTIVE: To understand and to apply heterostructures formed with metal, insulator, and semiconductor materials.

DESCRIPTION: A variety of growth techniques currently are available permitting the formation of amorphous, polycrystalline and single crystal heterostructures from dissimilar materials. These growth techniques include sputtering (thermal, E-beam) and epitaxial systems (liquid base epitaxy, chemical vapor deposition, organo-metallic CVD, molecular beam epitaxy). Candidate materials include metals, insulators and semiconductors. Particular Air Force interest exists in magnetic thin films on semiconductors, the combination of superconducting and semiconducting materials, epitaxy between non-lattice matched materials, optical multi-layers, and devices or other structures employing heterojunctions.

A detailed understanding is needed of the initial and subsequent stages of growth of heterostructure surfaces or interfaces. Theoretical simulations and a variety of characterization approaches need to be employed, particularly in combination. Novel growth techniques are of interest. Devices of interest include the high electron mobility transistor (HEMT), the heterojunction bipolar transistor (HBT) and more original structures.

AF88-237 TITLE: High Symmetry Structural Composites

OBJECTIVE: To establish the basis for a new generation of hybrid multi-phase structural materials whose constituents may be polymers, metals, ceramics or cements arranged in a regularly repeating highly symmetrical three-dimensional pattern.

DESCRIPTION: The currently available fiber reinforced composites demonstrate the remarkable possibilities of combining high modulus ceramic fibers with a polymer matrix. These materials show that delverately engineered microstructures produce materials with predictable mechanical properties. However, their usefulness is limited by the anisotropy of their mechanical properties. Principles are required to guide the design of multiphase composites which posses a much higher degree of symmetry than is possible in fiber reinforced laminate composites. We seek offerors with ideas for novel high symmetry composite microstructures who posses the capability to predict the mechanical properties of these model materials analytically and to fabricate and test these concepts. Concepts not requiring continuous fiber reinforcement and consisting of spherical elements and or whisker elements are encouraged. The combination of materials, geometrical arrangements or dimensional scale of the hybrid material may be arbitrary but must be justified with appropriate rational.

AF88-238 TITLE: Life Sciences Basic Research

OBJECTIVE: To provide fundamental data in toxicology, neurobiology, sensory information processing, and cognitive sciences.

DESCRIPTION: Basic research in five areas is supported:

Toxicology: Emphasis is on fundamental mechanisms that organisms use to respond to toxic chemical exposure, especially chemicals to which Air Force personnel are exposed. Primary objectives are to identify early indicators of toxic insult, to elucidate the mechanism of action of toxic chemicals, and to enhance natural detoxification of environmental chemicals through conversion of toxic agents into nontoxic metabolites.

Neuroscience: Fundamental studies of the neurobiology of learning and memory, biological rhythms, fatigue, stress, and arousal are one area of emphasis. Proposals for neurobiological research in which behavior is not studied explicitly but which would clearly further the understanding of behavior are accepted. Neurobiological research on visual and auditory information processing and higher cognitive functions and studies that bring together information about cellular and neural-circuit functions with information from studies of artificial intelligence are also supported. The relationship between neural architectures and formal computations that might underlie goal-directed behavior, learning, memory, and pattern recognition is emphasized.

Vision: Psychophysical research is supported leading to the discovery and quantitative modeling of featural processing mechanisms underlying visual recognition. Contrast detection and discrimination, motion, eye-movements color, and stereopsis are examples.

Audition: Psychophysical research is supported on the perception of complex sounds in normal human adults. The mechanisms underlying recognition, pitch, localization, and speech are examples.

Cognition: Research is supported on cognitive aspects of perception, memory, learning, representation of knowledge, problem-solving, reasoning, and judgement.

AF88-239 TITLE: Research in Mathematics and Computer Science

OBJECTIVE: To obtain mathematical models, methods, algorithms, and enhanced computing for modeling and control of complex systems.

DESCRIPTION: The Air Force needs better means to model and control complex systems occurring in many fields of application, including large space structures, robotics, electro-magnetic propagation and fluid flow. Enhanced computing and methods of artificial intelligence will play a significant role in developing such control systems, as will development of computer vision.

Basic research is required in several areas related to this topic. Mathematical models are required for many of the systems of interest, including those occurring in propulsion, robotics, and laser optics. Effective mathematical understanding, using both analytical and numerical tools, is needed for nonlinear equations such as those for transonic flow, laser focusing, detonation, stability of shear flows, geometrically exact elasticity, and nonstandard viscoelastic media. For example, models and a basic understanding of damping mechanisms in materials to be used in space structures are needed.

Related to this issue is the need for better simulation methods. Novel approaches to simulating complex systems, such as cellular automata, will be explored. Any such approach should be closely coupled to the physical processes which are being simulated.

Research is needed in several areas of mathematical control theory. Control of complex problems in robotics will likely require advances in adaptive control theory. Control of flexible systems will require advances in the theory of distributed parameter control. Research should address novel methods for dealing with nonlinear dynamics as well as model uncertainty and robustness. Control theories should be applicable to control of systems occurring in large space structures, robotics, or flow control.

Artificial intelligence approaches may be combined with control theory in order to control complex decentralized systems. Research in intelligent control methods, which couples these two approaches is needed.

Advances in software engineering and knowledge-based systems will be needed to implement computational models and control algorithms. Research is needed in knowledge-based systems with improved mechanisms for temporal reasoning for application to real-time critical problems. Research in software engineering should address issues of reusability, better programming environments, and the need to monitor changes dynamically.

Improvements in image processing should attempt to exploit the common mathematical framework provided by spatial statistics or employ the complementary approach to using expert systems. Research is needed to apply Bayesian approaches to capturing prior knowledge to accelerate and improve the imaging process.

An interdisciplinary approach to this class of problems will enhance the research efforts. For example, control of structural problems requires research in continuum mechanics as well as control theory. Robotics problems will require modeling of complex structures and systems, control theory, and methods of artificial intelligence. The interdisciplinary nature of these problems should be exploited from a mathematical and computer science perspective.

AF88-240 TITLE: Geomagnetic Pulsations as a Diagnostic of the Earth’s Magnetosphere

OBJECTIVE: Derive and validate indices of magnetospheric activity from ground-based observations and analyses of geomagnetic pulsations.

DESCRIPTION: Communications through and in near-Earth space can become disrupted during high levels of geomagnetic activity. Enhanced geomagnetic activity is one manifestation of disturbance of the magnetosphere called a magnetopheric substorm. Associated phenomena are aurora, x-rays, particle participation, ionospheric perturbations and geomagnetic pulsations.

Geomagnetic pulsations are magnetic fluctuations with periods ranging from about a second to ten minutes. A key element in understanding magnetospheric activity is to find a phenomenon which characterizes such disturbances and is related to changes in the structure and composition of the near-Earth space environment occurring during a magnetospheric substorm. Geomagnetic pulsations may provide such a phenomenon since they may indicate the natural or resonant periods of geomagnetic field lines and component parts of the magnetosphere. If these pulsations represent the characteristic periods of the Earth's magnetized plasma environment, they should offer a means of determining changes in the magnetosphere. As the properties of the magnetosphere change with the changing geomagnetic activity, there should be changes in the magnetic pulsations. Geomagnetic pulsations may be characteristic sound of the magnetosphere. These signals may provide a diagnostic tool but they also may afford an early warning system for magnetospheric substorms. Phase I should seek to answer the following questions: (1) Do global resonant oscillations of the magetosphere exist? (2) Do local or field line oscillations exist? (3) Are the properties of the oscillations significantly related to specific magnetospheric parameters? (4) Do the oscillations occur regularly enough to provide useful magnetospheric parameters? Depending on the results of Phase I, Phase II should develop indices of magnetic activity based on ground-based observations of magnetic pulsations and verify their utility as a diagnostic tool for near-Earth space conditions.

AF88-241 TITLE: Novel Electron-Beam-Driven Devices for the Generation or Amplification of Millimeter-Wave Radiation

DESCRIPTION: The Air Force is the single largest customer in this nation for vacuum electronic microwave devices. In spite of the popularity of solid-state devices, there are numerous applications in communication, radar, and electronic warfare whose power requirements exceed the capabilities of available semiconductors. At the same time, more demanding DOD requirements are putting increasing pressure on the industry to produce more compact, more lightweight, more efficient, and more reliable microwave tubes. In addition, future applications are expected to require tube output at higher and higher frequencies. The shorter the wavelength of radiation desired; the more intricate and expensive are the required fast wave tube structures. New tube concepts and geometries are needed to meet these future needs. In addition, the physics involved with beam-plasma interactions offer alternative mm-wave device concepts that beg exploration. Phase I efforts should provide a solid theoretical foundation for the new mm-wave amplifier or oscillator concept. Preliminary device design should also be addressed. Phase II should result in the design and construction of an actual prototype device along with preliminary performance optimization studies. Phase III should see the commercialization of the device concept.

AF88-242 TITLE: Novel Techniques in Seismic Detection

OBJECTIVE: To devise new techniques or instrumentation for improved seismic detection.

DESCRIPTION: Seisometry is based upon using seismometers which represent mature and perhaps dated technology. The goal is to incorporate new high-technology techniques and instrumentation to devise innovative detection schemes which improve accuracy, sensitivity, and/or frequency response to seismic signals.