AIR FORCE
PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBIR Program is with the Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. The Air Force SBIR Program Executive is R. Jill Dickman, (800) 222-0336. **DO NOT** submit SBIR proposals to the AF SBIR Program Executive under any circumstances. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-2 through 4.

Technical questions may be requested using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this system and other technical information assistance available from DTIC, please refer to section 7.1 on page 15 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the technical period of performance for Phase I will be nine (9) months, and the price will not exceed $100,000.

The primary research must be accomplished during the first six months of the contract. It is the bulk of the research for the Phase I effort. The primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. The proposal, alone, will decide who will be selected for Phase II.

Our evaluation of the primary research effort and the proposal will be based on the factors listed in the solicitation, and efforts that attract matching funds under the Fast Track will receive our highest priority in determining which proposals are requested and selected for Phase II.

Phase II proposals are by invitation only. If requested, the Phase II proposal must be submitted within six months from the start of Phase I to ensure that the proposal will be evaluated and is eligible for award. After the first six months, additional related research must be conducted that furthers the Phase I effort and puts the small business in a better position to start Phase II, if awarded. The last three months of the nine-month technical effort will not be considered in the evaluation process leading to Phase II awards.

Air Force Cost Proposal

Although proposals, including costs, are limited to 25 pages, be prepared to submit further documentation to substantiate costs if selected for award; the contracting officer may request further information to facilitate the contracting process.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, send one original and four (4) copies to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day. Be sure to read the Air Force instructions on the previous page for the nine-month Phase I contract to avoid the rejection of your proposal. To request notification of proposal receipt, send request (Ref A on page Ref 1) with a self-addressed stamped envelope. Do not call to ask whether your proposal has been received; due to time constraints, we will not be able to answer such telephone calls.

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS (Name and number for mailing proposals and for administrative questions)	CONTRACTING AUTHORITY (For contract questions only)
AF97-001 thru AF97-006	Air Force Office of Scientific Research AFOSR/NI (Dr Jerome Franck) 110 Duncan Ave, Ste B115 Bolling AFB DC 20332-0001 (Dr Jerome Franck, (202) 767-4970)	Ernest Zinser (202) 767-4992
AF97-007 thru AF97-042	Armstrong Laboratory AL/XPTT (Belva Williams) 2509 Kennedy Circle Brooks AFB TX 78235-5118 (Belva Williams, (210) 536-5429)	Don Norville (210) 536-6393
AF97-043 thru AF97-069	Rome Laboratory RL/XPD (Margot Ashcroft) 26 Electronic Parkway Rome NY 13441-4514 (Margot Ashcroft, (315) 330-3021)	Joetta Bernhard (315) 330-2308
AF97-070 thru AF97-081	Space & Missiles Technology Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Francisco Tapia (505) 846-5021
AF97-082 thru AF97-086	Advanced Weapons & Survivability Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Francisco Tapia (505) 846-5021
AF97-088 thru AF97-096	Propulsion OL-AC Phillips Laboratory/RKTC SBIR Program (S. Borowiak) 4 Pollux Dr Edwards AFB CA 93524-7760 (Ms Sandra Borowiak, (805) 275-5617)	Ms. Liliana Milhaleski (805) 277-3900

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS	CONTRACTING AUTHORITY
AF97-097 thru AF97-100	Geophysics OL-AA Phillips Laboratory/XPG SBIR Program (N.Dimond) 29 Randolph Rd, Bldg 1107, Rm 240 Hanscom AFB MA 01731-3010 (Ms Noreen Dimond, (617) 377-3608)	Mr. John Flaherty (617) 377-2529
AF97-101 thru AF97-111	Lasers & Imaging SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Francisco Tapia (505) 846-5021
AF97-112	Space Experiments SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Francisco Tapia (505) 846-5021
AF97-113	Plans & Programs SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418	Mr. Francisco Tapia (505) 846-5021
AF97-114 thru AF97-139	Avionics Directorate WL/AAOP 2011 8th St, Rm N2G21 Wright-Patterson AFB OH 45433-7623 (Sharon Gibbons, (513) 255-5285)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF97-140 thru AF97-154	Flight Dynamics Directorate Wright Laboratory WL/FIOP, Bldg 45 Wright-Patterson AFB OH (Madie Tillman, (513) 255-5066)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF97-155 thru AF97-173	Materials Directorate WL/MLIP 2977 P St, Ste 13 Wright-Patterson AFB OH 45433-6523 (Sharon Starr, (513) 255-7175)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF97-174 thru AF97-191	Aero Propulsion & Power Directorate WL/POM 1950 Fifth St, Bldg 18, Rm 105A Wright-Patterson AFB OH 45433-7251 (Betty Siferd, (513) 255-2131)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS	CONTRACTING AUTHORITY
AF97-192 thru AF97-198	Manufacturing Technology Directorate 2977 P St, Ste 6, Bldg 653 Wright-Patterson AFB OH 45433-7739 (Marvin Gale, (513) 255-4623)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF97-199 thru AF97-218	Armament Directorate WL/MNPB 101 W Eglin Blvd, Ste 143 Eglin AFB FL 32542 (Richard Bixby, (904) 882-8591)	Lyle Crews, Jr. (904) 882-4284
AF97-219 thru AF97-250	Technology Transition Office AFMC-TTO/TTP, Bldg 262 4375 Chidlaw Rd, Ste 6 Wright Patterson AFB OH 45433-5006 (Rebecca Holbrook, (513) 257-4439)	
AF97-252 thru AF97-254	Aeronautical Systems Center ASC/XRPA (LtCol Azeez Shamiyeh) 2275 D St, Ste 10, Bldg 16 Wright-Patterson AFB OH 45433-7227 (LtC Azeez Shamiyeh, (513) 255-2630, x3079)	Arnette Long (513) 255-6632
AF97-255 thru AF97-257	Electronic Systems Center ESC/XRR (Rod Young) 50 Griffiss St Hanscom AFB MA 01731-1624 (Rod Young, (617) 271-4718)	Iris Durden (617) 377-2907
AF97-258 thru AF97-260	Space & Missile Center SMC/XRR (Jun Rosca) 2430 E El Segundo Blvd, Ste 1611 Los Angeles AFB CA 90245-4687 (Jun Rosca, (310) 363-2613)	Norman E. Harrison (310) 363-6871

AIR FORCE 97.1 KEYWORD INDEX

AIR FORCE 97.1 TOPIC INDEX

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH, BOLLING AFB DC

ARMSTRONG LABORATORY, BROOKS AFB TX

ROME LABORATORY, GRIFFISS AFB NY

AF97-043 Innovative C31 Technologies
AF97-044 Large-Scale Knowledge-Base Technology
AF97-045 Automatic Code Generation for Real-Time Parallel Systems
AF97-046 Multi-Source Collaborative Distributed Information Systems
AF97-047 Futuristic C51 (Collaborative C41) Technologies
AF97-048 Active Intelligent Information Environments
AF97-049 Smart Networking Radio Technology
AF97-050 CAD Conversion Tools for VHDL-A Library Generation
AF97-051 Electromagnetic Environment Sensing/Recording System
AF97-052 Prognostic Assessment Technique/Tool for Electronic Equipment and Systems
AF97-053 New Diagnostic Tool for Evaluation of Material Surfaces
AF97-054 Design Tools for Minimizing Electronic Failure
AF97-055 Ultra-High Speed Bit Error Rate Tester
AF97-056 Large Area Nitride Substrates
AF97-057 InP-based Power Transistors for Optically Controlled Millimeterwave Transmitters
AF97-058 Ka-Band Satellite Link Quality Short-Term Forecasting Tool
AF97-059 Multifunction Phased Arrays
AF97-060 Information Exploitation for Identification
AF97-061 Advanced Data Fusion Technology
AF97-062 Information Storage & Retrieval: Optical Memories
AF97-063 Intelligent Desktop Assistant
AF97-064 Single-Channel Spectral Characterization
AF97-065 Automated Information Extraction Tools
AF97-066 Exploitation of GPS Controlled Imagery
AF97-067 Defensive Information Warfare Technology
AF97-068 RF Photonics Technology
AF97-069 Photonic Signal Processing

PHILLIPS LABORATORY - SPACE & MISSILES TECHNOLOGY, KIRTLAND AFB NM

AF97-070 Space Systems Technology Development
AF97-071 Attenuation of Acoustic Disturbances in Containerized Payload Systems for Reusable Launch Vehicle Systems
AF97-072 Ultra-Lightweight "Meter" Class Optics
AF97-073 Rigid Inflatable Structures
AF97-074 Advanced Isolation for Launch Vehicle Avionics
AF97-075 Microelectromechanical Systems (MEMS) Microrelays and Microswitches for Space
AF97-076 Substrate Improvement for LWIR Mercury Cadmium Telluride
AF97-077 Anomaly Resolution Using Case-Based and/or Model-Based Reasoning
AF97-078 Cryogenic Coolers for Space Applications
AF97-079 High Performance Quantum-Well/Superlattice Infrared Detector Development
AF97-080 Intelligent Solid State Switching
AF97-081 Momentum Wheel Energy Storage

PHILLIPS LABORATORY - ADVANCED WEAPONS & SURVIVABILITY, KIRTLAND AFB NM

AF97-082 Electromagnetic Effects, Measurements, Protection, Sources, and Satellite Protection
AF97-083 Elimination of Pulse Shortening in High Power Microwave Tubes
AF97-084 Automated Vehicle Identification
AF97-085 Wideband Sources, Antennas and Mode Converters
AF97-086 Electromagnetic Integration of Commercial-Off-The-Shelf (COTS) Equipment Into Military Systems

PHILLIPS LABORATORY - PROPULSION, EDWARDS AFB CA

AF97-088 Advanced Rocket Propulsion Technologies
AF97-089 Molded Polymeric Components for Combustion Systems and Extreme Temperature Applications
AF97-090 Innovative, Remote, Laser-Based Diagnostic Techniques for High-Pressure Combustion Applications
AF97-091 Electric Propulsion (EP) Thruster for Low Power Small Satellites
AF97-092 Solar Thermal Rocket Propulsion
AF97-093 Turbine Blade Cooling
AF97-094 Magnetic Bearing for Rocket Engine Turbopumps
AF97-095 Flight Weight Electro-mechanically Actuated Cryogenic Ball Valve
AF97-096 Cryogenic Liquid Level Indicator #20

PHILLIPS LABORATORY - GEOPHYSICS, HANSCOM AFB MA

AF97-097 Next Generation Atmospheric Turbulence Sensors
AF97-098 Flight Track Clear Air Turbulence (CAT) Model
AF97-099 Optical Sensors for Geophysical Remote Sensing, Environmental Monitoring and Target Characterization
AF97-100 Precision Orbital Microaccelerometer (POM)

PHILLIPS LABORATORY - LASERS & IMAGING, KIRTLAND AFB NM

AF97-101 High-Power, Doped Fiber Laser Amplifiers
AF97-102 Semiconductor Laser Technologies for Photodynamic Therapy (PDT) or Minimally-Invasive Surgery (MIS)
AF97-103 Direct Generation of Mid-IR Laser Wavelengths and Sensor Effects
AF97-104 Applications of Smart Vision Systems
AF97-105 On-Chip Real-Time Wavefront Sensor Array Development
AF97-106 Semiconductor Laser Technologies for Fieldable, Diagnostic and/or General Medical Applications
AF97-107 High Average Power Frequency Agile COIL (Chemical Oxygen Iodine Laser)
AF97-108 High Sensitivity Detection of Pulsed Laser Radiation for Differential Absorption Lidar (DIAL) Applications
AF97-109 Hand-Held Visible Diode Laser Illuminator/Designator
AF97-110 Scintillation Control for Imaging and Laser Propagation Systems
AF97-111 Optics Health Monitoring

PHILLIPS LABORATORY - SPACE EXPERIMENTS, KIRTLAND AFB NM

AF97-112 New Methods for Distributing Satellite Data to Users

PHILLIPS LABORATORY - PLANS & PROGRAMS, KIRTLAND AFB NM

AF97-113 Broad Area Technology Applications for Military Police Operations

WRIGHT LABORATORY - AVIONICS DIRECTORATE - WRIGHT PATTERSON AFB OH

AF97-114 Precision Reference Information State Error Measurement
AF97-115 Automatic Target Recognition (ATR) Technology Components
AF97-116 Sensor Management Across Multiple Platforms (SMAMPS)
AF97-117 Avionics Applications of Reinforcement Learning Systems
AF97-118 Multiple-Target Tracking for Avionics Platforms
AF97-119 Biological and Cognitive Foundations of Holistic Information Fusion
AF97-120 Solid State RF Electronics Applied Research
AF97-121 Innovative MBE Growth and Semiconductor Characterization Components and Techniques
AF97-122 Innovative Electro-Optic Device Technology
AF97-123 Support Technologies for Multi-chip Modules
AF97-124 Innovative Microelectronics Device Development
AF97-125 Adaptive Computing for RF Device and Component Modeling
AF97-126 Highly Sensitive Imaging Detectors for Laser Radar Systems
AF97-127 Architectures and Components for Modular, Multi-function Electro-Optical Avionics Systems
AF97-128 Robust Multi-Function Laser Sources
AF97-129 Nonlinear Optical Frequency Conversion of Ultra-fast Sources
AF97-130 Coherent Spectroscopic Instrumentation
AF97-131 Digital Multi-Function Sensor
AF97-132 Digital Frequency Modulation
AF97-133 Combined Ultra Wideband Radar/Communications Avionics
AF97-134 Chaff Dispenser Location Computer Model
AF97-135 Global Positioning System (GPS) P(Y)-Code Acquisition
AF97-136 Avionics Modeling and Simulation Technology
AF97-137 Electronic Design Automation
AF97-138 Single-Mode Reliable Optical Card-Edge Connector
AF97-139 Missile Warning System Scene Projection

WRIGHT LABORATORY - FLIGHT DYNAMICS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF97-140 Innovation Electron Beam (EB) Cured Structures
AF97-141 Distributed Actuation for Aircraft Maneuver and Performance Enhancement
AF97-142 Structural Integrity of Aging Aircraft
AF97-143 Flight Control Technology
AF97-144 Tactical-Uninhabited Air Vehicle (T-UAV) Operator Station Simulator
AF97-145 Full Color Autostereographic True Three Dimensional Displays
AF97-146 Global Diagnostic System for Unsteady Flow Fields
AF97-147 Cost Estimating Methodology for Advance Air Vehicles
AF97-148 Aeromechanics for Future Aircraft Technology Enhancement
AF97-149 Fire Detection/Suppression Systems
AF97-150 Innovative, Localized, Autonomous Cooling Systems
AF97-151 Spall Fragment Field and Surface Deformation Characterization System
AF97-152 Engineering Research Flight Simulation Technologies
AF97-153 Innovative Damping Concepts for Extreme Environments
AF97-154 Bare Base Operations

WRIGHT LABORATORY - MATERIALS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF97-155 Advanced Aircraft Coatings Systems
AF97-156 Environmentally Compliant Signature Control Coatings
AF97-157 Affordable Composites
AF97-158 Polymer/Inorganic Nanocomposites for Substructure Applications in USAF Rockets and Aircraft
AF97-159 Improved Tribological Systems for Spacecraft
AF97-160 Paint Stripping Methods
AF97-161 Gap Treatment Materials for Low Observable Aircraft
AF97-162 Affordable Multi-material System Alternatives
AF97-163 Gradient Materials Interface Design
AF97-164 Advanced Materials and Processes for Aging Aerospace Systems
AF97-165 Novel Nondestructive Evaluation Technology for Aerospace Components and Systems
AF97-166 Metallic Structural Materials for Air Force Systems
AF97-167 High Temperature Structural Materials for Advanced Air Force Systems
AF97-168 Design and Synthesis of New Bichromophore Laser Protective Materials
AF97-169 Advanced Liquid-Crystal Materials Development
AF97-170 High Temperature Superconducting Thin Films
AF97-171 Nonlinear Optical Materials
AF97-172 Failure Mechanism in Avionics Equipment Preventable by Dehumidification
AF97-173 Environmentally Benign Aircraft/Anti-icing Technology

WRIGHT LABORATORY - AERO PROPULSION & POWER DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF97-174 Aero Propulsion and Power Technology
AF97-175 Power Generation and Thermal Management
AF97-176 Advanced Capacitors for Power Electronic Systems
AF97-177 Advanced Battery Development
AF97-178 Special Purpose Power and Power Components
AF97-179 Advanced Power Technology Concepts
AF97-180 High Mach, Advanced Air-Breathing, Storable-Fueled Engine Technology
AF97-181 Accelerated Convergence Rate for Numerical Analysis of Ramjets and Scramjets
AF97-182 Advanced Instrumentation for Ramjet/Scramjet Combustors
AF97-183 Novel Sources of Electromagnetic Radiation for Advanced Combustion Diagnostics
AF97-184 Self Contained Dampers for Gas Turbine Engines
AF97-185 Thermally Stable Jet Fuels, Additives, and Test Methods
AF97-186 Advanced Techniques for Ultra Trace Analysis of Aviation Fuel
AF97-187 Aircraft Turbine Component Technology - Aerodynamics and Cooling
AF97-188 Compression System Design Methodology
AF97-189 Real Time Ontogenetic Engine Health Monitoring (EHM) of Gas Turbine Engines
AF97-190 Combustor Acoustics Modeling Technology Research
AF97-191 Adaptive Filtering for Improved Turbine Engine Performance and Component Estimation

WRIGHT LABORATORY - MANUFACTURING TECHNOLOGY DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF97-192 Whole Wafer Thermal Measurement
AF97-193 Systems Engineering Using Key Characteristics
AF97-194 New Methods for Copper Electro-Plating Advanced Printed Wiring Boards
AF97-195 Manufacturing Information for Electronics System Upgrades
AF97-196 Three Dimensional Semiconductor Substrate Inspection

AF97-198 Innovative Manufacturing Technology Concepts

WRIGHT LABORATORY - ARMAMENT DIRECTORATE, EGLIN AFB FL

AF97-199 Weapon Flight Mechanics Research
AF97-200 Advanced Flight Controls for Small Airframes
AF97-201 Tactical Kinematic GPS/IMU Algorithms
AF97-202 Multiple Sensor Inertial Measurement Unit
AF97-203 Guidance Research
AF97-204 Optical Detection and Discrimination Techniques for Laser Radar
AF97-205 Narrow Bandwidth Near-Infrared Tunable Optic Filter
AF97-206 High Performance Pulse Capture Circuitry for Near-Infrared Optical Receivers
AF97-207 Advanced Processing Techniques for Restoration and Super-resolution of Imaging Sensors
AF97-208 Data Fusion Using the Wavelet Transform, Fractal Theory, and Statistics
AF97-209 Armament Research
AF97-210 Expendable, Low Cost, Solid State Millimeter Wave Components
AF97-211 Infrared Fisheye Optics
AF97-212 Penetrator Communication Link
AF97-213 Pyrotechnic Initiator
AF97-214 Hard Target Influence Fuzing Technology
AF97-215 Munition Instrumentation and Performance Assessment Technology
AF97-216 Electronic Imaging Transient Stereo Photogrammetry
AF97-217 Blast and Ballistic Loading of Structures
AF97-218 Non-Intrusive, Remote Identification of Chemical Contaminants

TECHNOLOGY TRANSITION OFFICE, WRIGHT-PATTERSON AFB OH

AF97-219 Slipper Wear/Gouging Phenomena
AF97-220 Rail Tension/Compression Phenomena
AF97-221 Low Cost Laser Range Finder
AF97-222 Storing Energy Delivering Power Using Capacitors
AF97-223 Modeling the Effects of Gamma Irradiation on Electro-Optics Components
AF97-224 Sustainment Science and Technologies
AF97-227 Miniaturized/Universal Flight Termination System (FTS)
AF97-228 Miniature Munitions Aerodynamic Global Positioning System (GPS) Receiver/Transmitter (MMAGRET)
AF97-229 Multi-Spectral Airborne Common Calibration Source (MACCS)
AF97-230 Inertial Measurement Simulation for Global Positioning System (GPS) Guidance Receivers
AF97-231 Time-Space-Position-Information (TSPI) and Terrain Three Dimensional (3-D) Visualization (TT3DV)
AF97-232 Operation of Diesel Engines on Low Lubricity/Low Viscosity Fuels
AF97-234 On-Aircraft Radio Test Set
AF97-235 Remote Positioning Capability for Accurate Placement of Test Assets
AF97-237 Automatic Telemetry Stream Data Format Generation
AF97-238 Optical Slip-Ring Connector (OSRC)
AF97-239 Standard Automatic Test System (ATS) Interface
AF97-241 Robotic Test Probe
AF97-242 Non-Intrusive System for Replication of Interlayer Printed Electronic Circuit Patterns
AF97-243 Carboxyl-Terminated Polybutadiene (CTPB) Process for ANB-3066 Solid Rocket Propellant
AF97-244 Advanced Test Software Technologies
AF97-245 Adhesive-sealable Barrier Material
AF97-246 Environmentally Safe, In Situ Surface-Protection of Carbon Steel Structures
AF97-247 Tunable IR Laser for Spectroscopic

AF97-248 Non-intrusive Smoke Measurement
AF97-249 Combined Total Integrated Scatter (TIS) and Retro-Reflectance Instrument for Hyperspectral and Laser Line Sources
AF97-250 Long Taper Hone

AERONAUTICAL SYSTEMS CENTER, WRIGHT-PATTERSON AFB OH

AF97-252 Airborne Monitoring of Ground Vehicle Motion
AF97-253 Assessing Environmental Impacts on the Life Cycle of a System
AF97-254 Application of Genetic Algorithm to Optimization Problems

ELECTRONIC SYSTEMS CENTER, HANSCOM AFB MA

AF97-255 C41 Systems/Subsystems
AF97-256 Advanced Distributed C41 Simulation Capabilities
AF97-257 Improved Satellite Data Communications

SPACE & MISSILE SYSTEMS CENTER, LOS ANGELES AFB CA

AF97-258 Lightweight, Portable Tactical Weather Terminal
AF97-259 Electro Magnetic Suspension Two-Axis Gimbal Satellite Antenna System
AF97-260 Environmentally Conscious Solder Replacement for Surface Mount/Bench Applications

AF97-001 TITLE: Development of Nanostructured Electrode Materials for an Advanced Rechargeable Aerospace Battery

Category: Basic Research

OBJECTIVE: Improve the conductivity of the intercalation process, in compact power sources, by increasing the rate of diffusion of ions to liquid-like rates.

DESCRIPTION: The Air Force currently uses rechargeable Ni-Cd batteries for main aircraft batteries and other applications. Since these batteries contain cadmium, disposal is costly due to its' reactivity and the hazardous/toxic nature of the material. Theere have been a number of battery systems which have been in development and the focus of this solicitation will be intercalative battery systems. The approach would be development of an alternate intercalative rechargeable battery system without cadmium, there by, limiting the pollution problem. One of the limitations of the intercallative rechargeable battery system has been achieving a higher storage capacity for the intercalate and approaching the diffusion rates of liquids within the electrodes limiting transport. With graphite in particualr, exfoliation is a tremendous restriction to high loading and cyclic life. By designing nanostructured electrode materials with set layer separations, ion mobility and storage capacity may be improved, and, due to cathode protection from phase change, higher cycle life may be realized.

PHASE I: Concentrate on the development of a way to construct and assemble these nanostructed electrodes and electrochemically and physically characterize them.

PHASE II: Concentrate on the assemblage of the battery system with a deliverable battery prototype as the goal.

POTENTIAL COMMERCIAL MARKET: Besides possible space based applications both military and civilian, successful development could result in improvements over a number of existing battery designs for a wide range of industrial and consumer uses for small power batteries.

REFERENCES:
1. Carlin, R. T.; DeLong, H. C.; Fuller, J. and Trulove, P. C., J. Electrochem. Soc., 141, L73 (1994).
2. Zhang, Z. and Lerner, M. M., J. Electrochem. Soc., 40, 742 (1993).
3. Lemmon, J. P. and Lerner, M. M., Carbon, 31, 437 (1993)

AF97-002 TITLE: Low Power Electronics via Native III-V Oxides

Category: Basic Research

OBJECTIVE: Develop novel approaches to low power electronic devices exploiting the recently demonstrated native A1-oxides on GaAs.

DESCRIPTION: One of the strongest features of the unusually robust and flexible silicon-based electronics technology is the excellent native oxide, SiO2. This oxide and its superior interface with silicon underpins the pervasive CMOS technology. In addition to supporting very high levels of integration, CMOS enables low power circuits. Emerging AF and DOD electronic systems require ever lower levels of power dissipation. At the same time, many of these military applications simultaneously require advanced performance through higher speed/frequency of operation of wider bandwidth. Silicon circuits are unable to supply leading edge requirements of this type.

Devices and circuits based upon GaAs and related compound semiconductors are capable of meeting the high speed and bandwith requirements. However, they dissipate more power than corresponding CMOS circuits. A stable, high quality native oxide (or equivalent insulator) has long been sought that would lead to a GaAs CMOS technology. There is evidence that such an oxide is formed by the wet oxidation of AlAs. Several successful demonstrations have

been made of the use of these oxides in optoelectronic devices such a laser diodes and Bragg reflectors. What is sought here are convincing demonstrations of the use of these Al-oxides in electronic devices suitable for low power electronic circuits. Examples of device demonstrations are MOSFETs where the Al-oxide forms the gate insulator or other novel uses of buried oxide layers. The potential for low power applications is essential.

PHASE I: Design, fabricate and characterize a suitable electronic device incorporation A1-oxides.

PHASE II: Optimize the device design and processing; design prototype low power electronic circuits with these devices. It is essential to demonstrate the ability (or the potential) to complete with Si CMOS for power consumption while maintaining superior speed.

POTENTIAL COMMERCIAL MARKET: An appropriate commercial application for demonstratrion is front - end circuitry for portable, personal communications.

REFERENCES:
1. S. Guha et al, Appl. Phys. Lettr, 68 (7), 906 (1996).
2. E. I. Chen et al, Appl. Phys. Lettr, 66 9 20 0, 2688 (1995)

AF97-003 TITLE: Micromachined Optical Devices and Systems

Category: Basic Research

OBJECTIVE: Develop optical devices and / or systems taking advantage of the emerging science and technology of micromachining.

DESCRIPTION: The science, technology, and application of micromachining is rapidly developing in numerous directions. A wide variety of extremely promising applications to optical devices and systems have been demonstrated. These include the fabrication of microlenses and lens arrays, refradtive, diffractive, and combined, scanning devices, and various forms of light modulators and displays (projection and helmet mounted).

PHASE I: Research will be performed in any chosen promising aspect of the application of micromachining to new performance or greatly reduced cost optical components or systems.

PHASE II: Prototype devices and systems will be devised and demonstrated.

POTENTIAL COMMERCIAL MARKET: Numerous important commercial products to include: Imaging products, lighting products using lens arrays, small and large displays, and spatial light modulators and wavefront correctors.

AF97-004 TITLE: Human Cognitive Overload

Category: Basic Research

OBJECTIVE: Develop techniques for measuring individual cognitive load.

DESCRIPTION: Human cognitive overload causes errors when human decision-makers fail to consider all available evidence when forming rapid decisions. The problem of cognitive overload perhaps can largely be ameliorated by control of the decision-maker's environment using new technologies that remove decisions to a second operator or to a system for automated decision making. The proper allocation of decisions among decision-making elements, however, cannot be accomplished without an accurate measure of residual cognitive capacity of individual human operators. This topic seeks proposals to develop an understanding of the limits to human decision-making capacity through advanced techniques for measuring cognitive capacity. All approaches to objective measurement of cognitive workload are encouraged. For example, monitoring physiological state or overt behaviors and responses can both be considered. Proposed work should address research issues in the context of console operations tasks, and identify a research path toward a long-term goal of devices for measuring cognitive capacity in that domain. Proposals are

especially encouraged for techniques offering a non-invasive near real-time index of cognitive capacity and a sensitivity to the set of putative dimensions of cognitive work.

PHASE I: Experimental demonstration of cognitive workload assessment technique.

PHASE II: Demonstration of device for closed loop control of decision-maker workload.

POTENTIAL COMMERCIAL MARKET: Impact technologies of education and training, by revealing when training had yielded expertise, and technologies of occupational safety, by indicating periods of marginal operator cognitive capacity.

AF97-005 TITLE: Computational Tools for Modeling, Control Design and Analysis of Distributed Parameter Systems

Category: Basic Research

OBJECTIVE: Develop algorithms and software to construct mathematical models for designing and controlling distributed parameter systems.

DESCRIPTION: Innovative techniques are solicited to develop a workstation based computational tool to facilitate the development of control design models for various aerospace applications including boundary control of fluid/structure interactions, thermal processes, and propulsion. The product shall calculate the basic system matrices; provide tools for model reduction; include an effective control design and analysis capability; contain error analysis modules for standard parabolic, hyperbolic, elliptic and hybrid systems; and interface with current commercial control and design software.

The primary objective of the computational tool is to support the design and assessment of controllers for aerospace systems governed by partial differential equations. The tool must facilitate fast modeling of large complex systems and allow for quick design of low order controllers. The tool must contain standard control design methodologies such as LQG, Hoo, H2/Hoo, u-synthesis and feedback linearization.

PHASE I: This part of the investigation will include the development of a basic structure to generate finite dimensional models from standard partial differential equations control systems and the resulting models must be in a form useable by existing industrial control design tool boxes.

PHASE II: Produce a viable system and demonstrate its ability to construct low order models, practical controllers and to peform analysis of the control system. The tool should help determine locations of sensors and actuatoars for optimal performance. This system should be object oriented and contain either stand-alone design tools or interfaces with existing control design software.

POTENTIAL COMMERCIAL MARKET: A new modeling and design tool that can be used by large and small engineering firms, DOD laboratories, and research groups.

REFERENCES:

1. J.L. Lions, Control of Distributed Parameter Systems, Gauthier-Villars, Bordas, Paris, 1985.
2. Estimation and Control of Distributed Parameter Systems, Eds. W. Desh, F. Kappel and K. Kunisch, International Series of Numerical Mathematics, Vol. 100, Birkhauser Verlag, Basel, 1991.
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AF97-006 TITLE: Electric Propulsion for Small Satellites

Category: Basic Research

OBJECTIVE: Develop methods to improve life and efficiency of electric thrusters at sub- kW level through predictive capability.

DESCRIPTION: A national trend toward reducing the size of satellites is in progress, and is based on the belief that small satellites are significantly cheaper and quicker to produce, deploy and operate. However, small satellites (500 lbs. or less) are extremely mass and power limited, and thus impose new constraints on propulsion system designs. To keep the propulsion system wet mass fraction to a minimum, high specific impulse options like electric propulsion are being strongly considered. Current demands of the military use of space, smaller satellites with high mobility, requires highly accurate low thrust/low mass/high specific impulse electric propulsion systems for satellite station keeping, pointing and on-orbit maneuvering missions. Few devices look promising for power levels below 500 W if their performance can be improved. The objectives of this topic are: -to investigate the principal energy loss mechanisms for sub-kW arcjets which have much different physical mechanisms than high power arcjets. The research activities will focus on the viscous and thermal losses in the nozzle nad the arc instabilities. -Search prescriptions for the current waveform for the Ablative Pulsed Plasma Thrusters in order to match arc-circuit impedance. The goal is to optimize ablation, depolymerization, ionization and acceleration of solid propellant and to minimize the production of slow neutrals which adversely impact the performance. - understand, predict, and control plasma instabilities, excessive plume divergence, and insulator erosion in the Hall thrusters to achieve acceptable levels of performance and life, - explore new concepts.

PHASE I: Concentrate on the predictive design of a selected thruster and physically characterize it.

PHASE II: Manufacture a prototype of the selected thruster,for optimal parameters obtained in Phase I, and experimentally verify the findings.

POTENTIAL COMMERCIAL MARKET: Military and industry have been pushing the trend towards small satellites (e. g. MSTI, STEP,MIGHTYSAT, Teledesic, New Millennium), there are multiple potential users of this technology.

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AF97-007 TITLE: Human Systems/Subsystems Research

Category: Exploratory Development

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

DESCRIPTION: Proposers may submit ideas to enhance human performance as an integral part of Air Force systems and operations. Five directorates perform a full spectrum of basic and applied research including exploratory and advanced development: (Specify subtopic by letter).

a. The Human Resources Directorate conducts research in manpower and personnel, force management, training systems (including pilot training) and logistics/information technologies. The objective is to improve operational readiness and control costs by developing technologies for more effective selection, assignment, training and retention of a high quality military force.

b. The Crew Systems Directorate conducts research and development (R&D) to improve human performance, protection, and survivability in operational environments. R&D is conducted to: determine human responses to operational stressors, such as noise, impact, vibration, hostile fire, sustained acceleration, spatial disorientation, altitude, workload, and sustained operations; define human-centered design criteria and concepts for personal protection equipment and workstations; and optimize human-machine integration including visual/auditory displays and crew communication.

c. The Aerospace Medicine Directorate addresses the medical selection, protection and enhancement of humans in Air Force systems and operations. Mission related research and specialized operational support are conducted in aeromedical consultation, epidemiology, drug testing, hyperbaric medicine, and dental devices. Clinical sciences research is conducted to develop standards for aviator selection and retention.

d. The Occupational and Environmental Health Directorate assesses risks to personnel from hazardous materials, toxicology, noise, electromagnetic radiation, (Radio Frequency and Laser) and occupational processes and conducts research to reduce those risks. The goals are to mitigate impacts on health and to enhance the scientific understanding of the underlying biological mechanisms.

e. The Environics Directorate conducts in-house research and manages out-sourced contracted research on innovative technologies to fulfill Air Force requirements for site cleanup and environmental compliance. Site cleanup research emphasizes fuels and solvents. Environmental compliance emphasizes fuels, solvents, and other aerospace materials. Specific areas of research include the behavior, transport, and ultimate fate of chemicals in air, soil, or water; advanced contaminant characterization and pollutant monitoring; contamination cleanup technologies through control, conversion, or destruction using biological, physical, and chemical processes; and hazardous waste minimization. The goal is to find the most efficient, economical, and effective answers to eliminate, substantially reduce, or mitigate environmental consequences of Air Force operations.

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AF97-008 TITLE: Control of Microbial Biofilms in Dental Unit Waterlines

Category: Exploratory Development

OBJECTIVE: Identify technologies that can reliably and economically control or prevent the formation of microbial biofilms in dental unit water lines.

DESCRIPTION: Biofilms-consisting primarily of naturally occurring, slime producing bacteria and fungi-form on the walls of small-bore plastic tubing in dental units which deliver coolant water during dental treatment. Levels of contamination in dental unit treatment water often exceed one million colony-forming units per milliliter (CFU/mL). Although bacteria of human origin have been reported, most of the organisms are water bacteria often found in smaller numbers in drinking water.

Although there is no current epidemiological evidence of a public health problem, the presence in dental water lines of potential human pathogens including Pseudomonas, Legionella and aquatic Mycobacterium species suggests reason for concern. One study has reported two Pseudomonas aeruginosa infections in immunocompromised patients and two other studies have demonstrated elevated Legionella antibody titers in dental personnel suggestive of chronic exposure. A fatal case of Legionnaire's disease in a dentist has been linked to exposure to contaminated dental unit water.

The American Dental Association Council on Scientific Affairs recently published a statement on dental unit waterlines that challenges industry to produce systems that can reduce the level of bacteria used in dental treatment to less than 200 CFU/mL by the year 2000.

Methods proposed for control of waterline biofilms include filtration, UV irradiation, and chemical disinfection with or without the use of separate water reservoirs. Both separate water reservoir systems and filtration devices are commercially available. There is an urgent need for improved engineering methods designed to control or eliminate microbial biofilms in dental unit waterlines.

PHASE I: Phase I will identify a technology or combination of technologies that can reliably and economically control or prevent the formation of microbial biofilms in dental unit waterlines with minimal user intervention. Treatment water must not exceed the recommended ADA standard of 200 CFU/mL. The water produced must also be compatible with dental restorative materials and free of potentially toxic or carcinogenic

chemicals. Economical methods for clinical monitoring of the effectiveness of the treatment method should also be developed.

PHASE II: Phase II will result in a commercially viable system, including in-office monitoring techniques, which can be tested in a clinical setting.

POTENTIAL COMMERCIAL MARKET: Since virtually every one of over 150,000 dental offices in the United States (and thousands more worldwide) is affected by this problem, the commercial potential of user-friendly and cost effective technology for this purpose is very great. The technology developed would be applicable in both civilian and DOD dental clinics. Since biofilms and biofouling are major problems in a wide range of other areas including medicine and the food and pharmaceutical industry, there is potential for further commercialization outside of dentistry.

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AF97-009 TITLE: Active Noise Reduction Headphones

Category: Exploratory Development

OBJECTIVE: Develop headphones for hearing assessment which employ active noise reduction to attenuate environmental noise.

DESCRIPTION: The accurate evaluation of hearing acuity depends on being able to attenuate background noise. This is typically done by placing the patient in a sound treated room. These facilities are expensive, bulky, heavy and, as a result, require special installations. Recent work with active noise reduction (ANR) technology has been focused on hearing protection headsets. This technology uses active noise cancellation to effectively block hazardous noise from damaging the hearing of those working in hazardous noise environments. These headsets are quite effective for frequencies extending up to approximately 1000 Hz. Hearing test results are affected most by low-frequency noise. ANR technology should make it possible to test hearing in high noise areas and preclude the use of specialized sound-treated facilities. However, a novel approach would be needed to permit accurate transmission of the stimulus signal while attenuating the ambient noise. The stimuli used for audiometry include pure tones, narrow-band and broad-band noise, and more complex speech signals.

PHASE I: Develop a bench-level headset system, incorporating ANR technology to suppress ambient noise while leaving the stimulus unaffected.

PHASE II: Develop and validate a headset system that meets current ANSI specifications for delivery of auditory test stimuli (ANSI 69) while reducing ambient noise to meet current AF specifications (AFR 161-15) for audiometric test environments.

POTENTIAL COMMERCIAL MARKET: This technology could be used by all DoD and civilian facilities where hearing testing is conducted. This includes typical clinical environments as well as physicians offices, occupational health clinics, and newborn nurseries.

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AF97-010 TITLE: Transport and Shipping of Diagnostic Specimen and Etiologic Agents

Category: Exploratory Developmentent

OBJECTIVE: Develop system to transport large volume of specimens meeting federal/state handling and shipment regulations.

DESCRIPTION: All laboratories that ship diagnostic (clinical) specimens and etiologic (infectious) agents must have a system to ensure optimum integrity of these materials when shipped from point of origin to the reference (testing) laboratory. Specimen integrity is critical for the reference laboratory to ensure accurate analytical results. The current shipment system does not adequately control environmental conditions (i.e., temperature, pressure) that can affect the stability and analytical suitability of these materials. Equally important, the system does not eliminate safety problems associated with ordinary transportation (i.e., leakage of contents, breakage) and/or protect the laboratory staff who handle these packages.

PHASE I: This phase will result in the development of a disposable shipment container (outer). The container should be watertight, strong enough to withstand the rigors of handling and incidents associated with transportation, and capable of being disinfected if contents leak during shipment. The container should hold a minimum of 30 specimens allowing individual packaging of those specimens to include the required test requisitions or other documentation. The container must comply with applicable federal and international regulation on transportation of hazardous materials.

PHASE II: This phase will consist of production and testing of the shipment system. Prototypes will be produced and put into limited use to test efficiency and function. Changes to original design in order to address deficiencies detected during this phase will be accomplished and further testing will be performed. This phase will require close coordination with personnel of the Epidemiologic Research Division, Brooks AFB, Texas.

POTENTIAL COMMERCIAL MARKET: In both military and civilian medical communities, clinical laboratories have increased use of reference laboratories for high-volume, high-cost testing services. As part of their routine customer service, reference laboratories provide all the necessary supplies for specimen shipment to include the cost for transportation (i.e., postal, air express). Specific procedures for handling and transport of hazardous materials are strictly enforced by federal and international law. Therefore, there is a need to develop a transport system that is economical and safe. The major advantage to the system is that it could be recycled avoiding problems and expenses associated with disposal of biological medical waste.

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AF97-011 TITLE: Portable Auditory Diagnostic System

Category: Exploratory Development

OBJECTIVE: Develop a portable system capable of evaluating peripheral and central auditory deficits.

DESCRIPTION: Complete diagnosis of hearing loss includes assessment of peripheral and central auditory systems. These tests include standard pure tone audiometry, speech audiometry, measures of middle ear immittance, otoacoustic emissions, and auditory evoked potentials. Present abilities to fully evaluate auditory deficits require transporting patients to medical facilities where the complete range of diagnostic equipment is available. This equipment currently consists of separate systems, which are, by current standards, large and cumbersome. Yet, each unit is built around a microprocessor. It should be possible to take advantage of microprocessor technology to build a single system incorporating all of the diagnostic systems mentioned. A light-weight, deployable auditory diagnostic system would reduce the costs associated with patient transportation, provide diagnostic capabilities to remote locations, and facilitate medical evacuation procedures.

PHASE I: Develop a single, delivered prototype, microprocessor system capable of performing pure tone audiometry, speech audiometry, measures of middle ear function, otoacoustic emissions, and auditory evoked potentials.

PHASE II: Develop and validate an easily portable (i.e. briefcase size) full diagnostic system.

POTENTIAL COMMERCIAL MARKET: This technology could be used by all DoD and civilian medical treatment facilities, audiology and otolaryngology clinics.

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AF97-012 TITLE: Advanced Audio Interfaces

Category: Exploratory Developmentent

OBJECTIVE: Enhance operational Air Force audio systems.

DESCRIPTION: A requirement exists for effective voice communications, crew safety, and human performance controls that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, reduce workload and fatigue, and improve personal safety. These intuitive interface technologies include, but are not limited to: 1) auditory system modeling and neural networks for robust signal processing of speech, 2) digital audio technology to allow integration into aircraft systems, 3) voice communications countermeasures/counter-countermeasures, 4) noise-induced hearing loss protection, 5) active noise reduction, and 6) three-dimensional auditory display for spatial awareness and communications. A single interface issue or any combination of interface issues may be addressed in the offeror's proposal.

PHASE I: Phase I efforts would provide an assessment of the state of the art and an approach to develop an appropriate intuitive interface technology.

PHASE II: Phase II efforts would provide a demonstration and validation of the intuitive interface technology.

POTENTIAL COMMERCIAL MARKET: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields.

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AF97-014 TITLE: Chemical/Biological Warfare Defense Detection and Decontamination Technologies

Category: Exploratory Development

OBJECTIVE: Develop novel technology/methodology that will detect, identify, quantify or decontaminate biological/chemical agents.

DESCRIPTION: This requirement deals with highly toxic chemicals or pathogens (bacteria, viruses, spores, toxins, and other materials of biological origin). Methodologies and technologies will be used to address needs on airbases, aircraft, air cargo and personnel. Special interest exists in technologies that have the potential for operation with little manual intervention and that will provide detection and warning for the presence of hazardous material existing in the aerosol or vapor phase. Requirements in sensitivity are 1) parts per billion or less for chemicals in aerosol or vapor phase, 2) less than 1000 microorganism particles per liter of air, 3) less than 100 microorganisms per liter of liquid suspension, or 4) parts per million or less for chemicals in solution. The technologies of interest include (but are not limited to): 1) immunoassay techniques, 2) PCR/DNA probe technologies, 3) light scattering, 4) optical spectroscopy techniques, 5) methodologies for sorting target particles from background interferent particles, 6) methods to automate the preparation of sorted particles for identification, and 7) techniques to automate the identification by microscopy. In addition, novel but simple and robust methods suited to the removal, detoxification or destruction of chemical and/or biological materials are desired. The method must be environmentally friendly, safe to use on aircraft materials and non-hazardous to personnel. Optimal methods will involve inexpensive materials and/or devices, and be highly mobile and rapid. The contractor's proposal may involve a specific device or method to address any of these requirements in part.

PHASE I: Phase I will result in the design and fabrication of a laboratory breadboard system and the development of data which shall demonstrate the proof-of-concept with the use of chemical and/or biological agent simulants.

PHASE II: Phase II will design, optimize, and fabricate a brassboard system that will be laboratory and field tested against a range of chemical/biological simulants. The brassboard system will be delivered to the Air Force for an in-depth evaluation of the system's potential.

POTENTIAL COMMERCIAL MARKET: This technology applies to environmental protection, clinical diagnostic, and therapeutic areas. Technology may be applied to on-site continuous monitoring and/or contamination control of various industrial, environmental, or medical contaminants/pollutants.

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AF97-015 TITLE: Multi-modal User-Interface for Remote System Operation

Category: Exploratory Development

OBJECTIVE: Develop multi-modal user-interface concept to support coordinated remote systems operations in hostile environments.

DESCRIPTION: Distributive interactive systems are on the horizon. Such systems represent a bending of distributive information systems, such as the World Wide Web (WWW) system, and remote operation or manipulation systems, such as those used by NASA in space operations. There is a need to develop new, integrated user-interfaces that can handle information searching, data analysis, and information repackaging while at the same time providing an immersive you-are-there sense of presence to support operation of remotely-located objects. These new interface concepts will serve as the front-end for emerging WWW-based productivity and entertainment products, as well as for new remote operation systems in the military. One approach under consideration for future military operations involves the tactical use of remotely-controlled systems. Both unmanned aerial vehicles (UAVs) and unmanned tactical aircraft (UTA) are planned for development. Highly coordinated user actions involving several remote systems will be required to achieve military objectives. A critical element in the design of a remotely-controlled system needed to achieve this goal is the remote user-system interface. An interface is needed that (1) induces a sense of presence in the engagement area, (2) assists the user in acquiring and updating situation awareness, both locally (single system) and globally (engaging unit), (3) manages information flow and representation , and (4) interprets user commands and control inputs. The user interface for a remote system is envisioned to contain a volumetric visual-audio display and will contain a range of methods for system interaction through manual, gesture, voice, head, and perhaps eye and other forms of control. Complexities associated with information management, system state conditioning, weapons deployment, and integrated task performance present a formidable challenge to the user interface designer. This is exacerbated by the need to induce a sense of presence and avoid disorientation effects within the constraints of available interface technologies. The Air Force seeks innovative interface concepts for remote systems that will enable the user to meet performance requirements for coordinated tactical operations.

PHASE I: Create an innovative interface concept, analyze operator performance and technological feasibility, and produce and deliver a proof-of-principle demonstration, including performance analysis.

PHASE II: Optimize the interface system design, produce, evaluate and deliver a full-scale prototype of the new interface concept, including full software documentation.

POTENTIAL COMMERCIAL MARKET: User interface concepts for UAV/UTA systems will apply directly to any tele-operation system, including nuclear power generation, chemical processing, and environmental waste removal. The concepts may be particularly appropriate for virtual reality based tele-medicine applications. More broadly, the multi-modal interface concepts should be applicable as a front-end user interface for productivity and entertainment software products, especially those products based on distributive networks such as the World Wide Web.

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AF97-016 TITLE: Virtual Reality (VR) Control Centers for Unmanned Aerial Vehicles (UAV)

Category: Exploratory Development

OBJECTIVE: Develop UAV VR control center concept and required human systems interface technology development plan/strategy.

DESCRIPTION: As part of the Air Force Modernization Plan, there is a requirement to develop innovative ways to accomplish force enhancement and force application, combined with risk reduction to personnel in the battlespace of the future (2010 fielding). To this end, there is a current Air Force interest area focusing on expanding the use and battlefield roles of UAVs. One possible scenario involves essentially an unmanned battlespace. Such a scenario requires teleoperation ground control centers for controlling UAVs, where UAVs would perform reconnaissance and surveillance, communication relays, Air Base support, strike, defensive counter air and jamming operations. Since the functions and tasks of ground station personnel would be dramatically different than those performed by contemporary airborne personnel, innovative and immersive VR control center concepts are being considered. However, fundamental human performance research issues involving VR properties have either not been addressed or the data available are limited (e.g., design tradeoffs between VR properties and human performance variables in dynamically interactive synthetic environments). These issues must first be identified and then a VR/human systems interface (HSI) research plan and technology development strategy must be developed to ensure technology maturity for possible VR UAV control center fielding within fifteen years. Research issues of intelligent aiding and multi-operator decision support associated with optimal situational awareness, mission management, and training (appropriate for VR UAV control centers) must be addressed in the plan.

PHASE I: Phase I will result in: (1) identification of human performance variables/VR properties design tradeoffs issues; (2) HSI and VR technologies requiring development to ensure maturity necessary for a UAV VR control stations/centers; and (3) proposal for a UAV VR concept demonstration supporting intelligent aiding, decision support, and mission management flexibility.

PHASE II: Phase II will result in a concept demonstration based on the research defined in Phase I.

POTENTIAL COMMERCIAL MARKET: The development of the VR control centers have multiple industrial uses, e.g., remotely controlled construction and site investigations in hostile (weather/ chemical disasters) environments. The VR controlled UAVs could be used for immediate search and research operations in distant geographical areas, or inaccessible environments and for civilian drug interdiction efforts, as well.

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AF97-017 TITLE: Multi-Operator Performance Aiding by Information Sharing

Category: Exploratory Development

OBJECTIVE: Develop methods or techniques to enhance operational effectiveness of geographically-distributed time-critical manned systems with improved information flow.

DESCRIPTION: With the growth in numbers and variety of sensors, there is a requirement to select, fuse, and distribute a multiplicity of data and information among a large number of specialized operators who are geographically distributed and possibly unknown to each other. This information sharing and coordination situation is unlike that within a combat flight, mission control center, or air traffic control tower. Rather, the human network may add and drop nodes or elements in a dynamic fashion with many players never knowing their real contribution, nor even each other's existence, as part of a dynamic network. For example, a photo-reconnaissance expert and a weather analyst might never know why or by whom a special forecast is requested, yet the two independent analysts' timely and accurate predictions, based on diverse data sources, can critically affect the performance of a combat mission. Indeed, commanders and end-act operators depend on the services of many diverse units to accomplish their respective missions. Analyses are needed for all nodes and levels of activity within the human network. Information sharing concepts and human performance aiding concepts are needed especially for time-critical and time-constrained scenarios.

PHASE I: Phase I effort would provide an assessment of the state of the art and suggest candidate multi-operator performance-aiding concepts of value at any whole-network, sub-network, or single node level.

PHASE II: Phase II effort would provide a demonstration and validation of a multi-operator performance aiding concept entailing information sharing.

POTENTIAL COMMERCIAL MARKET: The problem of the timely distribution of multi-faceted information arising from a plethora of sources through an impersonal, diverse, and fluid human network is not unique to the military. Results of this effort can impact the structure and operations used by multi-national corporations, fast-reaction emergency and disaster civilian operations, distributed real-time medical operations, and financial decision making. Products can range from the design of entire networks to just single workstations.

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AF97-018 TITLE: Decision Support System To Enhance Performance In Decision-Making Teams

Category: Exploratory Development

OBJECTIVE: Development of software/computer system enabling the facilitation of shared awareness and team decision performance.

DESCRIPTION: There is a requirement for tools and methodology to facilitate the cognitive processes inherent in decision-making teams composed of members with different areas of expertise. This issue is relevant to many realistic decision scenarios, where interdependent team members must coordinate information and/or collaborate in order to achieve successful performance in a primarily intellectual (decision making) task. In this effort, the focus would be on decisions regarding resource allocation. Resource allocation dilemmas are commonplace yet often extremely difficult, whether the context be military battlefield logistics, corporate strategic planning, university research funding distribution, or public service settings. At this time, many team-based decision aids are marketed, but are not amenable to evaluation in that objective measures of successful team performance are usually not available. If measures are available, they are based on behavioral measures of team process (e.g., efficient communication) or team

outcomes (correct decision was achieved). What is needed is (a) identification of computer-based technology most likely to enhance team decision processes, and (b) a flexible, team-based task that enables measurement of cognitive as well as behavioral measures of team performance, in order to evaluate the impact of these tools on performance. The software would enable diagnosis of team functioning through examination of team-level cognitive structures and processes. For example, phases of decision making often include stages such as problem formulation and development of shared awareness of the expertise, resources, and interdependencies of all members. Research questions currently being addressed by various investigators include issues such as (a) to what extent does an expert team differ from a novice team with regard to these stages of decision making; (b) how is shared understanding best achieved; and (c) how can computer-based technology (such as artificial intelligence (AI) components, communication structures, etc.) enhance the cognitive processes such as problem formulation and collective awareness across team members. This effort would capitalize on existing knowledge regarding team decision processes and computer-based technology in order to identify computer-based tools and techniques to enhance decision making in teams with members with diverse perspectives.

PHASE I: Development of the team task prototype specifications. Phase I would result in identification of computer-based technology most likely to enhance decision making processes within a resource allocation scenario, particularly when team members have varying expertise. This will be based on a review of current research, with an emphasis on identifying cognitive processes within the team, and the means by which these processes can be enhanced through interventions. At the same time, a team task will be developed that will enable demonstration of the effectiveness of these interventions. The decision support system composed of the team task and corresponding technology will enable team-based decision making for a minimum of three team members using standard networked Pentium class or better platforms running Linux (or other Unix variants). The task would be highly flexible, allowing configuration to a variety of decision scenarios, from military command-and-control to corporate resource allocation dilemmas. The software should enable the study of networked teams of up to 20 members, with the capability of investigating the processes of subgroups within the overall team. Knowledge and performance measures will be generated by the software, to include the assessment of individual and team-level task knowledge, measures of team processes (such as communication and coordination effectiveness), and criterion measures of decision performance. A plan of research will also be produced, in the form of a technical report, delineating the stream of research made possible by this team task, with the objective of identifying strategies, principles, and/or decision aid tools to enhance resource allocation decisions in teams with distributed expertise.

PHASE II: Development, delivery, and demonstration of the team task and technology enhancements. Phase II will result in development and demonstration of the team-based task and computer support system specified in Phase I. The goal is the demonstration of computer-based technology and communication structures that will enhance shared understanding and performance within teams with distributed expertise.

POTENTIAL COMMERCIAL MARKET: Critical resource allocation decisions are made every day throughout military, private-sector corporations, and public agencies by teams comprised of individuals with differing expertise, perspectives, goals, and intentions, yet our understanding of the processes that affect team-based decision making is limited and often anecdotal. The team task itself can be transitioned to research facilities for use in team performance research. More importantly, the tools and techniques identified and developed in this effort can be transitioned for commercial use, such as for technical managers with limited resources. The opportunity for technology transfer, in terms of tools and techniques, is relevant to every facet (industry, education, military, public service) of organizational resource-allocation decision making.

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AF97-019 TITLE: Intelligent Cognitive Engineering Suite for Information Warfare Domains

Category: Exploratory Development

OBJECTIVE: Develop an intelligent cognitive engineering suite to assess, integrate, and design information warfare technologies.

DESCRIPTION: Information warfare is defined by (1) the characteristics of information systems (2) the constraints and capabilities of human cognition and (3) the contexts that afford mutual interaction and interdependence between humans and their information systems (e.g., multi-crew operations in theater missile defense). Yet, information warfare requirements demanded by cognition, collaboration, computation, and context are rarely leveraged in a way that will provide systematic planning, assessment, integration, and design of human system interfaces.

Cognitive engineering tools and techniques have been applied to contexts like information warfare but are often unidimensional, woefully under-developed , and applied in piecemeal ways. For example, they may only yield a task-analytical modeling perspective, or may be limited to a singular form of knowledge representation. Often, cognitive engineering is a paper-and pencil exercise, is conducted by a single engineer with a single domain expert, and does not take advantage of advances in computer science (e.g., collaborative computing technologies).

Requirements for a cognitive engineering suite for information warfare domains first necessitates the use of collaborative computing to support different types of integrated cognitive engineering processes. Group support systems for cognitive engineering redefine the area as a "distributed, participatory enterprise" wherein multiple engineers/multiple experts collectively establish joint assessments and mutual design rationale. Second, integrated cognitive engineering processes must interlock technological capabilities with knowledge-based, observer-based, and case-based modeling to perform analytical `what-if' and design synthesis activities. This highlights the need for intelligent retrieval systems, exploratory sequential data analysis tools, fuzzy logic categorization, case-based reasoning, and/or machine learning systems that can index, represent, and distinguish differences in situated cognition within multi-operator performance. These processes highlight acquisition, exploration, and transformation of operator-centered knowledge throughout different stages of the information warfare systems design. They simultaneously integrate multidimensional descriptions of the context in which information warfare activities occur and supply the cognitive basis for action in that context.

PHASE I: Phase 1 results in a comprehensive literature review of cognitive engineering applicable to (1) the general information warfare domain and (2) a specific context in the overall domain. This includes assessment/evaluative ratings of the appropriate computer technologies and cognitive engineering methods, tools, etc. to determine the best integrated suite. A detailed baseline description of the suite will be delivered. Documentation includes a technical report with an annotated bibliography.

PHASE II: Phase II results in the implementation/building of the cognitive engineering suite. The suite will be applied to the context defined in Phase 1 for verification/validation using a single site test; and then using a new target context will be field tested for collaboration at remote, distributed sites. A final technical report will document all progress on the project and a completed prototype will be delivered.

POTENTIAL COMMERCIAL MARKET: Relevance for commercialization is strong as it identifies/defines procedures for integrated cognitive engineering across a variety of information systems applications (e.g., use in intelligent highway or air traffic control systems). These processes would be easily managed and implemented using the suite. Potential customers include air traffic controllers, Department of Transportation, and advanced computing technology companies (e.g., Xerox PARC).

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AF97-020 TITLE: Universal Operator State Classifier

Category: Exploratory Development

OBJECTIVE: Develop system capable of accurately classifying human operator state during job performance.

DESCRIPTION: There is a requirement for accurate estimation of human operator state and for means of providing this information to the system the operator controls. Optimal implementation of complex systems requires that the human operator is functioning efficiently. Current systems do not have operator-state information even though the operator is a crucial component of the overall system. Operators become inefficient because of mental overload, fatigue, inattention, and boredom. By monitoring operator-state, the controlled system can alert the operator and/or make adjustments to itself to accommodate the level of operator functioning. Human operator state can be monitored by observing their psychophysiological condition and their overt performance. However, this is a new area and tools are not available that make operator-state evaluation practical. A system is needed that accepts psychophysiological and performance data from operators at their workstations, provides a broad selection of analysis and classification tools and yields a highly accurate classification algorithm that can be implemented at the workstation. The system would have capabilities to read the users' data regardless of the format, would provide a number of methods of viewing the data graphically, would make suggestions concerning the most appropriate type of classifier to use, provide easy access to an array of classifiers and would provide evaluation of the success of each classifier. Since data feature selection is crucial to accurate state classification, tools would be available to permit manipulation of the data to select and derive features from the input data. The system should handle large amounts of data, 60 or more EEG channels, heart rate, eye blinks, respiration and 50 plus channels of performance data from the system. A wide range of analysis tools would be available to the user to provide a complete understanding of the data. The system would permit the user to take advantage of individual operator and group data to achieve the highest possible classification accuracy of operator state. The system must be very user friendly, provide on-line help functions and use graphical user-interface schemes. A list of background literature should be provided. Analysis speed is very important since the system could be used at the work site. Classifier output would permit use by equipment worn on the operator and/or installed at the workstation to implement the on-line operator state/system interface. The developed system would also be used in human factors research to understand man/machine interactions, human cognition and in display design and evaluation.

PHASE I: Phase I will include an evaluation of area and system design, making use of the large number of commercially-available packages.

PHASE II: Phase II will yield a prototype system.

POTENTIAL COMMERCIAL MARKET: This system will be of use to all DOD branches since it will assess the whole range of human operator states. Other agencies using human-controlled systems will also be able to use this product and include Department of Transportation, FAA and NASA. Commercial sector can use to evaluate and enhance human/system interface. These include transportation (trucks, automobiles, trains and airplanes), process control, and system design.

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AF97-021 TITLE: Advanced Escape Technologies and Ejection Data Recording for Aircrew Members

Category: Exploratory Development

OBJECTIVE:Develop methods or techniques to improve aircrew escape systems through the use of ejection data recording and enhanced restraint systems.

DESCRIPTION: DOD has incorporated women into the cockpits of combat aircraft. Presently, all flyers must meet long-standing entrance requirements for body size. New training aircraft will accommodate a much broader range of occupant sizes. This expanded flying population will eventually fly ejection seat-equipped aircraft. This has generated a requirement for novel methods of providing restraint and harnesses, improved effectiveness in seat adjustability, control of aerodynamic loads to optimize these forces for the wide range of occupant weights, and recording of the seat response during an ejection. Contractors' proposals may address one or more of these issues related to advanced escape technologies. An integral part of these new requirements for the expanded aircrew population is the need to identify, develop, and test restraint and parachute harness systems which are compatible with an adjustable seat to better fit the expanded population range in escape systems. This research should examine the design of the restraint and harness system and the attachment points to the seat, as well as innovative techniques for adjusting the ejection seat within the cockpit. The technique should allow the expanded range of occupants to be located within the cockpit for proper vision, while maintaining acceptable arm and leg reach envelopes. Contour and adjustability of the seat bucket and cushions shall also be examined to determine the adjustments required to provide support and comfort for the expanded population. Closely associated with these new restraint and seat adjustment designs is the need to measure the actual ejection events by some type of "in seat" instrumentation package. The package needs to be a small, battery-operated data recorder/analyzer that uses internal sensors and attaches to the ejection seat. The collected data will be used to validate and improve the design of the ejection seat and restraint mechanisms in an attempt to reduce future injuries and deaths during ejections from aircraft. Current data have been obtained primarily from rocket sled ejection using manikins. No human data is being gathered on actual in-flight emergency ejection, since no ejection seats are fitted with data recorders.

PHASE I: Phase I will result in the identification and preliminary evaluation of advanced restraint and harness systems, advanced ejection seat adjustment concepts and/or the design and construction of a prototype data recorder.

PHASE II: Phase II will yield fully tested, promising technologies, including the integration of the recorder into R&D ejection seats for live-fire tests.

POTENTIAL COMMERCIAL MARKET: Anticipated civilian applications include improved restraint technologies for the automobile and airline industries, and innovative instrumentation measurement packages for the automobile testing industry.

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AF97-022 TITLE: In Situ Electrochemical Sensor Technology for Detection and Long-Term Monitoring of Organic Pollutants

Category: Exploratory Development

OBJECTIVE: Development of Electrochemical Sensors that will Provide Highly Specific, Sensitive, and Definitive Analysis of Organics in the Field.

DESCRIPTION: There is a requirement for fiber optic-based, low-cost, in situ, sensor technologies that will provide highly specific and sensitive measurements for environmental pollutants in soil and groundwater. Measurements should be real-time and possess detection capabilities on the order of parts per billion (ppb) or better. Electrochemical sensor designs may include pH, current, light (such as electrochemiluminescence) or other physical measurements of molecular recognition of target pollutants. Electrochemical biosensors using chemical or biological affinity surfaces are desired and will enhance the specificity of the sensor. Examples include antibody, enzyme, nucleic acid, novel bioreceptor, and whole prokaryotic or eukaryotic cell sensing elements and should be robust, sensitive, reusable, field portable and have relatively low power requirements. Technologies are especially needed for detection of chlorinated solvents such as trichloroethylene (TCE), tetrachlorothethylene (PCE), methylene chloride, carbon tetrachloride, etc. in soil and water. It is desirable that the technology be capable of identifying mixed waste samples, thus, the proposed technique should be capable of discriminating fuel components such as BTEX. Technologies also capable of sensing metals and nitroaromatics will be considered an added benefit. These sensors should be designed for definitive characterization of pollutants in the field and long-term monitoring purposes. The method of sensor deployment may vary, such as compatibility with cone penetrometry, mini hydraulically-driven and/or percussion-driven devices and should be capable of long-term monitoring if inserted in the ground in monitoring wells or at air monitoring points.

PHASE I: Phase I will provide the results of an empirical feasibility study, develop a breadboard sensor, and deliver a technical report.

PHASE II: Phase II will consist of fabrication of an engineering model, field demonstration(s), and a final technical report.

POTENTIAL COMMERCIAL MARKET: Electrochemical sensors for clinical, food industry, and other sensing applications have been constructed and tested previously. This technology will help to meet the chlorinated solvent detection and monitoring needs of Environmental Managers on Air Force and DOD installations as well as the needs of those responsible for similar commercial contaminated sites.

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AF97-023 TITLE: Risk Based Remediation Modeling

Category: Exploratory Development

OBJECTIVE: Develop methods to couple risk assessment with a groundwater fate and transport model in a common computational environment.

DESCRIPTION: Install risk assessment information and calculation techniques (probability distributions) into an existing three dimensional numerical groundwater contaminant fate and transport model to predict contaminant concentrations in groundwater at down gradient sites and receptor wells. The contractor shall thoroughly search the existing market for effective and available numerical three dimensional models. This effort does NOT include creating a new groundwater fate and transport code. Additional code will only be necessary to incorporate the risk-based analysis aspect of the model into the computational environment. The contractor shall also be knowledgeable of other risk-based models and build on progress made by these groups. Existing or developmental toxicological databases will be incorporated into the model to allow installation project managers a risk-based approach to decisions regarding remedial action alternatives. A major task will be incorporating the data base of chemical compounds of interest to the Air Force and their toxicity levels into the selected model. This will include databases which consider not only the human toxicity criteria but also the eco-toxicity which in many cases is more stringent than the human toxicity criteria. The end product will be a criteria for remedial action (RA) decisions from a risk-based perspective rather than cleaning to a specified maximum concentration levels (MCLs).

PHASE I: Phase I will result in selection of a groundwater fate and transport model and toxicological databases. In addition, the contractor will determine the approach to incorporate a risk-based analysis. The approach should be validated by a feasibility study. Phase I efforts will be summarized in a technical report.

PHASE II: Phase II will result in a risk-based remediation model, based on the description above, capable of analyzing contaminated groundwater sites according to risk. Phase II efforts will be summarized in a technical report.

POTENTIAL COMMERCIAL MARKET: The trend, as prompted by the EPA, has been to move away from decisions based on MCLs and toward the more sensible risk-based approach. Due to the regulatory involvement in this trend, all entities including government and industry will soon have the need for tools such as models to assist in risk analyses.

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AF97-024 TITLE: Emplacement Technology for In Situ Treatment Zones

Category: Exploratory Development

OBJECTIVE: Develop a cost-effective method of emplacing in situ treatment zones for the treatment of chlorinated solvent-contaminated groundwaters.

DESCRIPTION: In situ treatment zones are emerging as a potential alternative to the traditional pump-and-treat approach to groundwater remediation. One approach to in situ treatment zones, "funnel-and-gate" uses physical barriers to funnel contaminated water under natural gradient conditions to a permeable reactive zone where the contaminants are degraded. The reduction of chlorinated solvents by zero-valent iron appears to be the most

promising in situ treatment approach for chlorinated solvents-contaminated groundwater at the present time; however, the use of traditional sheet piling technologies for emplacement is costly. This has created the need for more cost-effective methods of emplacing in situ treatment zones. Options other than the funneling of contaminated groundwater to the treatment zone will be considered. Adequate permeability of the treatment zones is of considerable importance.

PHASE I: Phase I shall involve engineering design, cost analysis and possible laboratory testing of the technology to show the potential for successful emplacement.

PHASE II: Phase II shall focus on the demonstration of the emplacement technology at a field site.

POTENTIAL COMMERCIAL MARKET: Full-scale development of a technology capable of cost-effective emplacement of in situ treatment zones could be used at DoD hazardous waste sites and similar commercial contaminated sites. This process may reduce or eliminate the need for traditional pump-and-treat which will significantly reduce site remediation costs.

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AF97-025 TITLE: High-temperature Redox Catalysts

Category: Exploratory Development

OBJECTIVE: Develop catalysts that can decrease air pollutants in immediate or near combustion environment.

DESCRIPTION: There is a requirement for catalytic technologies that can be installed and function in an exhaust manifold or similar environment to convert NOx and incompletely reduced carbon species into nonpolluting products. Relevant experience will be a consideration in the selection of proposals for awards.

PHASE I: Phase I will result in a convincing experimental demonstration of the reductive (or oxidative) capability of the catalysts at elevated (greater than 500 C) temperatures and residence times of approximately a few milliseconds. The experimental effort and results will be presented in a technical report.

PHASE II: Phase II will result in an experimental evaluation of the mean time to failure of surface-supported preparations of one or more catalysts in a simulated or real exhaust stream, the targets being greater than 50 percent initial removal of the target pollutant(s) and greater than 50 percent retention of initial activity after 500 hours of exposure to a high-temperature, high-velocity exhaust stream at the highest temperature at which the catalyst preparation has been shown to be active. The experimental effort and results will be presented in a technical report.

POTENTIAL COMMERCIAL MARKET: Both the government and the private sector use a wide variety of combustion devices for heat, propulsion, waste disposal, and a range of other uses. These are or will be subject to regulation as either fixed or mobile sources of air pollution. The technology sought will allow these devices to be used without drastic impacts to base or local operating permits.

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AF97-026 TITLE: Evanescent Wave Fiber-Optic Sensor

Category: Exploratory Development

OBJECTIVE: Develop an integrated evanescent wave sensor, sprectrometer and data collection/analysis system.

DESCRIPTION: The use of fiber-optics in spectroscopy permits sample spectra to be collected in locations and environments remote from the spectrometer optical bench. Various designs of fiber-optic chemical sensors have been developed utilizing fluorescence, interference, and absorbance spectral properties. In the most common designs, radiation from the optical bench is carried via fiber-optics to a sample cell or viewing region, and allowed to exit the fiber-optic, interact with the sample, and returning or re-emitted radiation re-enters the fiber-optics for transmission back to the optical bench. An alternative form of fiber-optic spectroscopy uses interactions between the sample, surrounding the fiber-optic, and the evanescent wave of the radiation. Material outside the fiber-optic of an evanescent wave sensor interacts with the evanescent wave and can absorb radiation at wavelengths characteristic of the sample. Since the evanescent wave accounts for only a small portion of the energy of the radiation being carried through a fiber-optic, this form of spectroscopy is not highly sensitive. However, the cladding of the fiber-optic, this form of spectroscopy is not highly sensitive. However, the cladding of the fiber-optic media can absorb external sample material and concentrate it, thus increasing spectral response. Evanescent wave fiber-optic spectroscopy is useful in the ultraviolet through visible to mid-infrared spectral regions. Evanescent wave fiber-optic sensors for the Air Force should be rugged enough for field use and should be capable of detecting organic fuel and solvent vapors in air, water, or headspace matrices. Some typical analytes which may be of interest to the Air Force include fuels (including jet fuels), cleaning solvents (suchg as trichlorethene, tetrachloroethene, methylene chloride, chloroform, and carbon tetrachloride), and aromatic hydrocarbosn (such as benzene, toluene, xylenes, more highly substituted benzene derivatives, naphthalene, naphthalene derivatives, and polynuclear aromatic hydrocarbons). The ideal sensor should yield quantitative responses, although the quantitation of individual analytes in mixtures will require the use of chemometrics to isolate the response of a target analyte from other compounds in the mixture.

PHASE I: Phase I will result in the design and proof-of-concept of an evanescent wave sensor including a prototype demonstration in a laboratory setting at the Armstrong Laboratory, Environics Directorate and a technical report. Prototype chemometric tools required for qualitative and quantitative interpretation of the sensor's data should also be constructed (or selected from commercial sources) and demonstrated.

PHASE II: Phase II will result in the design and fabrication of a final prototype evanescent wave sensor. Chemometric tools to support the sensor should be demonstrated in an integrated prototype at the Phase II level. Testing and demonstrations of the Phase II product should include testing with analytes in air, groundwater, and soil matrices, at an Air Force selected site. The results of the development will be documented in a final technical report.

POTENTIAL COMMERCIAL MARKET: These sensor systems will be useful and have commercial value in both the Government environmental and the commercial economy. Civilian uses include additional environmental monitoring and chemical process monitoring. Use of the system with analytes other than those used by the Air Force would require chemometric classification and quantitation systems to be retrained with samples of the new analytes.

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AF97-027 TITLE: Attenuated Total Reflectance (ATR) Sensor

Category: Exploratory Development

OBJECTIVE: Develop an Attenuated Total Reflectance (ATR) Infrared Radiation (IR) device for cone Penetrometer use for the detection of Dense non-aqueous phase liquids (DNAPLs).

DESCRIPTION: There is a requirement for technologies that can detect and delineate the extent of contaminants underground. This need is particularly acute when the contaminant is a dense non-aqueous phase liquid (DNAPL). When the DNAPL source is a solvant (such as Trichloroethylene, tetrachloroethene, methylene chloride, chloroform, and carbon tetrachloride), there is no in situ device available for detection. In addition, a danger exists using the cone penetrometer in environmental site characterization if an aquitard restraining a source of DNAPL is penetrated, causing possible further spread of the DNAPL contaminant. Diamond tipped ATR sensors using mid IR radiation have been developed for harsh environments, such as monitoring acidic reactions. A diamond tipped ATR sensor placed in the tip of a cone penetrometer, coupled to the surface by fiber optic cable, could be used to detect DNAPL sources.

PHASE I: Phase I will result in the design and proof-of-concept of a diamond tipped ATR sensor for use in a cone penetrometer, including a prototype demonstration and a technical report.

PHASE II: Phase II will result in the design and fabrication of a final prototype ATR sensor and incorporation of the sensor into the cone penetrometer. Testing and demonstrations of the Phase II product should include testing with analytes in air, groundwater, and soil matrices, at an Air Force selected site. The results of the development will be documented in a final technical report.

POTENTIAL COMMERCIAL MARKET: These sensor systems will be useful and have commercial value in both the Government environmental and the commercial economy. Civilian uses include additional environmental monitoring and chemical process monitoring. The diamond tipped ATR system could also be used in harsh production and process monitoring applications. Use of the system with analytes other than those used by the Air Force would require chemometric classification and quantitation systems to be retrained with samples of the new analytes.

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AF97-028 TITLE: Environmental Gas-Phase Sensor Array

Category: Exploratory Development

OBJECTIVE: Develop a sensor array for detecting and monitoring gas phase hydrocarbon and organic chemical vapors.

DESCRIPTION: Gas phase sensor arrays have shown considerable promise for identifying odors and other gas phase mixtures. These arrays utilize a collection of gas phase sensors, each with a different response characteristic, to generate a pattern of responses from vapors which enter the sensor array. The individual sensors in the array have different responses to vapors of different compounds and compound mixtures. The pattern of responses can thus be used to identify and classify odors and other vapor mixtures through the use of pattern recognition techniques or artificial neural networks. The individual sensors of the array should yield quantitative responses. Gas phase sensor arrays should be applicable to the detection and classification of spilled fuels and solvents in the air, water, and soils. If the devices can be made with sensitive enough responses to aromatic hydrocarbons, they should also be applicable to the detection of water-soluble fuel components in headspace over groundwater and groundwater samples. Such sensor arrays should be useful for initial environmental site surveying, site characterization, and monitoring. Typical analyte mixtures which may be of interest for the Air Force include fuels (including jet fuels), cleaning solvents (such as trichloroethene, tetrachloroethene, methylene chloride, chloroform, and carbon tetrachloride), and aromatic hydrocarbons (such as benzene, toluene, xylenes, more highly substituted benzene derivatives, naphthalene, naphthalene derivatives, and polynuclear aromatic hydrocarbons). Sensors intended for detecting and monitoring these analytes should yield quantitative responses, although the quantitation of individual analytes in mixtures will probably require the use of chemometrics to isolate the response of a desired target analyte from the other compounds in the mixture. There are a variety of ways to utilize gas phase sensor arrays in conducting environmental surveys. Devices may be designed and optimized for examining samples from groundwater monitoring wells, or for use within the wells themselves. Also, it should be possible to combine such sensor arrays with site surveying systems such as cone penetrometers and geoprobes. Gas phase sensor arrays should also be directly useful for detecting and monitoring atmospheric pollutants. The ideal gas phase sensor array for environmental use should include simple and inexpensive sensor elements. The manufacturing techniques used in the sensor and array fabrication should permit the arrays to be reproducibly mass produced with sufficient precision that the responses of duplicate arrays will be reproducible. Such reproducibility will be required in order that neural networks, classification rules, and calibrations developed with one sensor array will be equally valid for all members of the mass produced series. The ideal gas sensor array should also permit simple and easy acquisition of the array's responses and interfacing with computers for data interpretation and chemometric analysis.

PHASE I: Phase I will result in the design, proof-of-concept, and technical report fully documenting the gas phase sensor array, including the demonstration of the Phase I prototype in a laboratory setting at the Armstrong Laboratory, Environics Directorate. Prototype chemometric tools required for qualitative and quantitative interpretation of data from the array should also be constructed (or selected from commercial sources) and demonstrated in Phase I. For Phase I, it should be sufficient to demonstrate the device with directly introduced gas phase analytes and mixtures. The device should be capable of speciating and quantifying mixtures with small numbers of components (five or fewer), and it should be capable of identifying complex mixtures (e.g., gasoline, jet fuel, or diesel fuel).

PHASE II: Phase II will result in the design and fabrication of a final prototype gas phase sensor array with considerations for mass production and commercialization in Phase III. Chemometric tools to support the sensor array should be demonstrated in an integrated prototype at the Phase II level. Testing and demonstrations at an Air Force selected site of the Phase II product shall include testing with analytes in air, groundwater, and soil matrices and be fully documented in a technical report.

POTENTIAL COMMERCIAL MARKET: These sensor systems should be useful and have commercial value in both the Government environmental and the commercial economy. Civilian uses include additional environmental monitoring and chemical process monitoring. Use of the system with analytes other than those used by the Air Force would require chemometric classification and quantitation systems to be retrained with samples of the new analytes.

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AF97-029 TITLE: Laser Output Field Test Measurement System

Category: Exploratory Development

OBJECTIVE: Develop a rugged, field-portable system to measure laser exit spot size, beam divergence, average output power, and temporal characteristics.

DESCRIPTION: Accurate output parameters (especially beam divergence and average power) measured at the system exit aperture are required to perform hazard analyses on DOD laser systems. Laser manufacturer's specifications are usually based on performance requirements or theory. As a result, many systems require safety-specific measurements. Small lasers can be sent to Armstrong Laboratory for measurement; however, large laser systems or systems on aircraft require field measurements. We need an automated, portable system to facilitate these field measurements. Specifically, we need a hardware prototype and a laptop (486 processor + Windows) interface with supporting software. In addition to Armstrong Laboratory use, this system could be used to verify laser system performance on the flight line by maintenance personnel. Verifying the laser's performance prior to aircraft takeoff will enhance mission effectiveness by helping to avoid in-flight aborts due to degraded laser output.

PHASE I: Phase I will result in the feasibility, technical design and proof of design for an apparatus and associated laptop PC interface to measure, determine and display laser output parameters. The laser output parameters will include laser exit spot size, beam divergence, average power (energy), and temporal profile.

PHASE II: The Phase II end product will be a prototype measurement system and PC laptop interface (including ability to output results to screen display, printer and word-processing files).

POTENTIAL COMMERCIAL MARKET: This system can be used as a quick, convenient method of characterizing the output of lasers located in any manufacturing facility, medical facility, or laboratory. It can also be used by companies running laser light shows to help verify compliance with FAA safety guidelines.

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2. Terry Lyon, "DOD Laser Measurement Techniques Guide for a Hazard Evaluation", U.S. Army Environmental Hygiene Agency Technical Guide No. 192, August 1992, Unclassified, unlimited, AD-A254545.

AF97-030 TITLE: Environmental Noise Modeling and Measurement Projects

Category: Exploratory Development

OBJECTIVE: Develop improved capabilities for modeling and measuring subsonic and supersonic aircraft noise.

DESCRIPTION: To comply with the requirements of the National Environmental Policy Act, the Air Force must predict the environmental effects of major changes in flight operations, including effects of supersonic and subsonic aircraft noise on humans, animals and structures. Changes for which the noise effects must be assessed include the introduction of new aircraft, moves of squadrons or wings to new locations and development of new training routes, military operations areas, special use airspace and weapons ranges. In order to use scientifically acceptable methodologies for modeling noise exposure and predicting the effects of noise exposure, research and development projects are being sought in the areas of noise measurement and modeling. The Air Force has need for better noise modeling capabilities to assess the impacts of subsonic and supersonic aircraft flight activity. Proposals are invited on

all aspects of noise modeling, from better propagation algorithms, innovative weather and operations data collection, noise contouring, noise measurement equipment, noise measurement procedures, and interface of models and monitoring data with Geographic Information Systems (GIS).

PHASE I: Phase I will result in feasibility analysis for various noise sources, data collection systems, microphones, methodologies, or improved plotting and GIS application.

PHASE II: Phase II will result in fully developed equipment or computer programs for modeling or measurement of aircraft noise that could be used for civil as well as military noise sources.

POTENTIAL COMMERCIAL MARKET: The research and development efforts needed to predict and assess the effects of aircraft noise will result in technical capabilities that can be used by hundreds of acoustical and contractor firms that support various federal agencies in addressing environmental noise issues. Agencies such as the Army and Navy, the Federal Aviation Administration, the National Aeronautics and Space Administration, the Department of Transportation, and the National Park Service all use commercial acoustics firms to perform acoustic analyses which could potentially use the products of the research and development sought under this solicitation. Zoning boards use it to specify land use.

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2. Seidman, Harry, "Incorporation of Environmental Impact Indices into NOISEMAP", AFAMRL-TR-81-31, November 1981, AD-A108616.
3. Lee, Robert A., "Air Force Boom Event Analyzer Recorder (BEAR): Comparison with NASA Boom Measurement System", AAMRL-TR-89-039, July 1988, Unclassified, unlimited, AD-A204292.
4. Lucus, Michael J. and Plotkin, Kenneth J., "ROUTEMAP Model for Predicting Noise Exposure from Aircraft Operations and Military Training Routes", AAMRL-TR-88-060, September 1988, AD-A203849.
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AF97-031 TITLE: Laser Spectrophotometer

Category: Exploratory Development

OBJECTIVE: Develop a laser system which can measure the optical density of samples from the ultraviolet to near infrared up to an optical density of 6.0.

DESCRIPTION: The Air Force and Navy are currently developing new laser eye protection for air crew members. Measuring the protection capability of these new laser eye protection devices is difficult for several reasons. The currently available commercial spectrophotometers used to measure the optical density as a function of wavelength are limited to measurements of optical density less than 4.0 but some of these new laser eye protection devices have optical densities above 5.0. Another factor which makes testing difficult is the small sample chambers in typical spectrophotometers. Some of the new eye protection devices are helmet visors and they need to be tested in multiple places across their surface; these measurements are impossible inside the chambers of current systems. Either a larger sample chamber is needed or possibly some flexible delivery/capture system, such as fiber optics. Optical density and size are not the only problems. Some of the technologies being investigated are polarization sensitive, so the devices need to be measured while carefully controlling the incident polarization.

PHASE I: Phase I will result in the design/cost tradeoff analysis of a laser spectrophotometer system which can measure the optical density of aircrew helmet visors up to an optical density of 6.0 in the nominal visual range from 400nm to 760nm, and to an optical density of 5.0 from 200nm to 400nm and from 760nm to 1200nm. The system design will include a linearly polarized output with some method of controlling the polarization which is incident on the sample.

PHASE II: PHASE II will produce the formal design, construction, and initial testing of a spectrophotometer system. The system will be computer controlled via an IBM compatible personal computer (PC). Phase II will also produce a developed set of procedures to repeatably and reliably calibrate the system to a traceable standard.

POTENTIAL COMMERCIAL MARKET: This system can be used by companies conducting chemical research into photoreactive compounds, or pharmaceutical development. The field of medical research has recently seen a rapid rise applications for photoluminescent and optical diagnostic equipment. The laser spectrophotometer system could also be used in applications where photoluminescence measurements are necessary such as in medical research where they are studying the details of chemical processes which take place in biological systems or in medical diagnostic laboratories for tissue or culture analysis.

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1. R.W. Boyd, Radiometry and the Detection of Optical Radiation, pp 63-66, John Wiley & Sons, New York, 1983.

AF97-032 TITLE: Development of Electromagnetic (EM) Dosimetric Evaluation Software

Category: Exploratory Development

OBJECTIVE: Develop novel methods to computer model propagation of radiation through biological tissue.

DESCRIPTION: An understanding of how EM radiation interacts with living tissue as it passes through the organs of the human body has direct application to public health issues, and to medical procedures like cancer treatment or imaging. Military and civilian projects involving devices which radiate EM energy cannot proceed without determination of what mechanisms are operating and what dangers actually exist. Current tools in use, primarily Finite-Difference Time-Domain (FD-TD) techniques, have computational limitations. The Air Force seeks a more efficient algorithm.

PHASE I: Phase I will result in the production of a computational demonstration of a novel algorithm for modeling EM propagation in biological tissue which will show that speed can be enhanced over current methods while maintaining good accuracy. The results will be documented in a technical report.

PHASE II: Phase II will result in the development and delivery of a mature computer program capable of accepting data defining the internal structure of a complex organism and modeling the propagation of EM energy throughout the body. Using such a data base, to be supplied by the Air Force, perform a calculation which predicts radiation conduction and energy deposition in the organism. Comparison will be made to experimental data, also to be supplied by the Air Force, for determination of accuracy, and to timed runs by the Air Force, using its own computer code, for determination of speed. A technical report will also result from this effort.

POTENTIAL COMMERCIAL MARKET: Power companies, airport, TV stations, manufacturers of cellular phones, etc. need software to evaluate the design of facilities in order to safeguard the populace. The same needs extend to the military, which also must be concerned with high-power radar and microwave communications.

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AF97-033 TITLE: Toxin and Metabolite Analyzer: Breath

Category: Exploratory Development

OBJECTIVE: Develop and test a transportable laboratory- and field-deployable instrument for assessing body burden and metabolism of toxins.

DESCRIPTION: Biologic and environmental toxins are common everyday exposures in all human environments, and are special hazards in some industrial and military environments. Presently, there are no convenient or effective tools for assessing body burden or metabolic impact of common toxins in humans. Non-invasive breath analysis has proven to be more sensitive and specific than available tests of either blood or urine for common industrial solvents in recent studies at Hill AFB. Breath analysis can be used to assess exposure to any volatile toxin and/or their metabolites, including alcohols, aliphatic hydrocarbons, chlorohydrocarbons, ketones, and others. Normal human breath contains a few to several hundred distinct, quantifiable compounds that reflect both environmental loads and metabolic products, some far larger than previously anticipated for "volatile" compounds - as large as 400 to 600 atomic mass units per molecule. Yet the analytical methods remain relatively simple and clean compared to blood, urine, or tissue analysis. The American Conference of Government Industrial Hygienists has published Biological Exposure Indices for breath levels of the following chemicals: benzene, carbon monoxide, ethyl benzene, n-hexane, perchloroethylene, trichloroethylene, and perchloroethane. A laboratory- and field-deployable tool will rapidly accelerate this area of research and will eventually lead to a much-improved clinical assessment capability.

PHASE I: Phase I will result in a proof-of-concept for the development of prototype sampling/analysis hardware. Technically feasible designs will be recommended for development during the Phase II effort, and a detailed roadmap will be provided for implementing and testing a prototype system. The results will be documented in a final technical report.

PHASE II: Phase II will result in the production of a prototype of the Phase I proposed system. Demonstrations and tests of the prototype system will be required to ensure that it meets its intended specifications and potential. Industrial hygiene/toxicology field trials will be conducted to collect preliminary data from actual operational procedures. A complete description of all the software and hardware designs along with the results of demonstrations, tests and environmental toxicology trials will be provided in a final technical report.

POTENTIAL COMMERCIAL MARKET: Once this tool is developed, it will be a "must-have" for every industrial toxicology, occupational medicine and environmental assessment program in the country.

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1. Phillips, M. and J Greenberg, "Ion Trap Detection of Volatile Organic Compounds in Alveolar Breath", 1992, Clin Chem.38/1, 60-65.
2. Sackett, R.E., "Neural Net Analysis of Chemical Compounds in Nonrebreathing Fisher-344 Rat Breath", 1995, AFIT/GEE/ENG/95D-02, AD-A303775.
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AF97-034 TITLE: Automated Player Control Station

Category: Exploratory Development

OBJECTIVE: Develop a system which allows a single operator to redirect behavior of computer-controlled simulated entities in real-time.

DESCRIPTION: There is a requirement to manipulate and control multiple simulated entities within the conduct of multiparticipant training environments in real-time. Many synthetic learning and training environments contain a mixture of human and computer-generated participants. In order to optimize the effectiveness of the training environment, it is often desirable to introduce, eliminate, or alter in some way the actions of the computer-generated

entities. For example, the instructor may wish to reposition computer-controlled entities or change their goals during the execution of a real-time training exercise to force the human players to learn to react to the unexpected. There are a number of instances in which the ability to control the simulated entities "on the fly" would result in more effective training. Current capability in this area is extremely limited. The entities are identified and positioned in advance according to prespecified scenario scripts and once the exercise has started, the entities perform in a preprogrammed fashion through the conclusion of the scenario. In addition, current displays depict the location and type of computer-generated entities in two-dimensional plan views. In many training environments, the activity is taking place in three dimensions. A three-dimensional display would aid the instructor or entity controller to more effectively decide when and how to introduce changes to the ongoing training activity. Initial applications would involve control of airborne enemy threat vehicles operating in a multiservice simulated combat scenario.

PHASE I: Phase I will result in a system requirements analysis to include computational requirements, networked information transmission requirements, a proposed functional architecture, and estimated time and cost to develop and implement the proposed system. The results of Phase I will be documented in a technical report.

PHASE II: The results of Phase II will be a preliminary system specification, development of software necessary to support a feasibility demonstration of the system to a selected application area within the multiservice distributed combat training area, and a real-time feasibility demonstration. The results of Phase II will be documented in a technical report.

POTENTIAL COMMERCIAL MARKET: The capability provided by this effort will be an asset to all forms of education and training which involves real-time operation of training scenarios in which the behavior of any entity is depicted with a computer-generated, automated (or semi-automated) program. The flexibility afforded by being able to adapt the training environment "on the fly" according to the instructional goals and behavior of the human participants should significantly increase the overall training effectiveness. Training of air traffic controllers, assembly line operators, surgical teams, firefighters, and law enforcement teams are examples of application areas that should profit from this technology. Additionally, this capability could be applied to some nonreal-time areas for aiding in the decision making process for rapid prototyping or design work, e.g., highway/traffic flow management and design.

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AF97-035 TITLE: Development of Authoring Tools for Advanced Internet Multimedia Training Delivery
Category: Exploratory Development

OBJECTIVE: Develop prototype authoring tools that support development/maintenance of Internet Multimedia Training.

DESCRIPTION: There is a requirement for authoring tools which support easy development and maintenance of interactive training systems on the internet. The internet is a new gateway for delivering instruction worldwide through individual interaction and group interaction. The opportunity here is to provide training in a greater capacity by reaching more personnel in more geographically diverse situations. Access to training and efficiency and cost effectiveness of training delivery is essential. The internet supports a multitude of training delivery requirements but the current education and training delivered through the internet is a melting pot of multimedia styles, methodologies, and software. The requested proof-of-principle internet authoring tools should be able to apply graphics (3-D, still

graphics, image maps, etc.), Java scripts, hypertext markup language (HTML), video, sound, animation, and simulation as a minimum. The proof-of-principle authoring tools will be used to develop training in several domains and will be evaluated in a fielded environment. This is an opportunity to create new instructional strategies and evaluate them empirically and pedagocially in a fielded environment as well as using current pedagocially sound instructional strategies from a laboratory environment and proving them in a field setting.

PHASE I: Phase I will result in proof-of-principle development tools and a technical report which demonstrates that it is possible to provide instructional authors with the capability to easily implement internet/multimedia instruction that is pedagogically sound, in that it is based on instructional strategies validated through pedagogically sound empirical research.

PHASE II: Phase II will result in an expanded full-scale, tested authoring system prototype and a technical report supporting a broad range of instructional domains requiring different pedagogical strategies.

POTENTIAL COMMERCIAL MARKET: Dual-use potential exists for commercially viable authoring tools which can be marketed as internet/multimedia authoring tools. Examples might include technical areas such as flight dynamics, orbital mechanics, computer programming, aircraft maintenance, aircrew training, and medicine or in academic areas such as fundamental skills, statistics, foreign languages, etc.

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AF97-037 TITLE: Electronically-Assisted Ground-based Learning Environments (EAGLE)
Category: Exploratory Development

OBJECTIVE: Develop electronic learning systems to reduce aircrew (academic) knowledge preparation time/effort for aircraft training.

DESCRIPTION: A requirement exists to reduce time and workload associated with aircrew ground-based, pre-simulator, and pre-mission training. A transfer-of-training "gap" exists between the acquisition of knowledge in the classroom (academics) and its implementation in the cockpit. Part of this challenge includes assisting the pilot in comprehending the complex interaction of multiple aircraft in the context of mission engagements. This comprehension is essential to the accurate conceptualization of air combat tactics as a precursor to simulator and aircraft training. Recent research indicates application of modern modeling and simulation technologies could significantly improve the impact of academics phases upon subsequent training of aircrews.

PHASE I: The objective of Phase I will be to conduct a comprehensive data collection and analysis of the challenges, feasibility, and expected benefits of EAGLE for aircrew training. Work completed in this phase will be documented in a technical report.

PHASE II: The objective of Phase II will be to develop and implement a prototype EAGLE in an operational aircrew training setting. The system and its implementation and evaluation will be documented in a final technical report.

POTENTIAL COMMERCIAL MARKET: EAGLE would increase the efficiency of aircrew training by overcoming learning problems and instructional drawbacks which impede current academics programs. EAGLE would have general applications in many aspects and levels of public, private education, and industrial training programs. Such

learning systems would enable instructors to employ visual and acoustic displays to generate and manipulate simulations of many complex and potentially dangerous tasks and phenomena, e.g., heavy equipment operation, chemical and nuclear processes, and abstract scientific/mathematical concepts) which are difficult to learn via static, e.g., textbook or linear media, e.g., videotape. High school and college students must learn math and physics principles, which involve some of the same time and motion components, as do pilots. Computer-controlled electronic learning systems will facilitate concept demonstration and practice, and cooperative exploration of such topic materials in the classroom without the complications, potential hazards, and expense of using physical processes and materials.

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AF97-038 TITLE: Intelligent Agents for Education and Training Applications

Category: Exploratory Development

OBJECTIVE: Develop intelligent agent(s) for delivery of adaptive training systems in synthetic environments.

DESCRIPTION: There is a requirement for software methods (intelligent agents) to automate the process of individualizing instruction in multi-user synthetic environments. These agents would perform the functions of what is conventionally referred to as the instructor and expert models in intelligent tutoring systems; however, in addition to the functions performed by these models, agents would be capable of operating in simulated environments with multiple students, each performing actions which can alter the environment. Consequently, agents must be a part of the simulated environment, acknowledging changes in it effected by other agents or students and taking these changes into account when providing instruction to the student. These agents must be capable of autonomously learning individual student abilities, selecting instructional objectives, and coaching/remediating an individual student in a multi-user synthetic environment.

PHASE I: Phase I will result in a technical report including a review of existing capabilities of intelligent agent architectures, particularly for pedagogical purposes, specifications for implementing such an agent in a synthetic environment, and a suggested approach for doing so.

PHASE II: Phase II will result in the development of a pedagogic intelligent agent, its implementation in a synthetic environment, and a technical report.

POTENTIAL COMMERCIAL MARKET: This agent-oriented architecture can be applied to education and training systems within the DoD, private and public education institutions, and commercial training organizations. Products developed under this topic can be sold directly to corporate training departments and consulting firms which produce training for their clients. In addition, they can be used to produce training systems for particular subject matter, such as, math or science, and sold through software publishing companies directly to the public or educational institutions.

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AF97-039 TITLE: Virtual Reality for Embedded Assessment of Personnel Characteristics

Category: Exploratory Development

OBJECTIVE: Develop and validate methodology for embedded assessment of personnel characteristics using virtual reality.

DESCRIPTION: There is a requirement for creating a personnel assessment system that is embedded in a virtual reality scenario. Given limitations of current assessment methods, it is envisioned that the proposed product will consist of a virtual reality technology that encompasses the advantages of current selection test methods, but also uses state-of-the-art technology to address limitations of current assessment systems. Specifically, the proposed product will require candidates to perform a virtual reality task so challenging and intrinsically interesting that the evaluation aspects will not be salient and, therefore, the behavioral responses will be more reflective of typical compared to maximal performance. The task will superficially resemble a job sample, as it will require a continuous series of responses to stimuli, as compared to a test battery made up of discrete subtests or tasks. The net effect of this assessment format will never be obvious to the candidate as to precisely how or when responses are being scored. As a result, this system will add to the validity of current assessment procedures.

PHASE I: Phase I will result in the specifications of the virtual reality task, including hardware and software requirements, the nature of the task, and the methodology for embedding reliable and valid performance measures into the task. The specifications will be documented in a technical report. Phase I will also result in a prototype version of the virtual reality task that demonstrates the feasibility of the embedded assessment methodology.

PHASE II: Phase II will result in full-scale development of the embedded assessment system and in an empirical demonstration of the reliability and validity of the system for measuring job-related characteristics. The results will be documented in a technical report. Software will be delivered, tested, and validated.

POTENTIAL COMMERCIAL MARKET: The virtual reality embedded assessment system will have applications to any military or civilian organization that selects, classifies and assigns employees to perform jobs in complex technological environments. Other possible applications include job analysis and cognitive task analysis for situations in which no empirical data is available, such as the proposed design of the flight deck for a next-generation aircraft.

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AF97-041 TITLE: Full-Color, High-Definition Head-Mounted Display for Pilot Training

Category: Exploratory Development

OBJECTIVE: Develop a prototype head-mounted display for use in pilot training applications.

DESCRIPTION: It has been shown that near 20/20 visual acuity head-mounted displays (HMD) are required for high fidelity pilot training. The Air Force is seeking innovative dual-use, lightweight HMD technologies capable of presenting a full-color, high-definition (4620 x 2600 minimum resolution) display. In addition, the display should have a center-of-gravity approximating that of the user's head and be capable of wireless, video signal transfer to allow unencumbered use. Reliability and maintainability must be considered.

PHASE I: Provide a technical report determining feasibility of the concept and provide a demonstration of the feasibility of the display.

PHASE II: Phase II will result in prototyping and testing the system proposed under Phase I and a technical report.

POTENTIAL COMMERCIAL MARKET: Dual use potential exists for commercial flight simulation, air traffic control, video games, and scientific applications.

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AF97-042 TITLE: Design of Scenario-Based Test Technology for Job Performance Measurement

Category: Exploratory Development

OBJECTIVE: Develop a system to create job knowledge tests that measure airmen's capability within their job context.

DESCRIPTION: There is a requirement for job knowledge and skills tests that are plainly relevant to successful job performance. Present job knowledge and skills tests are sometimes criticized by senior non-commissioned officer's (NCO's) for capturing test-taking ability, measuring book knowledge, placing too much emphasis on verbal abilities, and missing pertinent job knowledge. Advances in cognitive task analysis have shown that by placing airmen in contexts of task completion, knowledge that is critical to successful task completion is made salient; background knowledge that is irrelevant is safely ignored. What is really needed is a test development system that creates scenario-based tests that clearly measure airmen's ability to perform within the context of their job. Scenario-based tests will require three phases for test development. The first phase is constructing realistic and representative test scenarios. To take an example from car mechanics, one scenario is that a car doesn't start one morning when the operator turns the ignition key; the underlying cause is a rotted cable from the car battery. The second phase is presenting the scenario to the test-taker so that the flow of the scenario is maintained. The third phase is scoring the test takers' proficiency. Although the scenario-based test system can assume that multi-media and virtual reality presentation modes are available for test delivery when appropriate; this project is concerned with methods and tools for developing scenario-based tests rather than the development of high-fidelity presentation media.

PHASE I: Phase I will result in a prototype version of the scenario-based job knowledge and skills tests for one enlisted Air Force specialty. It will also result in documented specifications for (1) test construction, (2) software, (3) hardware, and (4) maintenance requirements for keeping the scenario-based tests current as the Air Force technology grows.

PHASE II: Phase II will result in a software package for the development of scenario-based job knowledge and skill tests. This software package might be sold as expert system shells are sold today. The "Job Assessment" shell might lead the user through (1) how to specify a representative set of job scenarios; (2) how to present scenarios to the test taker and collect responses from the test taker, and (3) how to score the test taker. The software package should be tested by developing scenario-based job knowledge and skills tests for at least four enlisted Air Force specialties. The specialties for which tests are built must include at least one specialty from each of the four classes of Air Force Speciality Codes (AFSCs) (electronic, mechanical, administrative, and general). The tests should be evaluated for validity and reliability.

POTENTIAL COMMERCIAL MARKET: Scenario-based job knowledge and skills tests can be applied in any organization, public or private, that wishes to accurately evaluate the capability of its workers. Occupations which can be evaluated by scenario-based tests include doctors, mechanics, bankers, florists, administrators, cashiers, teachers, or any occupation listed in the Department of Labor's Dictionary of Occupational Titles.

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AF97-043 TITLE: Innovative C4I Technologies

Category: Exploratory Development

OBJECTIVE: Develop innovative technologies for enhancing the performance, availability, and affordability of C4I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of C4I pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: communications, including networks and network management, radio, and wireless communications; signals exploitation; intelligence data handling; sensor exploitation radar signal; image and speech processing; computer science, including high performance computing, parallel processing, distributed systems, computer systems technology, and artificial intelligence; applications of photonics systems for ultra-fast optical communications and optical data storage; electromagnetic (EM) technology, including phased array antennas, null steering and scattering, and computational electromagnetics; reliability and diagnostic technology; virtual reality and other information presentation technologies; data fusion; and information warfare technologies emphasizing information protection. This topic offers great flexibility for proposers to offer innovative technologies with revolutionary impact on C4I systems and subsystems. Proposal titles must reflect the specific technology problem being addressed.

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype device, subsystem, or software program.

POTENTIAL COMMERCIAL MARKET:
Many C4I technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

AF97-044 TITLE: Large-Scale Knowledge-Base Technology

Category: Exploratory Development

OBJECTIVE: Develop tools and techniques to provide seamless access, storage, and retrieval of knowledge within massive knowledge base systems.

DESCRIPTION: Large-scale knowledge-base (KB) technology will provide the foundation for intelligent systems that can quickly search massive KB's for relevant information; help users to evaluate the effects of complex courses of action; and work with users to develop, share, and effectively use knowledge about complex systems and processes. Distributed KB's will be the backdrop of all Intelligent systems. Widely shared KB's, coupled to reasoning programs, will help transform data into information, supplying necessary but missing detail to a number of Air Force and commercial domain applications.

Mechanisms to be investigated include but are not limited to; KB libraries and associated construct/edit tools, KB acquisition/ discovery tools, and high performance KB computing techniques. Advanced tools and techniques in these areas will allow system developers to build large-scale knowledge bases (millions of objects) quickly and economically and efficiently deal with excessive demands for querying mixed media resources. Proposals may also draw on current visions involving the Internet and the way autonomous intelligent information specialists might populate cyberspace in the future. To do so will involve looking at the future directions of KB systems, with focus on large-scale knowledge-bases and applications.

PHASE I: Identify, investigate, and prototype advanced knowledge-base capabilities and identify potential Air Force and commercial users of these products.

PHASE II: Develop and demonstrate unique large-scale knowledge-base capabilities and tools from phase I in both Air Force and commercial domains.

POTENTIAL COMMERCIAL MARKET:
Rapid accessibility to integrated, massive KB's increases choices for consumers in both civilian and defense applications. This technology could have a major impact on applications that require integrated decision making and timely and accurate information such as nuclear power plant control, autonomous vehicles, aircraft operation, hospital life support systems, decision support systems, and military command and control.

AF97-045 TITLE: Automatic Code Generation for Real-Time Parallel

Category: Exploratory Development

OBJECTIVE: Develop techniques or prototypes for migrating legacy real-time sequential code onto high performance computing platforms.

DESCRIPTION: In order for embedded real-time legacy software systems to realize the increased processing power available on high performance computing architectures, software support is required to help minimize the cost/effort involved in migrating these systems. Automatic parallel code generation is one area of research that could make a significant impact in the process of migrating legacy real-time systems. Automated code generation would significantly reduce the level of effort involved in rewriting sequential software so that it will run on these new hardware platforms. Automatic parallel code generation can be looked at from several different aspects. One approach is to provide techniques that allow sequential code (Jovial, C, Fortran, Ada) to be synthesized, identify the inherent parallelism, and then automatically produce the parallel code for the selected high performance architecture. Another approach would be to graphically represent the inherent parallelism that exists in the sequential code, allowing the developer to manipulate the graph, and then from the graph generate parallel code. The goal of this topic is to define a practical technique for automatically generating parallel code for real-time systems. This technique will then be demonstrated on a real-time C4I application.

PHASE I: This phase will develop the requirements for a prototype system, as well as a working demonstration of the system for automatically generating parallel real-time code.

PHASE II: This phase will develop a working prototype of the proposed system. The final deliverable under this phase will be a beta version of the automatic parallel real-time code generation system.

POTENTIAL COMMERCIAL MARKET:
The proposed research possesses significant application to the development of a number of commercial computer and software systems. Areas of potential commercial use exist in modeling and simulation, database transaction processing, and medical imaging systems.

AF97-046 TITLE: Multi-Source Collaborative Distributed Information Systems

Category: Exploratory Development

OBJECTIVE: Develop a multi-source collaborative environment in which geographically dispersed users can jointly edit, create, view, and manipulate multi-source data.

DESCRIPTION: C4I application environments which support collaborative computing requirements on a large scale have never been sufficiently investigated. Most existing collaborative systems emphasize a point-to-point communication capability for information sharing. A collaborative environment supporting such applications demand real-time information exchange and synchronized group decision making. Therefore, new techniques are needed to ensure synchronization of objects/applications in a distributed environment, exploitation of shared memory, and buffer management mechanisms for information management and new concepts associated with message passing and remote procedure calls. Intelligent real-time mechanisms or agents are required for providing integration of multi-source pieces of information from heterogeneous collaborative distributed data information systems. These advanced agents will provide services for encapsulation of processes for correlating multi-source data residing on distributed repositories for sharing among users in a collaborative distributed environment.

This environment would provide an advanced collaboration domain between users with the support of a powerful distributed data information system which can provide a wide variety of services. Such an environment can be used to support the C4I for the Warrior, the Joint Warrior Interoperability Demonstrations (JWID), and DARPA's Joint Task Force (JTF).

PHASE I: Design and development of the techniques to support a collaborative information environment mentioned above.

PHASE II: Demonstrate a complete integrated collaborative information environment.

POTENTIAL COMMERCIAL MARKET:
This technology will have a major impact on applications that require information to be pulled together from different data information systems for collaborative group decision making. Typical applications include joint planning systems, aircraft operations, surgical diagnosis for physicians, logistics, disaster relief, and educational services

AF97-047 TITLE: Futuristic C5I (Collaborative C4I) Technologies

Category: Exploratory Development

OBJECTIVE: Develop methods to maximize speed and quality of planning, wargaming, and battlefield management via improved data visualization, navigation, and manipulation for collaborative knowledge based systems.

DESCRIPTION: To be responsive to 21st century demands of the information warrior, the Air Force must be more responsive to short time scales for decision making and delivery of increasing amounts of information. For example, planning for air battle command operations must be done quickly in order to increase the tempo of operations. People

and databases involved in tri-service battlefield interactions, such as Planning and Control, may be geographically distributed. The ultimate goal is to give the battlefield commander and support staff access to all information needed to win the campaign - when they want it, where they want it, and how they want it. Systems are needed to augment human intellect and understanding and support collaborative decision making through "virtual" meeting facilities. Methods for data visualization are also needed so that users can navigate through and discover information on the way. Improvements to current state-of-the-art data visualization and manipulation technologies must provide a paradigm shift away from stand-alone documents and isolated information systems to a heterogeneous collection of malleable interdependent documentation and supporting data accessible through internets and intranets via linking. This effort will integrate knowledge, tools, and management processes by designing the collaborative communication-oriented aspects of Air Force applications (e.g., distributed planning environment, wargaming, and battlefield management scenarios) with visual methods to integrate various kinds of data (e.g., journals, email, plans, and time lines) and tools needed to make their decisions as a team.

PHASE I: To be responsive to this SBIR topic, any one of the following three Phase I objectives may be met:

1. Investigate hypermedia capability infrastructure (such as integrated applications, explicitly structured documents, addressable objects, view control, shared screens, and hyperdocument libraries) needed to support collaborative knowledge based systems for planning, identifying commercial information technologies that provide such functionality, and proposing a strategic design for developing the key elements of such a system.

2. Identify current limitations and proposed innovative techniques which offer significant improvements over current state-of-the-art data visualization and manipulation technologies.

3. Develop a prototype tool for textual information. This tool should allow a user to navigate (browse) the information space graphically, without resorting to typed queries. In Phase I, the amount of data may be limited to several domains in order to show the feasibility of the technology being pursued.

PHASE II: The following are objectives for Phase II:

1. Design, develop, and demonstrate a prototype collaborative system on a real Air Force planning problem.

2. Accomplish a prototype development and/or demonstration which incorporates and demonstrates the proposed Phase I enhancements.

3. Further develop the Phase I prototype to handle a much larger amount of textual information. This data will vary widely in its subject area, in order to show how the techniques used can deal with the visualization of information from many different domains. A sophisticated graphical user interface will be developed to allow the user to navigate through the data in a non-obtrusive manner, discovering the data they need in the process.

POTENTIAL COMMERCIAL MARKET:

Although military systems might have shorter time scales and require more integrity due to the potential loss of human life in Air Force missions, all commercial organizations have similar needs for better organizational performance. Despite the enormous investments in information technology, white-collar productivity has risen slowly. One reason for this disappointing result is that today's computer systems fail to truly augment knowledge workers in their tasks. The technology from this SBIR will help improve end-to-end management processes in a wide range of management information situations in business such as digital libraries and financial domains, the medical community, and education

AF97-048 TITLE: Active Intelligent Information Environments

Category: Exploratory Development

OBJECTIVE: Develop a common core of capabilities for designing, developing, and integrating large-scale active information systems.

DESCRIPTION: As the 21st Century approaches, we are just entering the knowledge age in which we must develop new knowledge from data and information. Integrated access and cooperation among functionally independent intelligent systems and information bases is becoming increasingly critical to support planning and optimization efforts for a number of applications. Quite often, complexity is overwhelming due to several interrelated factors - timely

access, vast amounts of data, diverse data types, ability to share large amounts information, difficulty in defining the goals and constraints of the problem, dynamic and stochastic environments, and independently developed and geographically-distributed subsystems.

DARPA and Rome Laboratory are exploring ways to evolve growth and usable potential of large-scale information systems. However, research is needed to bring active information systems development and integration into the next century. Basic research in areas such as knowledge discovery and active knowledge base technology will help provide more value from data, as well as help the knowledge to be managed more efficiently so that information can be automatically filtered, manipulated, and summarized. Research areas of interest include; collaborative computing techniques, representation languages and standards, negotiation and reasoning protocols, planning, resource allocation techniques, intelligent active data/knowledge bases, problem solving, machine learning, and human-computer interaction. In addition, techniques are needed to monitor and update large amounts of data/information, maintain configuration management, and permit change notification and consistency control in information systems.

Mechanisms to be investigated include (1) information rich hypeprogram web technology, (2) use of objects for real-time information integration, (3) seamless information access and collaboration, and (4) evolvable data/knowledge base primitives for scalable information aggregation/processing. Technical challenges include use of video, fax, graphics, images, voice, and textual data for domain engineering and architecting.

PHASE I: Investigate development of techniques for designing, developing, and integrating large-scale active information systems using massive multi-source data rich repositories.

PHASE II: Demonstrate an integration environment for core knowledge bases in appropriate scalable information processing domains/platforms.

POTENTIAL COMMERCIAL MARKET: Rapid accessibility to integrated systems and information increases choices for consumers in both civilian and defense applications. This technology could have major impact on applications that require integrated decision making and timely and accurate information such as planning/scheduling systems,autonomous vehicles, aircraft operation, hospital life support systems, decision support systems and personal military command and control.

AF97-049 TITLE: Smart Networking Radio Technology

Category: Exploratory Development

OBJECTIVE: Develop an advanced radio technology which supports intelligent, seamless, and robust information networks.

DESCRIPTION: The U.S. has a global communications requirement to enable rapid application of air combat power via assured connectivity with timely, reliable, responsive, yet affordable, dissemination of information from HQ's down to the lowest, mobile, tactical force elements. The Air Force needs innovative research to enhance our ability to transfer large amounts of data, quickly, accurately, and securely. This data includes voice, image, and computer data. Researchers must identify promising wireless technologies which will provide substantial immunity to hostile action (electronic warfare), maintain connectivity in the face of battle damage (link outages), meet requirements for high performance in capacity and timeliness, be user-friendly, and enable transparent connection and interoperation with other services and friendly forces.

Specific task areas for innovative research include methods and techniques that:

a) Enhance Quality of Service (QoS); Speed of Service (SoS); streamline interfaces to wide area information assets and advance radio architectures; and increase modularity, programmability, security (including Low Probability Intercept/Detection and Anti-Jam techniques), interoperability, and compatibility throughout various military and civil services and across the frequency spectrum.

b) Enable radios to sense and dynamically adapt to the signal environment and demands for services. The radios should optimize performance through signal detection, waveform recognition, parameter estimation, passive

surveillance, interference excision, resource management, and mobility management. Expert system-based radio and network control should be an avenue for consideration.

c) Enable radio operators; via flexible, user-friendly man-machine interfaces (MMIs); to quickly and efficiently manipulate functions within integrated communications assets, with minimal errors and training.

d) Provide efficient means to model innovative communications technologies as custom software module(s) for commercial-off-the-shelf link and network simulation environments. Also, identify the optimum configuration of future wireless tactical communication networks and their interfaces into commercial networks (e.g., Asynchronous Transfer Mode (ATM), SONET, etc.). For example, using computer models, demonstrate the effects of the channel on innovative image and speech compression techniques; or demonstrate innovative techniques for processing data over dynamic wireless radio networks, such as may be encountered in a stressed (loss of links, high noise/interference, difficult terrain, etc.) military or commercial environment.

e) Define the framework for integrated control and management architectures containing detailed protocol options. Establish seamless internetworking radios and a framework to specify user access interfaces and subnetwork coupling options for the integration of commercial/tactical networks.

PHASE I: Identify techniques, explore algorithms, design interfaces, analyze, and define designs for task areas a-e above. Provide comparison and simulation support for design decisions and detail trade-offs. Supply test and analysis data. Justify both military and commercial potential for Phase 2.

PHASE II: Develop and demonstrate, usually through hardware fabrication or some form of prototyping, Phase I algorithms, concepts, or techniques. Provide comparison between this phase of implementation and Phase 1 analysis and computer simulation. Supply test and analysis data. The end result should show clear potential for commercialization.

POTENTIAL COMMERCIAL MARKET:
The commercial sector is urgently in need of secure, reliable communications which are free of benign interference and noise. Advanced communications techniques; such as spread spectrum, interference excision, waveform recognition, etc.; perform as well to counter noise, interference, spectral congestion, and other civil communications difficulties. Innovations in multi-band antennas and couplers, wideband transceivers, and MMI techniques are also transferable to the commercial user. Conversely, commercial communications means will be exploited extensively for military use. Programmable and flexible interfaces between military radio equipment and commercial networks will enlarge dual-use potential

AF97-050 TITLE: CAD Conversion Tools for VHDL-MS Library Generation

Category: Exploratory Development

OBJECTIVE: Develop an automated tool environment converting existing Simulation Program with Integrated Circuit Emphasis (SPICE)-based models into an IEEE VHSIC Hardware Description Language-Mixed Signal (VHDL-MS) compliant model.

DESCRIPTION: There is an increasing need for electronic design automation (EDA) tools to support the mixed-signal (digital/analog) design engineer. The mixed-signal language extensions to VHDL, known as VHDL-MS (IEEE P1076.1), provide the basis of a solution. For VHDL-MS to be immediately useful, however, there must be a mechanism available for utilization of the vast number of existing libraries of simulation models implemented for SPICE and other mixed-signal and analog simulators. The ability to provide for the reuse of existing analog and mixed-signal models within VHDL-MS will allow the analog and mixed-signal design engineer to benefit from the top down and multi-level abstraction design approaches available through the use of VHDL-MS. The technical challenge is to design tooling which will take the existing analog simulation models and convert them into VHDL-MS compliant source code. The availability of such a tool would allow users to quickly realize the benefits of reduced system design time, technology and vendor independence, and system life cycle support in their design process.

PHASE I: This phase will consist of the development and documentation of the scope of the generators and the approach which will be taken in their development.

PHASE II: This phase will develop and document the generators with both alpha and beta releases completed.

POTENTIAL COMMERCIAL MARKET:
The ability to provide for reuse of existing simulation models with VHDL-MS will allow design engineers to benefit from the advantages of VHDL-MS, such as multi-level abstraction, without starting their designs from scratch. This technology will dramatically reduce the initial design cost for both commercial and military applications. As further capabilities are added to the VHDL-MS tools, a mature mixed-signal modeling and simulation environment will be developed, thus filling the void in existing proprietary approaches to design, diagnostics, and test of analog and mixed-signal electronic systems. Tools developed for this area will provide a decrease in the development time as well as reduce overall system costs including those of initial system design, life cycle support, and reprocurement for both commercial and military applications. This technology will have a major impact on applications for automobiles, communications, medical, and aerospace systems.

AF97-051 TITLE: Electromagnetic Environment Sensing/Recording System

Category: Exploratory Development

OBJECTIVE: Develop a system to monitor, record, and time correlate electromagnetic fields.

DESCRIPTION: Electromagnetic (EM) fields are suspected of causing system upset and failure on Air Force platforms. An understanding of the fields at the time of system upset can improve system reliability, reparability, and ultimately availability and maintainability. This is especially true for C4I systems being developed which employ large phased array radars for airborne surveillance systems. An understanding of the EM environment will be obtained with the development of an electromagnetic environment sensing/recording system. The environmental sensing system is a sensitive, wide bandwidth EM energy sensor system that will detect, record, and time correlate the real time occurrences and wavelengths of high EM fields on military platforms with a minimum of measured field perturbation. Sensor power and data are passed between the remote sensor and the centrally located signal processing unit in such a way as to minimizing the interaction between these signals and the environment. The signal processing unit performs the frequency discrimination and data recording functions. The functioning system will provide a powerful troubleshooting tool correlating EM environmental data with other upset/failure reports and data to significantly reduce costly Retest OK (RTOK) often encountered when equipment is brought into Air Force or contractor facilities for first or second level repair action. The EM environment sensing system will be designed to be utilized as both a stand alone system, or as a "smart" sensor for a Time Stress Measurement Device (TSMD) system, depending upon monitoring requirements. The EM sensor system capability can also be applied to areas such as commercial aircraft, fly by wire systems, automotive digital engine/transmission controls, air bags/antilock brakes, digital displays/entertainment systems, nuclear power plant monitoring/control room status displays, alarms and reactor control signals, and anywhere where wireless communication systems are utilized. All of these areas are known to have problems with EM fields of various levels.

PHASE I: Phase I involves the conceptual development of the system. Particular interest is in the signal processing electronics, and the interface of the sensor to the signal processing electronics. Realizing a prototype of the frequency discriminating system would be of great benefit.

PHASE II: Phase II involves the design, fabrication, and demonstration of a prototype stand alone system, with plans for interfacing with TSMD technology.

POTENTIAL COMMERCIAL MARKET:
Commercial markets would be the airline manufactures, especially with the fly-by-wire systems being developed such as used in the Boeing 777; hospital life support and monitoring equipment manufactures; wireless communication network manufactures

AF97-052 TITLE: Prognostic Assessment Technique/Tool for Electronic Equipment and Systems

Category: Exploratory Development

OBJECTIVE: Develop prognostic techniques and hardware for assessing health of electronic equipment/systems.

DESCRIPTION: Microelectronic semiconductor devices degrade as they age (transistor diffused or doped regions degenerate, metal / semiconductor contacts break down, metal traces degrade from electromigration, etc.) there is potential to measure system level radiated signals with external (non-contact) probing for the purpose of assessing the health of electronic equipment. The device level degradation causes reduced device and system performance. Furthermore, (as the equipment ages) this degradation may modify the ambient radiation inherent to all electronic equipment and can potentially be measured by external non-contact probing of various signals. Thus an innovative technique designed to measure and characterize life-cycle status of electronic equipment and predict necessity for replacement of system components is desired. It is envisioned that the technique/tools developed would have the capability to predict/estimate time to failure for the system under test and provide advance information on the life-cycle disposition of an electronic system. Additionally, the technique should have the ability to localize degraded devices within the system.

PHASE I: This consists of identifying appropriate measurable signals that are indicative of the health of electronic equipment and testing the feasibility of using these signals as a diagnostic/prognostic indicator for equipment under test. This may include simulations and empirical testing of hardware.

PHASE II: This phase would entail building a prototype system to be used as the prognostic tool (sensors, data processing, analysis of recorded information, etc.).

POTENTIAL COMMERCIAL MARKET:
There would be a large commercial potential from this effort. The ability to assess the health of electronic equipment could potentially dramatically impact both military and commercial practices regarding electronic equipment and maintenance

AF97-053 TITLE: New Diagnostic Tool for Evaluation of Material Surfaces

Category: Exploratory Development

OBJECTIVE: Develop a marketable technique for routine measurement and comparison of material surfaces during integrated circuit manufacture.

DESCRIPTION: The problem is that the reliability of microelectronic devices is dependent on the consistent quality of material surfaces and interfaces. There is no one routine measurement to provide a simple complete surface description. The technical challenge is to develop a new diagnostic tool for evaluation of material surfaces to determine consistency of current manufactured lots with previous known "good" lots. Surface structure is known to change with deposition and substrate parameters. Presently there is no standard method to determine the quality of the surface or to compare one surface with another surface. Grain size, surface roughness, and grain orientation are parameters to be considered, but they need to be monitored and analyzed in such a way as to promote easy comparisons. One technique might be to determine the fractal dimension of the surfaces using a kinetic model with Smoluchowski equations and Jullien's solution.

PHASE I: Develop a robust, consistent technique for routine surface quality measurement of nanometer structures.

PHASE II: Manufacture and market tool for use by microelectronic firms to routinely monitor surface quality of materials used in microelectronics.

POTENTIAL COMMERCIAL MARKET:

A readily available technique for surface quality measurements is imperative to producing high quality reliable microelectronic devices for both commercial and military applications. Such a technique would allow in-process monitoring of microelectronic materials for surface and interface quality before addition of more value to the product. The tool would also assist small companies with older deposition equipment to produce a high quality, more reliable product. Resultant reliable devices would be available for commercial (medical, transportation, and communications) and military (transportation, communications, and weapons) applications at more competitive prices.

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AF97-054 TITLE: Design Tools for Minimizing Electronic Failure

Category: Exploratory Development

OBJECTIVE: Develop a computer aided design tool minimizing the failure of Very Large Scale Integrated (VLSI) microcircuits and integrate them.

DESCRIPTION: The failure of electronic components and systems has adverse effects on the readiness, effectiveness, availability, and affordability of military systems. It increases maintenance costs, and aggravates the quantity of spares required during deployment. Managing the failure of electronic systems and components involves building electronic systems and components that are not susceptible to end of life failure mechanisms, and that can perform the required functions when some of the components or some part of a component has failed. In order to build reliability into electronic components and systems, design techniques and tools must be developed which guide design processes such as synthesis and technology mapping based on reliability and fault tolerance. Reliability analysis and simulation during logic design assist in making circuits reliable.

The management of failure includes constraining circuit susceptibility to failure mechanisms like electromigration through design processes such as synthesis and technology mapping, analyzing physical layouts of VLSI designs to make the design more robust, and exploiting fault tolerant design techniques to increase the reliability of the overall circuit when some portion of it has failed. The models, algorithms, and techniques will be integrated into a commercializable CAD tool that can be interfaced with commercial design frameworks, and employ widely accepted design modeling languages such as VHSIC Hardware Description Language (VHDL).

PHASE I: Define and detail the proposed algorithms that need to be developed and implemented. Create a preliminary design of the proposed methods and tools including the interfaces to commercial design frameworks.

PHASE II: Develop the proposed algorithms and techniques and implement them in a prototype tool that can be commercialized. Investigate how the proposed methods and algorithms affect circuit area, power, and performance.

POTENTIAL COMMERCIAL MARKET:
The ability to manage circuit failure during the design of the circuit reduces the time required to develop advanced microcircuits, while maintaining high confidence in the availability of electronic systems. This technology is important both for the use of these circuits in military applications and in the commercial sector. The tools developed under this topic will have a significant effect on military electronic systems because the failure of the electronics can severely damage mission success rates and increase system support costs and the number of spares needed. The tools will reduce development time, which is the driving force for commercial electronics and defines the profitability of electronic companies. Electronic systems will benefit by reducing the number of spare parts needed when they are deployed by reducing the amount of time needed for system repair, and by increasing the availability of the system for operational use. Tools developed for this area will reduce the overall cost and time associated with developing reliable advanced microelectronic circuits. End of life failure mechanisms, that pervade the circuit population, must be eliminated as early as possible during circuit development. The tools developed under this topic will enable circuit

designers to minimize the circuit's susceptibility to these mechanisms, and minimize the effects of device failure on circuit performance. The tools will reduce life cycle support costs for both military and commercial electronics including automotive, communications, and aerospace applications.

AF97-055 TITLE: Ultra-High Speed Bit Error Rate Tester

Category: Exploratory Development

OBJECTIVE: Develop a 25Gbit/s bit error rate tester (BERT).

DESCRIPTION: Current fiber optic links have only partially realized the enormous bandwidth available using single-mode optical fiber. The military and the telecommunications industry have had bandwidth requirements which have been increasing each year by a factor of greater than two. These demands are driven by the transmission of images and the increase in traffic on the world wide web. Current commercial systems operate at speeds up to 2.5Gbit/s with future upgrades planned for 10Gbit/s (OC-192). The Air Force and several other government agencies have immediate requirements for data transmission rates in the 10 to 40Gbit/s range and future requirements as high as 100Gbit/s. DARPA has a new program entitled "Ultra Photonics" whose objective is to increase the speed of current information processing systems by a factor of 10 to 100. The components needed to build fiber optic links with data transmission rates up to 40Gbit/s are available commercially but the test equipment needed to measure their performance is not. Measurement of the performance of these systems requires a high speed bit error rate tester (BERT). The highest speed BERT available commercially is 12Gbit/s and very expensive ($300K). The goal of this program is to design, develop, and commercialize a reliable and affordable 25Gbit/s BERT and establish the framework necessary to develop a 40Gbit/s BERT. The commercial availability of this instrument will accelerate the development and utilization of much higher speed fiber optic links than presently available. Collaborations are encouraged.

PHASE I: Design and demonstrate the feasibility of developing a 25Gbit/s BERT.

PHASE II: Develop, fabricate, test, and deliver a prototype 25Gbit/s BERT to the Air Force.

POTENTIAL COMMERCIAL MARKET:
The demand for this product will be driven by the telecommunications industry, which is a multi-billion dollar market

AF97-056 TITLE: Large Area Nitride Substrates

Category: Exploratory Development

OBJECTIVE: Develop a domestic source of large area III-N epitaxial substrates using cost effective manufacturing methods.

DESCRIPTION: Nitride semiconducting devices have demonstrated capabilities for solar blind detection, visible emission for heads-up displays, short wavelength sources for ultra high density data storage, and short wavelength optical communications. Cost effective manufacturing of these devices for subsystem insertion depends on the availability of large area nitride substrate materials. GaN-suitable substrates must be compatible with existing semiconductor handling equipment. GaN and related materials are currently grown by epitaxial means upon surrogate substrates. Epitaxial deposition and substrate technology must be developed to demonstrate device quality material growth on economical, large area substrates. Program expectation is for demonstration of III-Nitride growth on large area substrates, with demonstration of material quality through demonstration of optoelectronic componentry. Teaming and collaborative relations, especially in Phase II, are encouraged.

PHASE I: Experimentally demonstrate growth on 75mm substrates, and feasibility of scaling substrate diameter in excess of 150mm.

PHASE II: Qualify substrate design, reactor configuration, and growth process for manufacturing. Demonstrate material growth through fabrication and characterization of optoelectronic componentry.

POTENTIAL COMMERCIAL MARKET:

GaN substrates are suitable platforms for blue lasers and blue LED's. The market for blue light emitting diodes (LED's) is expected to be as large as the present market for red and green LED's, which is on the order of 10 billion parts per year. The substrate requirement to achieve this level of production is conservatively estimated to be over one million wafers per year, or approximately $100M/yr. The estimated price of $100 per wafer is expected to come down as the volume increases over time, as new applications such as blue lasers are brought into production.

AF97-057 TITLE: InP-based Power Transistors for Optically Controlled Millimeterwave Transmitters

Category: Exploratory Development

OBJECTIVE: Develop high power InP-based transistor technology for millimeter wave and optoelectronic integrated circuits.

DESCRIPTION: Microwave and millimeter-wave communication and radar systems require high power transmitters capable of producing directional beams of EM radiation. Presently,
thermionic devices, such as traveling wave tubes, are often used. These tubes and their power supplies often drive system design through their weight, size, MTBF, and voltage requirements. An alternative to microwave tubes is a monolithic array of power combined semiconductor microwave sources, such as Gunn diodes or microwave transistors.[1] A shift to solid-state power devices; such as the InP-based HBTs, HEMTs, and MISFETs; would reduce weight and size of such systems, as well as dramatically improve system life and reliability. High power density InP devices are readily integrable with optical control and mm-wave radiating antenna elements. Integration of these structures on a common chip would reduce the necessity for coaxial interconnects, and advance system performance though enhanced amplifier efficiency. High electron saturation velocity and high thermal conductivity make InP a promising material for microwave power devices. The use of InP-based devices will allow integrated optical control functionality. Insulated gates are preferred over Schottky barrier gates for microwave power applications, since larger operating voltages and higher output powers are attainable before the onset of drain-to-gate breakdown. The performance-limiting factor of III-V insulated gate devices is the high density of traps at the insulator/semiconductor interface. Several approaches to improve and stabilize the surface of InP prior to insulator deposition have been demonstrated. Interface control layers (ICLs) are used to avoid the native oxides of III-V semiconductors or prepare the III-V surface for subsequent processing.[2] Another method introduced to improve the electrical properties of III-V semiconductor surfaces is sulfur passivation.[3,4]

PHASE I: Develop processing procedure for discrete InP-based power transistors.

PHASE II: Design and fabricate a mm-wave integrated circuit the combines the power of individual devices to produce a directional beam of mm-wave radiation. Demonstrate a wafer-scale integrated power-combining source on an InP substrate with over 100 radiating elements, capable of producing 25W of continuous wave power t, or above, 20GHz. Integrate the optical control of phase information to be distributed to individual elements.

POTENTIAL COMMERCIAL MARKET:
Integrated power circuits are highly applicable to airborne and space borne systems which are sensitive to payload mass, volume, and power requirements. Such systems include commercial communication and radar systems. An integrated solution would also be applicable to systems requiring high reliability, especially those which currently use heavy, redundant tubes to guarantee high power microwave capability in the 20, 40, 60, and 100GHz frequency bands.

REFERENCES:
1 "A 100-MESFET Planar Grid Oscillator," Z.B. Popovic, R.M. Weikle, M. Kim, and D.B. Rutledge, IEEE Transactions on Microwave Theory and Techniques, Vol 39, No 2, February 1991.
2 "Si3N4/Si/InGaAs Depletion-Mode Metal-Insulator-Semiconductor Field-Effect Transistors with Improved Stability," D.S.L. Mui, Z. Wang, D. Biswas, A.L. Demirel, N. Teraguchi, J. Reed, and H. Morkoc, Appl Phys Ltr, Vol 62, No 25, 21 June 1993.
3 "Dramatic Enhancement in the Gain of a GaAs/AlGaAs Heterostructure Bipolar Transistor by Surface Chemical Passivation," C.J. Sandroff, R.N. Nottenburg, J.C. Biscoff, and R. Bhat, APL, Vol 51, No 1, 6 July 1987.
4 "Indium Phosphide Passivation Using Thin Layers of Cadmium Sulfide," K. Vaccaro, H.M. Dauplaise, A. Davis, S.M. Spaziani, and J.P. Lorenzo, Appl Phys Ltr, Vol 67, No 4, 24 July 1995

AF97-058 TITLE: Ka-Band Satellite Link Quality Short-Term Forecasting Tool

Category: Basic Research

OBJECTIVE: Develop a small, low-cost device to forecast impending attenuation on satellite links in the Ka-band.

DESCRIPTION: Ka-band (20 to 40 GHz) satellite links, particularly at low elevation angles, often degrade due to rain, clouds, or excessive moisture content in the atmosphere. Link operators cannot adequately predict how impending weather will affect their datalinks and fail to optimally react to rapidly degrading propagation conditions, resulting in lower signal-to-noise (SNR) ratios and, consequently, reduced data rates and throughput. Current forecasting techniques use passive radiometers, which simply measure the overall sky temperature. Potential errors abound due to the inhomogeneous distribution of expected brightness temperatures, which does not allow for correct estimation of the local attenuation. A simple, low-cost device is needed to provide advanced warning for operators to respond by reconfiguring their communications assets to either reroute data via different satellites, use landlines if available, or adjust power levels. This device will be placed alongside satellite terminals to provide a short-term, 60 minutes or less, forecast of the potential attenuation on satellite links in the Ka-band. The data will be displayed, recorded, processed, and interfaced with existing communications equipment to automatically adjust for changing SNR ratios and will also be used as input to take actions to change system parameters or switch to alternative communication paths.

PHASE I: Develop weather attenuation prediction algorithms at Ka-band frequencies.

PHASE II: Design and fabricate a Ka-band satellite link quality short-term forecasting tool based on weather attenuation prediction algorithms.

POTENTIAL COMMERCIAL MARKET:
The commercial application of this Ka-band satellite link quality short-term forecasting tool is expected to be excellent since many satellites under development for deployment are being planned for the Ka-band to take advantage of the larger channel bandwidths. These commercial systems will benefit from a warning device when changing atmospheric propagation conditions degrade the link sufficiently for data rate changes to occur

AF97-059 TITLE: Multifunction Phased Arrays

Category: Basic Research

OBJECTIVE: Develop affordable K-band phased array antenna and sensor technology for future vehicles.

DESCRIPTION: Military, commercial, and private air, ground, and sea vehicles of the future will require sophisticated but affordable antennae and sensors for aircraft and other mobile platforms. Expected performance needs vary from high gain, multi-element arrays to low gain, multiple function single elements. Digital beamforming, adaptive control, and neural networks will lead to more flexible and cheaper antennae and sensors for commercial and military systems. New capability needs include: improved low noise amplifiers (1 to 1.3 dB noise figure is desired), dual simultaneous polarization antenna elements, efficient RF power combining circuits, smart control for array antennas that can sense failures and correct or compensate antenna patterns, super-resolution and neural network techniques that can perform accurate direction finding with smaller systems using less accurate, lower cost components, automatic system calibration based upon the use of available beacons, and adaptive cancellation of interference for mobile satellite terminals. These capabilities allow the use of small, low cost radar, and communication antennae and sensors with increased capability due to the flexibility of adaptive digital smart control. Since most of this flexibility will be implemented by and under computer control, the development of low-cost, digital beamformer modules containing all components from radiating element to A/D converter is key to this initiative. The emerging technology of direct digital synthesizers based on fast D/A converters will drive digital beamforming on transmit. Components developed under this SBIR have the potential to greatly enhance and encourage a quickly growing multi-faceted market.

PHASE I: The contract should target a specific antenna application; refine the concept by a thorough theoretical analysis, trade study, and error analysis; and perform preliminary experiments on key subsystems that will test the overall idea.

PHASE II: The contract should demonstrate the full RF performance expected by a prototype operating in a realistic environment; and deliver a component, subsystem, or full system implementation so as to attract Phase III venture capital with a working prototype.

POTENTIAL COMMERCIAL MARKET:
An expanding commercial use of high technology products will include radar and communication capabilities for a variety of portable and mobile systems. These systems will face increasing demands for improved performance, while maintaining pressure to continually lower cost.

REFERENCES:
1. Proceedings of the Antenna Applications Symposium, Sep 1995, Allerton Park, IL

AF97-060 TITLE: Information Exploitation for Identification

Category: Exploratory Development

OBJECTIVE: Develop new techniques for the exploitation of information to identify threats and potential targets.

DESCRIPTION: Information exploitation is the assimilation and analyses of data obtained from heterogeneous sources for the identification of threats and targets. The concept is to correlate and fuse information from a varietal set of sources and exploit the resultant data product for unique characteristics that would provide indications of the presence of a target and/or threat and its identification.

PHASE I: This consists of developing concepts for the assimilation and exploitation of information for target identification.

PHASE II: This would consist of the design and development of an information exploitation capability.

POTENTIAL COMMERCIAL MARKET:
Information exploitation is a potentially valuable tool for the analysis of data in processes of creating and sustaining competitiveness: new business opportunities can be identified; information fusion generates innovation strategies; discovered information is rapidly assimilated into the organization by learning; and available technologies are more readily commercialized. The present challenge for the information management business is to develop more effective mechanisms for distilling data into useful and valuable information through fusion, information discovery, and exploitation.

AF97-061 TITLE: Advanced Data Fusion Technology

Category: Exploratory Development

OBJECTIVE: Develop new all-source fusion technology applied to distributed environments implementation utilizing expert system fusion.

DESCRIPTION: Data Fusion has been defined [Joint Directors of Laboratories (JDL), Technology Panel on C3 (TPC3), Data Fusion SubPanel (DFSP)] as: "Information processing that deals with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimation, complete and timely assessments of situations and threats, and their significance in the context of mission operation. The process is characterized by continuous refinement of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results." Current data fusion techniques beyond level-1 (correlation) are mainly manual and cannot keep pace with the highly mobile, dynamic forces likely to be faced in the future. Current Level-1 fusion techniques only support limited sources, not all-source information. In addition, distributed data fusion is currently not available. This topical area will address advanced computing technologies for all-source data fusion, as well as distributed data fusion.

Develop an expert system fusion system for management and implementation of dynamic control, multiple assignment, and tracking algorithms. The concept of expert system fusion has long held intuitive appeal as a method of providing improved multilevel control capabilities. There are many cases when the shooter will turn off the fusion system because it simply does not work. Research is needed to manage and implement the dynamic control of multiple assignment and tracking algorithms which employ knowledge based systems/fuzzy logic approaches. Included should be the capability to plot target separation versus sampling time for nearest neighbor, cluster/raid tracks. Special purpose system portability and object orientation are essential features. Develop an expert system fusion system for management and implementation of dynamic control, multiple assignment, and tracking algorithms.

PHASE I: Develop an innovative concept to provide truth, alignment, association, assignment, tracking, and a system output capable of feeding back information through a knowledge based/fuzzy logic algorithm manager. Phase I will investigate advanced computing techniques (e.g., statistical, artificial intelligence, artificial neural networks, fuzzy

logic) applicable to all-source data fusion. Phase I will result in a detailed plan and prototype software, which demonstrates the feasibility of a potential Phase II effort.

PHASE II: Implement the technology in a fusion to shooter experiment and a commercial test system. Phase II will design and develop the advanced computing techniques applicable to all-source data fusion, as well as distributed data fusion as recommended in Phase I, and then prototype a subset of the design to demonstrate partial distributed data fusion functionality.

POTENTIAL COMMERCIAL MARKET:
This topical area has dual-use potential wherever data from different (or even similar) sources are required for decision making. Examples of potential industries include: drug enforcement/interdiction, medical, environmental, aerospace, automotive, and manufacturing. The system developed under this program will immediately contribute to the sensor fusion community by providing a neuro-fuzzy adaptive expert system fusion system which could be used for concealed weapon detection for airport security.

REFERENCES:
1. Tang-Kai Yin, C. S. George Lee, "Fuzzy Model Reference Adaptive Control", IEEE Transactions on Systems Man and Cybernetics, Vol 25, No 12, December 1995.
2. Mori, Chong, Tse, Wishner, "Tracking and Classifying Multiple Targets without A-Priori Identification", IEEE Transactions on Automatic Control, Vol AC-31, No 5, May 1986

AF97-062 TITLE: Information Storage and Retrieval - Optical Memories

Category: Exploratory Development

OBJECTIVE: Develop and experimentally validate concepts for volumetric optical storage that demonstrate an optical advantage.

DESCRIPTION: Rome Laboratory is investigating the use of photonic technology in advancing the state-of-the-art in data storage. Optical memories show promise in many areas of the data storage hierarchy. Applications include: archival storage, random access memory, read only memory, cache memory, and associative (content addressable) memory. Three dimensional optical memory offers the potential of terabit storage in volumes on the order of a cubic centimeter. High data transfer will be crucial for military applications as well as civilian uses.

This initiative is directed towards exploiting the "Optical Advantage" of storing digital data in the form of optical volume or three-dimensionally. Concepts such as content addressable memory; either numerical, textural, or image identification techniques can be implemented in memory; results isolated; and effectively provide acceleration of output speed and access time. Correlation, auto-correlation, and change detection concepts within the memory itself should also be exploited.

PHASE I: Identify and characterize candidate media, lens architecture's, or beam steering concepts to provide storage capacities of 10E10-10E12 bits per cubic centimeter, or at least 10E3-10E6 discrete locations per centimeter.

PHASE II: Incorporate these concepts into a usable architecture and demonstrate feasibility via brassboard.

POTENTIAL COMMERCIAL MARKET:
Image exploitation would be greatly enhanced by the development of faster storage devices, not to mention the benefits of terabit of data accessible at any instant. Medical data will benefit from the advancement of these technologies as well. Imagine your entire medical history available to a physician in another town should medical attention be necessary away from home. A library of x-ray files stored digitally that not only are available on demand, but, now that images are stored digitally, a computer would assist the doctor in detecting tumors earlier than would have been possible before. The development of the "Information Superhighway" will hinge on the development of memory systems capable of storing more data than ever before, as well as transferring that data faster than ever before.

REFERENCES:
1. J. Ford, S. Hunter, R. Piyaket, Y. Fainman, S. Esner, "Write/Read Performance in 2 Photon 3-D Memories," SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories, Vol 2026, pp 604, Jul 1993.
2. D. Parthenopoulos, P. Rentzepis, "Three Dimensional Optical Storage Memory," Science 245, pp 843-845, 1989.
3. E. Maniloff, S. Altner, S. Bernet, F. Graf, A. Renn, U. Wild, "Spectral Hole Buurning Holography in Optical Memory Systems," SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories, Vol 2026, pp 592, Jul 1993.
4. P. Marchand, A. Krishnamoorthy, P. Harvey, G. Yayla, S. Esner, "Motionless-Head for Parallel Readout Optical Disk for Optoelectronic Content Addressable Memory System," SPIE Proceedings, Photonics for Processors, Neural Networks, and Memories, Vol 2026, pp 653, Jul 1993

AF97-063 TITLE: Intelligent Desktop Assistant

Category: Advanced Development

OBJECTIVE: Develop an intelligent desktop computer assistant to autonomously access, evaluate, retrieve, and fuse information from the growing number of on-line information sources available.

DESCRIPTION: The intelligent desktop assistant (IDA) will use machine learning techniques to familiarize itself with user styles, techniques, preferences, and interests. IDA will be able to guide users through the process of on-line information source selection, utilization, and interaction management (i.e. cost tracking, query refinement, etc.). Documentation will not be required as IDA adjusts user interface characteristics to reflect the changing experience of the user. IDA will schedule and execute multiple information retrieval tasks in accordance with user priorities, deadlines, and preferences. The software will be capable of evolving the processes by which it interacts with other systems, learning the characteristics of their interfaces and languages.

PHASE I: Prototype user and system interfaces and identify the learning algorithms required to support both. Develop a mechanism to specify deadlines, so that tasks can be completed in accordance with user defined priorities.

PHASE II: Implement a fully functional prototype and test it in a controlled environment. Develop a commercialization plan and define the target user base.

POTENTIAL COMMERCIAL MARKET:
The potential commercial market is literally the size of the personal computer market. This capability would be highly useful to any individual with a computer that is connected to any network

AF97-064 TITLE: Single-Channel Spectral Characterization

Category: Exploratory Development

OBJECTIVE: Develop the Adjustable Bandwidth Concept Signal Energy Detector (U.S. Patent 5,257,211) for enhancement to existing and well known spectrum analyzer designs.

DESCRIPTION: Rome Laboratory, through a series of contractual and in-house efforts, has developed a variety of approaches to characterize signal activity in user selectable RF band segments. In particular, proof-of-concept, FFT (Fast Fourier Transform)- based, single channel signal energy detectors (i.e., spectrum analyzers) have been implemented which are capable of detecting and "grouping" dispersed signal energy to form estimates of the composite bandwidth, center frequency, and signal-to-noise ratios. While multi-channel approaches exist and have many desirable characteristics, these techniques likewise require orders of magnitude increases in implementation

complexity, size, maintainability and cost over that of single channel techniques. Similarly, Time-Frequency distribution approaches, while useful in many scenarios, also have rather complex processing requirements. Currently available commercial spectrum/signal analyzers, including those that employ FFT-based Fourier analysis, lack the composite signal grouping, and parameter estimation reporting functionalities. With such capabilities, the enhanced spectrum analyzer becomes an extremely useful RF spectrum characterization device. The "Adjustable Bandwidth Concept (ABC) Signal Energy Detector" shows particular promise as a technique for spectral analysis enhancement and is the focus of this research effort. Essentially, this technique allows for the grouping and parameter report generation of signals with various bandwidths within the RF segment analyzed. Specifically, the ABC detector allows for averaging narrowband signals more over time and less over frequency, while simultaneously averaging wideband signals less over time and more over frequency for improved detection, grouping, and parameter estimate performance.

PHASE I: In this phase of the effort, a proof-of-concept implementation of the ABC Signal Energy Detector will be developed (e.g., in the MATLAB language) for development purposes. At the same time, a theoretical analysis will be performed to optimize the ABC detection algorithm performance. The signal parameter report contents and format shall be developed in this phase. Basic user definable device settings, along with appropriate operator interface considerations, will be addressed. The intent of this phase is to lead into the design and development of a real-time implementation in phase II, which leverages currently existing spectrum analyzer and associated equipment designs.

PHASE II: Design, develop, and test an enhanced spectrum analyzer prototype utilizing the ABC Signal Energy Detection technique and contractor developed enhancements for real-time signal activity grouping and simultaneous generation of a computer compatible parameter report.

POTENTIAL COMMERCIAL MARKET:
In recent years the private sector has witnessed a burgeoning growth in the sales and service of personal communications equipment, including such devices as the cellular telephone and Global Positioning System (GPS) receivers. This is in addition to the plethora of devices already common in the private sector, with purposeful and/or unintentional RF generation abilities. Both the communication engineer and the electromagnetic compatibility engineer, designing to meet FCC regulations, have come to rely upon various laboratory bench tools to properly develop and test their designs. In particular, the traditional spectrum analyzer is indispensable. The enhancements to the traditional spectrum analyzer as identified in this research have the potential to decrease communication equipment development time and cost, via superior signal analysis capability and automated specification testing. Regulatory agencies can likewise benefit from the development of the enhanced spectral analysis device.

REFERENCES:
1. Noga, A. J., "Adjustable Bandwidth Concept (ABC) Signal Energy Detector," U.S. Patent Number 5,257,211 Oct. 1993. (Unclassified

AF97-065 TITLE: Automated Information Extraction Tools

Category: Exploratory Development

OBJECTIVE: Develop Natural Language Understanding (NLU) tools that automate the extraction of information from unformatted text, and the porting of these capabilities to new domains.

DESCRIPTION: The Information Age has brought with it the need for tools to help people exploit the overwhelming volumes of textual information now available to them. Unformatted text is a rich source of potential information. Tools that automatically find and extract simple data from unformatted text could be of enormous value to any industry or organization that deals with large volumes of textual information. Data that can feasibly be extracted from text includes "shallow" information such as the names of people, places, locations, organizations, and equipment; quantities; and dates. The ability to extract such data and to put it into a structured form would enable a multitude of powerful applications; including automatic document indexing, automatic data base generation, and data visualization (for analytical purposes). Tools would also be developed to make the toolset portable to new domains, so it could

easily learn about and recognize previously unseen information (e.g., people's names for a new country, equipment names related to a new application area, etc.)

PHASE I: Research the area of information extraction. Develop and refine the requirements for "shallow" information extraction tools; tools capable of recognizing and extracting simple (i.e., feasible) data from text, such as names, places, locations, organizations, equipment, quantities, and dates. Include requirements for making the tools portable to new application domains.

PHASE II: Develop the shallow information extraction tools. Test them out in commercial settings where large quantities of unformatted text are processed, and collect feedback on their performance. Iteratively refine the toolset in accordance with user feedback.

POTENTIAL COMMERCIAL MARKET:
Tools for shallow information extraction would be useful in any industry or organization that processes large volumes of unformatted text. This includes financial institutions (e.g., tracking competitors/business intelligence analysis), law enforcement agencies (e.g., automatic data base generation from police reports, visualization of data from unformatted text to help investigators analyze crime data), and the publishing industry (e.g., automatic document indexing).

REFERENCES:
1. Hobbs, Jerry H.; The Generic Information Extraction System, from Proceedings Fifth Message Understanding Conference (MUC-5), Morgan Kaufmann Publishers, Inc., CA, 1993, pp 87-91. Jacobs, Paul S., Text-based Intelligent Systems: Current Research and Practice in Information Extraction and Retrieval, Lawrence Erlbaum Associates, Publishers, Hillsdale, N.J., 1992

AF97-066 TITLE: Exploitation of GPS Controlled Imagery

Category: Exploratory Development

OBJECTIVE: Develop new and innovative methods, techniques or products that take advantage of GPS controlled imagery. DESCRIPTION: Technology developed under this effort will replace traditional techniques for estimating airborne imagery exterior orientation parameters before exploiting the imagery. This will result in improved techniques for producing current imagery products. GPS controlled imagery will also support the development of new imagery products that were not feasible with current techniques.

GPS controlled imagery provides an estimate of the airborne imagery exterior orientation parameters. Technology developed under this effort will take advantage of the GPS information. These techniques will assist in working with blocks or strips of airborne imagery, imagery acquired at different times or from different sensors, and metric information available with GPS controlled imagery. The new products produced will take advantage of GPS controlled imagery to produce image mosaics, change detection; providing new methods to catalog imagery or obtain metric information.

PHASE I: Focus on defining, developing a specification and demonstrating the method, technique or product that is proposed. This should result in showing the required input information, an estimate of the processing time required and the accuracy of the output information. The contractor should supply any GPS controlled imagery required to support any proposed demonstration.

PHASE II: Focus on implementing and demonstrating a working prototype of the proposed method, technique, or product. This should result in showing the military and commercial benefits of the proposed method, technique, or product.

POTENTIAL COMMERCIAL MARKET:
This topic has high Dual Use Commercialization Potential. Both the military and the commercial sectors have sources for GPS controlled imagery. Although the sources may differ, methods to exploit the imagery can be similar. The commercial sector can utilize image mosaics and image catalogues for resource management; and the military can use image mosaics and image catalogs for wide area search applications. Imagery acquired at different times or from

different sensors can be exploited for change detection by the commercial sector for detecting storm damage or environmental health. The military can use change detection for detecting changes in military activity.

REFERENCES:
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2. Boller, Robert A., 1994. Reverse Photogrammetry II - Space Resection. 1994 ASPRS-ACSM Annual Convention, Volume One: ASPRS: pgs 100-106.
3. Dornheim, Michael A., 1995. New Sensors Show Two Paths to Reconnaissance. Aviation Week & Space Technology, July 10, 1995, pgs 42-46.
4. Habib, Ayman, and Kurt Novak, 1994. GPS Controlled Aerial Triangulation of Single Flight Lines. 1994 ASPRS-ACSM Annual Convention, Volume One: ASPRS: pgs 225-235.
5. Israel, MGEN Kenneth, 1994. The Defense Airborne Reconnaissance Office. American Intelligence Journal, Vol. 15, No. 2, pgs 61-67

AF97-067 TITLE: Defensive Information Warfare Technology

Category: Exploratory Development

OBJECTIVE: Develop improvements to the state-of-the-art in Defensive Information Warfare technologies by providing innovative basic research in information system integrity, availability, security, and vulnerability assessment.

DESCRIPTION: Defensive Information Warfare technologies span a number of different areas. Information Warfare planning functions are needed which provide for the application of defensive technologies. Application of these technologies must include the entire system of systems and not just individual elements within the system. Recovery techniques and technologies are required to ensure continuous information operations. The ability to automatically perform near real time vulnerability assessment and subsequent modification of the information system is needed to address increases in both the number and sophistication of threats. Predictive analysis capabilities are needed to provide analysis of intrusion potential, which will provide the greatest amount of lead time to protect and contain information threats (e.g. Indications and Warning).

PHASE I: Define and propose the development of Defensive Information Warfare technologies and capabilities for use within existing and future information systems. Rudimentary proof of concept prototypes should be developed to demonstrate the ideas proposed.

PHASE II: Design, develop, and implement a prototype demonstrating the proposed concept or technology. This prototype should be consistent with the philosophy of the Air Force and focus primarily on COTS based information systems.

POTENTIAL COMMERCIAL MARKET:
Technologies developed should have the widest global applicability to both Air Force and commercial information systems. The Air Force is quickly adopting COTS as the primary information system medium and, therefore, commercialization of the non-military specific portion of the Defensive Information Warfare technologies or concepts should be highly desirable

AF97-068 TITLE: RF Photonics Technology

Category: Exploratory Development

OBJECTIVE: Develop innovative RF photonics technologies to enhance RF performance, availability, and affordability of C4I systems.

DESCRIPTION: Investigate and develop innovative technologies and techniques using RF photonics to improve and otherwise enhance the performance of electronic communications, command, and control systems. Develop new methods to apply RF photonics technology to systems performance resulting in improvements to existing systems and innovative approaches for new systems where RF photonics implementation will result in lower cost, higher performance, and/or lighter weight.

Fabrication of advanced RF optical and RF electro-optical components into subsystems with generalized compatibility with existing systems is encouraged. Specific areas of interest include, but are not limited to, the following:

OPTICAL RF INTERCONNECTS: High RF frequency, high power, low noise optical sources; high RF frequency, high optical power, low noise photodetectors; high frequency low V1 photonic modulators; and reconfigurable, integrated RF optical signal routing techniques. Frequency responses to be considered are broadband up to 100 Ghz minimum with minimum bandwidths of 20% in specific bands of interest.

OPTICAL RF BEAMFORMING: Photonically-based RF true time delay techniques for RF phased arrays and photonically implemented RF phased arrays operation up to 100 Ghz. Minimum requirements are 30% bandwidth.

OPTICAL RF SIGNAL PROCESSING: Direct RF antenna nulling using new innovative broadband - minimum of 4 Ghz RF bandwidth - techniques.

PHASE I: Conduct concept verification and experimentation justifying the technology need and proving the value of the planned approach. Develop a demonstration plan for Phase II.

PHASE II: Fabricate hardware that verifies the concepts by providing a demonstration of a well defined brassboard level subsystem.

POTENTIAL COMMERCIAL MARKET:
RF signal remoting for high frequency radio systems. Reconfigurable RF interconnects. Lossless RF routing systems. RF antenna nulling for frequency reuse.

REFERENCES:
Although a number of references exist, those that are relevant to this technology are not for unlimited distribution. Current and recent SBIR programs carry a four year restriction on release. Contact the POC for specific information on available limited distribution references

AF97-069 TITLE: Photonic Signal Processing

Category: Exploratory Development

OBJECTIVE: Develop innovative approaches to apply optoelectronics technology to Air Force C4I signal processing systems platforms.

DESCRIPTION: The performance limits of conventional approaches to air and ground surveillance are now being stressed by the emergence of low-observable threats, sophisticated electronic countermeasures, increased target densities, and the complexity of engagement of the modern battlefield. A number of multi-spectral sensor fusion techniques and electronic counter-counter measures have been widely identified as a means to increase surveillance capabilities against these threats. Processing requirements of many of these schemes, however, remain prohibitive, outpacing the rate of advance of conventional electronics. Estimated near-term processor requirements are in excess of two orders of magnitude beyond those of all-electronic contemporary surveillance platforms. Investigate and develop optical techniques that may offer potential solutions to this processing dilemma.

Investigate and develop innovative technologies and techniques using photonic and opto-electronics technology to improve and otherwise enhance the performance of electronic communications, command, and control systems. Develop new methods to apply photonics processing technology to systems resulting in performance improvements to existing systems and innovative approaches for new systems where a photonics based implementation will result in lower cost, enhanced capability, and/or lighter weight.

Fabrication for insertion of advanced photonics and electro-optical components into subsystems with generalized compatibility with existing systems is encouraged. Specific areas of interest include, but are not limited to, the following:

OPTICAL PROCESSING TECHNIQUES AND SYSTEMS: Application developments to include Bragg cell based processing, photorefractive devices, and other non-linear optical devices to implement processing algorithms without the necessity of optoelectronic conversion. Digital optical processing to include optical interconnects, architectures, algorithms, switching, and logic, non-linear optics aimed at low power systems which process totally in the optical domain with minimal or no electronic conversion.

INTEGRATED OPTICAL SUB-SYSTEMS: Methods for systems integration of high data rate sources/detectors/modulators for analog and/or digital operation, network optical processing for multi-gigabit per second transmission, integrated optoelectronic circuits (OEICs), and integrated optomicrowave circuits (OMICs) for future low cost reproducible implementation of advanced photonic systems.

PHASE I: Conduct concept verification and experimentation justifying the technology need and proving the value of the planned approach. Develop a demonstration plan for Phase II.

PHASE II: Fabricate hardware that verifies the concepts by providing a demonstration of a well defined brassboard level subsystem.

POTENTIAL COMMERCIAL MARKET:
Transferred to the civilian sector, this technology will be used to provide increased capability in FAA radar surveillance and safety, and in newly capable real-time imaging medical system applications at reduced overall cost. Rapid processing of multispectral signals also finds use in mass communications and entertainment systems.

REFERENCES:
Although a number of references exist, those that are relevant to this technology are not for unlimited distribution. Current and recent SBIR programs carry a four year restriction on release. Contact the POC for specific information on available limited distribution references.

AF97-070 TITLE: Space Systems Technology Development

Category: Basic Research

OBJECTIVE: Develop innovative methods for improving performance, endurance and survivability of future space and missile systems.

DESCRIPTION: Advanced Space Systems need a host of integrated technology developments in order to meet improved performance requirements. We are seeking innovative approaches and technology developments which will provide improved space system performance, endurance and survivability. The proposed approaches shall emphasize "dual use technologies" that clearly offer private sector as well as military applications. Some examples of dual-use technologies include High Definition Television (HDTV), advanced communications, Energy and Environmental Conservation, plus many more. Proposals emphasizing "Technology Transfer" will receive additional consideration. Specific areas of interest include the following:

Space Power Systems: Approaches to high specific energy and specific power at lower cost are needed. Specifically: long life, high energy density energy storage; advanced, high efficiency solar cell designs; light weight, low volume solar arrays; and power management and distribution electronics.

Thermal Management: Advanced spacecraft thermal control technologies in all temperature regimes are sought. Technologies for improvement include (but are not limited to): heat pipes, micromachined refrigerators and heat pumps, capillary pumped loops, integrated microelectronic cooling packages, thermal storage devices, deployable radiators, cryocoolers and cryogenic components.

Space Electronics: The following are sought: Innovative advanced processor, memories and digital logic components; advanced micro-electronics packaging; micro-electromechanical systems and instruments; optoelectronic, photonic and analog processing electronics, particularly those that lend themselves to operation in the space

environment. Candidate solutions must be radiation tolerant or leverage commercial processes to exploit radiation resistance.

Space Systems Software: Advanced concepts in expert system design, fuzzy systems, distributed expert systems, object oriented database, the integration of existing software (COTS and NDS) into an object-oriented environment, and user interfaces.

Sensors: Innovations in developing ultra-violet to very long wave infrared detectors, readouts, focal planes and sensors. Innovative approaches in active sensors concepts including LIDAR, RADAR and associated signal processing, signal conditioning, including related devices and subsystems are needed.

Space Structures: Innovative minimum weight structural concepts are needed that can withstand high-G space launch and ambient environment effects. Active and passive vibration suppression, control, advanced material applications, design and analysis methods are needed.

Astrodynamics: Innovative ideas are sought related to determination, prediction adjustment, and optimization of trajectories in space: space navigation and mission analysis; perturbation theories and expansions; and spacecraft attitude dynamics and estimation.

PHASE I: Further develop the concept and perform analyses required to establish the feasibility of the proposed approach.

PHASE II: Complete the Phase I design and develop a demonstrator or prototype. Document the R&D and develop a technology transition and/or insertion plan for future systems and commercial ventures.

POTENTIAL COMMERCIAL MARKET: Space systems for DoD and commercial use require advanced technology that is highly reliable, high performance, and is survivable to a variety of man-made and natural environments. These technologies have immediate and definite commercialization potential in consumer goods and infrastructure improvements such as highway safety, environmental monitoring, etc.

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AF97-071 TITLE: Attenuation of Acoustic Disturbances in Containerized Payload Systems for Reusable Launch Vehicle Systems

Category: Exploratory Development

OBJECTIVE: Develop a methodology for the design and implementation of acoustic attenuation technology into containerized payload systems for reusable launch vehicles.

DESCRIPTION: Current conceptual designs for reusable launch vehicles (RLVs) utilize container systems for the integration of payloads to the RLV. Payloads are integrated into standardized containers with standardized interfaces. These containers then allow for rapid integration into the RLV and result in much lower costs. However, like their expendable launch vehicle counterparts, these containers are subjected to acoustic and structure-borne disturbances which are in turn translated to the payload. Acoustic disturbances drive the high frequency design requirements for satellite systems, especially secondary structure such as solar arrays and antennae. If the containers could be designed to attenuate a portion of these acoustic disturbances, design requirements could be lowered, resulting in lower cost systems. Innovative concepts for the incorporation of acoustic attenuation technologies into the containerized payload systems for the RLV are sought. The government desires a performance improvement goal of 20 dB attenuation in the frequency band from 20-500 Hz. Passive blanket technology works well above 500 Hz (providing ~20 dB attenuation), but provides approximately 3 dB attenuation below 500 Hz. The Government desires to improve performance in this frequency band. Although not required, it is highly recommended that in some fashion the small business team with an RLV contractor. The small business must demonstrate an understanding of the actual technical challenge. Proposers must be cognizant of the fact that their proposed systems will eventually have mass, volume and power constraints. Interest in or acceptance of the technology by an RLV contractor is critical for demonstration of

commercialization. The Phillips Laboratory will not provide industry contacts with the RLV contractors. It is the small business' responsibility to develop the necessary relationships with potential industrial partners.

PHASE I: Thoroughly define the problem. This includes specification of the container system, the acoustic environment the container will be subjected to at launch, and any potential restrictions or limitations faced in implementation of an acoustic attenuation system. State system level performance goals. Develop system level and component level conceptual design. Analytical and simulation results will be presented to demonstrate performance of proposed system. Unique proposed hardware may be developed and tested at the brassboard level.

PHASE II: Design, analyze, fabricate and test a sub-scale demonstration system for evaluation.

POTENTIAL COMMERCIAL MARKET: Both DoD and NASA are interested in reusable launch vehicle technology for cost effective means of increasing the U.S. lead in space operations. Decreasing the acoustic disturbance loading satellite manufacturers must design to would give this launch vehicle technology a distinct advantage. This technology also has potential application in the aerospace industry to quiet passenger jet and turbo-prop planes, and noise reduction in commercial HVAC systems, automobiles, washing machines, etc.

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AF97-072 TITLE: Ultra-Lightweight "Meter" Class Optics

Category: Exploratory Development

OBJECTIVE: Develop graphite fiber composite-based, lightweight, meter class optics for use in infrared and visible band applications.

DESCRIPTION: Lightweight optics have been of interest for many years. In the past, they have taken the form of beryllium optics, lightweight glass optics, and, more recently, silicon carbide optics. In each case, collateral efforts included developing metering structures or optical benches that possess similar thermal properties to those of the optics in an attempt to "a thermalize" the optical assembly.

It is well known that from a pure thermal stability point of view, graphite fiber composites offer the optimum combination of minimum weight plus high thermal stability. Unfortunately, this material does not enjoy the same appeal when considered for an optic substrate because of the heterogeneous materials, presence of residual stresses and material variability. The proposal should center around large size stable optics that leverage off the use of composite materials.

PHASE I: Identify the main parameters that influence the performance of the optics. Determine the means to control those parameters so that their impact on the ultimate optical assembly is minimized. This will be done analytically and empirically, thus establishing the feasibility of building a stable, lightweight optic that performs in the IR band and possibly the visible band.

PHASE II: Design, analyze, and fabricate a meter size optic after thoroughly characterizing each critical parameter affecting this size optic.

POTENTIAL COMMERCIAL MARKET: There are many military, scientific, and commercial applications that would benefit from the application of graphite fiber, composite based, lightweight optics. Host platforms would include NASA and DoD aircraft, commercial remote sensing satellites and commercial aircraft for clear air turbulence detection sensors.

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AF97-073 TITLE: Rigid Inflatable Structures

Category: Exploratory Development

OBJECTIVE: Develop processes for rigidizing inflatable structures while maintaining dimensional tolerances and stability.

DESCRIPTION: Inflatable structures potentially allow the construction of very large but very light structures in space. Structures which bear little load but are required to have a specific shape can be constructed from a thin film and then inflated with a low pressure gas. This gas must be carried on-board, and the gas supply must be sufficient to compensate for losses due to membrane permeability, punctures from micrometeroids, gas volume changes due to temperature, etc. The need for replenishment gas can be eliminated if some means of rigidizing the structure is available.

Define, develop, design, build, and test a seamless and goreless inflatable integrated gossamer foam 9m X 7m off-axis parabolic concentrator for a Solar Orbital Transfer Vehicle. The system shall be of correct size and weight to fit in the payload bay of a Pegasus XL launch vehicle. The reflector must be rigidized: the dimensions of the structure must not change significantly during the rigidization process, or must change by a predictable amount, in order to ensure adequate functioning of the structure.

PHASE I: Review the results of the "Gossamer Baggie Torus" contract that ended during FY93. Also review the "Gossamer Structures Phase I and II," "Concentrator Technology," "Single Chamber Concentrator," and "Thin Film Creep-Formed Concentrator" Small Business Innovative Research technical reports. Review the "Gossamer Structures" technical report. Define the requirements. Perform trade studies and analyses on how to reflectorize the curved part of the structure. Evaluate the concepts and how they will integrate with the chosen concentrator concept.

Compare the performance of various rigidization technologies (design tools, rigidizing agents, catalysts, delivery mechanisms, etc.) to determine which method(s) offer the greatest potential for large-scale applications. The chosen method(s) must be demonstrated through the fabrication of a small-scale structure for a ground demonstration (e.g., a small parabolic reflector).

PHASE II: Determine how best to reflectorize (silver) the off-axis parabolic section of the gossamer structure. Build integrated sub-scale and full-scale gossamer concentrators. A system optics test shall be performed.

The measured data should demonstrate less than 2 mrad RMS slope accuracy error and 2mm RMS surface accuracy error after rigidization (using the system chosen in Phase I).

Extend the chosen system from Phase I to a larger structure, a seamless and goreless 9m x 7m off-axis parabolic concentrator. Ground testing should include a packing and deployment system representative of a flight system to ensure the robustness of the system to pre-launch handling.

POTENTIAL COMMERCIAL MARKET: The results of a successful Phase II approach would lead to reliable off-the-shelf structural components which are lighter than current components for use in a variety of commercial ground and space-based applications. In space, inflatable structures have potential uses as communication antennas, radar antennas for remote sensing, telescopes, solar collection for power or propulsion, or for non-load bearing structural parts. Ground-based uses in industry could include rapid prototyping of parts, use as improved packaging or insulating materials, use as a replacement for styrofoam, or use as a buffer between moving parts. Automotive uses such as bumpers or airbags for the outside of cars are also possible, as are a wide range of marine applications, including rapid construction of marine dry-docks, boat hulls, life rafts or lifesaving rings. Recreational uses include inflatable pools, sculptures or decorations, and form-fitting ski boots. Finally, disaster relief applications such rigidizable tents and patches for application to sidewalks or other light-duty structures following earthquakes would be feasible.

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AF97-074 TITLE: Advanced Isolation for Launch Vehicle Avionics

Category: Exploratory Development

OBJECTIVE: Develop an advanced vibration isolation system for launch vehicle avionics which is capable of transferring the required thermal load to the airframe.

DESCRIPTION: Current launch vehicle avionics are hardmounted to the vehicle airframe primarily due to thermal management issues. The avionics generate a great deal of heat, and the airframe forms the heat sink necessary to keep the avionics from overheating. As a result, these avionics must be designed and test to very high vibration specifications. This drastically increases the life-cycle cost of such items. If a thermally-conductive vibration isolation system could be developed specifically addressing the unique requirements of the launch environment, potentially lower cost aircraft avionics could be used. Such a system would allow the launch vehicle industry to take advantage of COTS technology, thereby greatly reducing procurement and testing costs. Innovative vibration isolation concepts for launch vehicle avionics are sought. The government desires a performance improvement goal of 20 dB attenuation in the frequency band from 10-500 Hz. Although not required, it is highly recommended that the small business team with a launch vehicle contractor in some fashion. The small business must demonstrate an understanding of the actual technical challenge. Proposers must be cognizant of the fact that their proposed systems will eventually have mass, volume and power constraints. Interest in or acceptance of the technology by a launch vehicle contractor is critical for demonstration of commercialization. The Phillips Laboratory will not provide industry contacts with the LV or avionics contractors. It is the small business' responsibility to develop the necessary relationships with potential industrial partners.

PHASE I: Thoroughly define the problem. This includes specification of the launch environment to be attenuated, any potential restrictions or limitations faced in implementation of the isolation system and all thermal conductivity issues. State system level performance goals. Develop system level and component level conceptual design. Analytical and simulation results will be presented to demonstrate performance of proposed system. Unique proposed hardware may be developed and tested at the brassboard level.

PHASE II: Design, analyze, fabricate and test a full-scale demonstration system for evaluation.

POTENTIAL COMMERCIAL MARKET: DoD, NASA and commercial launch vehicle manufacturers are interested in decreasing vibration loads on avionics. Decreasing the vibration disturbances which avionics manufacturers must design to would give U.S. launch vehicle technology a distinct advantage. This technology also has potential application in the aerospace and industrial machining industries to protect sensitive equipment from operational disturbances.

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AF97-075 TITLE: Microelectromechanical Systems (MEMS) Microrelays and Microswitches for Space

Category: Exploratory Development

OBJECTIVE: Develop, design, fabricate, and characterize various types of MEMS microrelays and microswitches for future use in space systems.

DESCRIPTION: For the same reasons that macrorelays flourish today, it is necessary to consider microrelays and microswitches as an important aspiring class of MEMS device. While many research groups have built prototype microrelay devices, they all remain impractical novelties due to problems ranging from ineffective actuation, series loss, and degradation of contact resistance. The problems of dry contacts in macroelectromechanical relays and switching devices are well understood, yet seemingly little has been done to improve the understanding of present and prospective instantiations of MEMS-based versions.

We seek novel and practical solutions to the development and insertion of microrelay and microswitch devices for space-based digital, analog, radio-frequency (RF), and power electronics applications. As such, we expect offerors to present approaches in their proposals that present extremely low series loss, low contact resistance, high isolation, and very high reliability. It is expected that many dozens or even hundreds of such relays should be able to be constructed within the size of a normal integrated circuit (IC). For RF applications, offerors should address the frequency-dependent performance potential of the devices, discussing any issues that affect their transmission line or full wave behavior (e.g., dispersion, reflection, etc.). For digital applications, moderately low loss and coupling are desired, with high density being of greatest importance. For power applications, series loss is of most direct importance. Finally, for analog (e.g. instrumentation/sensor) applications, signal fidelity and isolation are of the greatest importance. Of course, the space environment must be considered. Various radiation effects (such as total ionizing dose) and temperature range are of great concern here. For example, these switches might be immersed in a cryogenic environment for infrared imaging sensors. Another area of concern is the need for hermeticity or the ability to operate in non-hermetic conditions. If exposed microrelays/switches are indicated, offerors need to consider spacecraft charging/atomic oxygen/contamination issues. Of course, disadvantages in one sense become advantages in other cases. To expand the range of possibilities, we would welcome creative exploitation of the weaknesses of microrelays. For example, exposed micro-relays could be used to monitor degradation of contacts in a meaningful way, so as to glean useful information (perhaps) regarding its operating environment.

PHASE I: Efforts should define and validate models of prospective microswitching devices. It may be within the realm of reason to attempt to construct a prototype through a supported foundry such as MCNC.

PHASE II: Efforts would need to address more demonstrably the performance and long term reliability of practical devices in space environments. It is minimally expected that the contractor develop and deliver fully functional arrays of devices which should be packaged and demonstrated to perform reliably in the space environment.

POTENTIAL COMMERCIAL MARKET: Since micro-relays have a latent potential for interesting commercial applications, we expect serious consideration of commercialization (as well as space) opportunities for these devices.

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AF97-076 TITLE: Substrate Improvement for LWIR Mercury Cadmium Telluride

Category: Exploratory Development

OBJECTIVE: Develop innovative process and screening techniques for fabrication of large, high-quality substrates for mercury cadmium telluride-based focal plane arrays.

DESCRIPTION: The development of large format, long wavelength (12-micron cutoff and longer), mercury cadmium telluride-based focal plane array technology for low-background applications is seriously impeded by the limited size, purity, and crystalline perfection of currently available substrates. High performance, under the above conditions, requires lattice-matched substrates with low defect densities (less than 5 X 10E5 defects per sq. cm) and very low impurity concentrations (less than 10E14 impurities per cu cm). Currently available substrates are of limited size (typically on the order of 15 to 24 sq. cm), which severely limits the number of large format arrays which can potentially be formed on these substrates. In addition, while substrates can be screened reasonably for flatness and crystal quality (including defect density), too often the substrates are found to be the source of fatal contamination after considerable expense and effort of growth, fabrication, and testing of detector array lots. The development of LWIR array technology for low background applications would be facilitated greatly by the ready availability of large, lattice-matched, high-purity substrates. The Air Force is seeking innovations which would make available the high-quality substrates as described above to all MCT developers. In addition to addressing the above needs, it is very important that any approach include: 1) the development of cost-effective detection and screening techniques to identify material contamination at very low levels from receipt of source material through the entire substrate fabrication process, and 2) process improvements to ensure the purity of the final delivered substrates.

PHASE I: Develop preliminary processing and material screening steps to select most promising implementations. Some processing improvement and material/substrate screening demonstrations are desirable.

PHASE II: The contractor shall set up and demonstrate fabrication and screening of high-quality substrates for strategic MCT applications. The contractor shall deliver four substrates to the government for independent evaluation and shall develop plans for process/screening insertion into commercial substrate fabrication production lines.

POTENTIAL COMMERCIAL MARKET: The processes/screening techniques developed will support all long wavelength infrared focal-plane array imaging based on mercury cadmium telluride detector array technology. Commercial uses of this technology include remote detection, identification, and tracking of airborne pollutants emanating from industrial plants, and space-based earth and atmospheric condition imaging for environmental monitoring and natural resource assessment and management. The latter applications are now a multi-billion dollar industry worldwide which requires many high-performance arrays. Current capabilities are limited by array cooling requirements and performance capability. The results of this SBIR effort would enable much greater capability and flexibility by making available larger, higher performance arrays which would directly translate into reduced satellite power and array cooling requirements and broader spectral and spatial coverage for each array. The latter would be accomplished with greater detail than presently available, significantly enhancing the value of the products currently being marketed.

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AF97-077 TITLE: Anomaly Resolution Using Case-Based and/or Model-Based Reasoning

Category: Exploratory Development

OBJECTIVE: Develop methods to demonstrate how model-based and/or case-based reasoning systems can be used to assist a satellite operator in identifying unknown anomalies.

DESCRIPTION: Air Force satellite operators require an accurate and timely method for satellite unknown anomaly determination and resolution. Expert systems provide good tools for known satellite anomalies when knowledge is available. For unknown anomalies, a system must reason based on how the system works (model-based reasoning) and/or on the history of the system (case-based reasoning). Input to the reasoning system is satellite real-time health and status data captured from monitoring satellite telemetry and models of the spacecraft systems. The output is anomaly determination and resolution assistance presented to the satellite operator. What form this assistance takes must be determined, but may include recommendations, schematics, simulations, history, etc.

Computation must be timely to meet real-time requirements of satellite operations. Case-based reasoning potentially speeds anomaly resolution by recalling solutions to similar problems seen in previous experience. The utility of a case-based reasoning system is greatly enhanced if machine learning techniques are used to capture pertinent characteristics of the current problem and its eventual solution. Otherwise, if no learning capability exists, a case base must be derived from some other source.

Model-based reasoning is advantageous for solving unknown anomalies because component models can identify non-working components despite the failure mode. A significant problem in implementing a model-based diagnosis system is finding appropriate models; a significant opportunity for solving this problem is to capture design information (e.g., CAD schematics in popular file formats) and use it to generate models automatically. Identifying the correct level of abstraction for the model is also an important challenge and can impact the real-time performance, certainly a consideration for telemetry anomaly resolution in real-time.

Consideration should be give to the accuracy of the reasoning system developed. Verification is difficult for complex software, but some metrics of goodness will be necessary before widespread acceptance of the technology can be expected.

PHASE I: Address whether model-based and/or case-based reasoning or some combination is best suited for unknown anomaly resolution, how it should be implemented into a satellite control system, and how accuracy is verified. The government will provide telemetry stream parameters necessary to conduct analysis. Develop a demonstration prototype using a subset of a satellite subsystem. Identify verification metrics and the results of testing the prototype.

PHASE II: Provide a prototype demonstration of an entire satellite onboard subsystem. Identify methods of extending this enhanced prototype to other satellites or other domains. Report any additional verification metrics or methods developed and test results obtained during development.

POTENTIAL COMMERCIAL MARKET: Potential application for this technology includes DoD, NASA, and commercial satellite ground stations. Other applications include process control such as automobile manufacturing, nuclear power, and robotics. Anomaly identification and resolution in satellite telemetry (at least) require a sizable portion of available resources; automated methods for anomaly identification potentially reduce the resources required and hence the cost of those resources.

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AF97-078 TITLE: Cryogenic Coolers for Space Applications

Category: Exploratory Development

OBJECTIVE: Develop cryogenic cooling, and/or associated technology improvements.

DESCRIPTION: The evolution of cryogenic cooling requirements necessitates reduced size, weight, input power and induced vibration, longer life and increased reliability and increasing net cooling load for these devices. Improvements in cryocooler design, efficiency and reliability for the temperature regime of 10 to 150K are desired. Of special interest are concepts which show potential to provide cooling in the temperature range of 10 to 65 K as well as cooling capacities in the range of 0.3 to 5 W. The cryocoolers rejected heat should be removed in the temperature range of 275-325 K. If reduced induced vibration is a specific improvement area, it can be reduced by either inherent design features or external vibration reduction methods. Proposers may submit new concepts for improvements in basic cryogenic cooler designs, associated component level improvements, increased reliability and maintainability, or other significant technologies which promote cryogenic cooling for the Air Force and private sector use.

PHASE I: In Phase I of this SBIR the contractor shall develop initial designs and associated analysis to select the most promising approach. Preliminary demonstration of the chosen design is preferred but not required.

PHASE II: In Phase II of this SBIR the contractor shall further develop and demonstrate the preferred Phase I approach. Develop a plan for insertion of the Phase II demonstrated design into applicable Air Force and commercial systems.

POTENTIAL COMMERCIAL MARKET: Cryogenic cooler designs benefiting from improvements under this topic will be extremely useful for commercial applications. The cryogenic cooling potential applications include, but are not limited to, communications, commercial satellites, computer and data systems, power applications, and medical instrumentation. Cryogenic cooling applications for communications include cooled or superconducting electronics for improved Signal-to-Noise ratio, efficiency and reliability. Commercial satellite applications can range from optics/sensor improvements similar to Air Force uses, to increased thermal management utilization. Computer and power applications benefits are similar to the communication applications described, with increased performance associated with higher speed cryogenic electronics and increased cost savings associated with improved efficiency and reliability. Medical uses of cryogenic cooling are widespread today (MRI, cryo-surgery), but use bulky and costly stored cryogenic fluids which could be replaced by cryogenic refrigerators. Commercial applications also include replacement for current terrestrial refrigeration systems which require CFC's.

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AF97-079 TITLE: High Performance Quantum-Well/Superlattice Infrared Detector Development

Category: Exploratory Development

OBJECTIVE: Develop multiquantum-well/superlattice infrared detectors that have high optical responsivity and low dark current.

DESCRIPTION: Multiquantum-well and superlattice infrared detectors are very promising for space surveillance and imaging applications because of their adjustable band gaps and device structures. The most mature of the many different material systems being developed is the GaAs/A1GaAs system. The devices made of this material system have outstanding radiation hardness and uniformity; however, they suffer from their inability to absorb normally incident light. The currently pursued approaches of incorporating beveled edges and gratings to overcome this problem

yield low optical responsivities while increasing the processing complexity and crosstalk. Another problem with these detectors is that the measured dark currents are significantly larger than the theoretical predictions. Hence, there is a strong need for new, innovative approaches for improving the optical responsivity and to reduce the dark current in these detectors.

PHASE I: Identify and systematically investigate one or more innovative approaches for improving the optical performance of multiquantum-well/superlattice infrared detectors and/or reducing the dark current, and demonstrate the concepts.

PHASE II: Develop prototype multiquantum-well/superlattice infrared detectors with increased optical performance and reduced dark current based on the findings of Phase I, and characterize them. Develop a plan for technology transition and commercialization.

POTENTIAL COMMERCIAL MARKET: Because of their adjustable band gap, multiquantum-well/superlattice detectors could be designed to detect very long wavelength radiation for astronomy applications. High-performance multiquantum-well/superlattice devices could be used for semiconductor lasers, optical signal processing, nonlinear optics, and a variety of optoelectronic applications. Hence, it is anticipated that the results of this technology effort will benefit not only DoD, but also NASA and the optoelectronic industry in both the public and private sectors.

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AF97-080 TITLE: Intelligent Solid State Switching

Category: Exploratory Development

OBJECTIVE: Develop an intelligent solid state switching device as an alternative to mechanical relays and fuses.

DESCRIPTION: Mechanical magnetic latching relays that are efficient and radiation-hardened have been used for decades in aerospace applications. These relays are large and heavy, do not provide for in-rush current limiting functions and/or circuit breaker functions, and have a limited lifetime at overrated switching currents. Recent advances in power electronics and microcontrollers have made it practical to design solid state relays which have the efficiency and simplicity of actuation of mechanical relays along with in-rush and short circuit current limiting capabilities. Intelligent solid state switching can provide significant weight reduction and improved performance in the area of telemetry and fault management. These switches can provide an alternative to fuses, relays, and current sensors which are historically costly and unreliable.

PHASE I: Through cooperation with the Air Force, analyze existing spacecraft relay, fusing and current sensing designs used in telemetry and for circuit breaker functions. Based upon this analysis, design the architecture for an intelligent solid state equivalent with built-in testability. Provide demonstrated proof that solid state based technology devices can reliably replace the mechanical counterparts presently used in space.

PHASE II: The Phase I concept will be fabricated as a prototype system and tested to validate that requirements are met. Testing will include environmental exposures and operational constraints. From this, performance and requirement specifications shall be developed.

POTENTIAL COMMERCIAL MARKET: The intelligent solid state relay concept is applicable to all markets that presently use relays and circuit breakers. This would include, but is not limited to, commercial and residential buildings, certain appliances and machinery.

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AF97-081 TITLE: Momentum Wheel Energy Storage

Category: Exploratory Development

OBJECTIVE: Develop novel momentum wheel energy storage, possibly combined with spacecraft stability control designs and components.

DESCRIPTION: The power system size and payload capability of a satellite increasingly will be limited by the specific energy density of chemical batteries. Concepts combining energy storage with spacecraft momentum wheel stability are being solicited for development. The system concept shall be defined and technical risks identified and a program developed to solve each technological uncertainty. The device shall be capable of storage of a minimum 50kw/hr of energy, be compatible within spacecraft bus, and possess life capability of >30,000 cycles.

PHASE I: Identify approaches, procedures, tests/analyses and establish a conceptual design. Plans, cost, and schedule shall be accomplished. Critical experiments and analysis shall be performed to insure the success of Phase II.

PHASE II: Finalize design/produce an operational prototype unit. Provide demonstration to Air Force requirements.

POTENTIAL COMMERCIAL MARKET: The results of a successful Phase II development would lead to energy storage devices combined with altitude control momentum wheels which could be used in both military and commercial satellite buses.

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AF97-082 TITLE: Electromagnetic Effects, Measurements, Protection, Sources, and Satellite Protection

Category: Basic Research

OBJECTIVE: Develop high power electromagnetic or Radio Frequency (RF) sources, measurement techniques, protection, and new methods for addressing threat phenomena to satellites.

DESCRIPTION: The Phillips Laboratory is in need of new and innovative approaches in the development and demonstration of compact, lightweight RF sources for both weapons and commercial applications. The technology sought should address sources capable of delivering gigawatt levels of power in microsecond or shorter pulses. Both

narrow and wide band sources are of interest. The technologies that may be addressed in this effort include pulsed power, high power microwave tubes, transmission lines, mode converters, and antennas. Also of interest are methods and techniques for measuring the performance of these components, the effects that such environments will have on electronic systems, and methods of protecting systems from electromagnetic environments over a wide range of frequencies and field levels. Protection against electromagnetic effects is becoming critical with the increased use of electronics, lower power semiconductors with reduced noise immunity thresholds, reduced shielding through increased use of plastics and composite materials, and increased RF emissions from commercial and military radiators. The increased use of Commercial-Off-The-Shelf (COTS) equipment in military systems will also require improved protection approaches to effectively use COTS without major redesign and expense. Application of electromagnetic technologies for other areas such as security systems, law enforcement, medicine, and information systems are also of interest. In addition to the application of electromagnetic protection to satellites, additional protection is needed for other threat environments such as radiation, thruster firings, space debris, orbit dependent chemical reactions with naturally occurring species, and solar or laser radiation. Many of these environments are natural or occur during normal operations, but others may be threats faced by satellites during a wartime situation. Reliance on commercial satellites for future military functions is likely to increase, and reliable, survivable satellites are a must for both peacetime and possible wartime conditions. Additional technologies of interest include high energy plasma production, measurement, and applications.

PHASE I: Feasibility experiments and demonstrations will be conducted. A proposed schedule for implementing the proposed approach, specific commercial applications, and possible market partners will be included in the final report. Commercial partners committed to Phase II support are desired.

PHASE II: Develop and implement the Phase I approach or preliminary design, producing a prototype model, device, and/or process which must be demonstrated to be effective either at full operation or scaled to laboratory bench parameters. Prototypes developed during Phase II will be delivered to the PL in operating order with sufficient documentation to allow for validation testing. Identification and commitment of commercial partners (if not accomplished Phase I) shall be pursued. A viable private sector marketing approach must be developed and implemented.

POTENTIAL COMMERCIAL MARKET: Many of the necessary technologies required for military weapons systems have similar commercial applications. High power sources and antennas can be used to locate and identify buried unexploded ordinance needed in base clean up efforts. Other technologies associated with ultra wide band sources can be used to improve airport and other security systems operating at lower power levels commensurate with personnel safety. Protection of future electronic systems is a must in a society with ever increasing dependency on reliable operation of automobiles with airbags, anti-skid brakes, electronic transmissions and steering, and engine control. Fly-by-wire aircraft, information highway systems, and home appliances are among other systems critically dependent on reliable operation of electronic subsystems. Increased use and dependency on satellites for everything from communications, global positioning systems for both military and commercial aircraft, weather information, and many other applications, combined with the high cost and difficulty of repair require that these systems be designed to protect them from threat environments both during normal operation and in case of wartime to protect our interests in the world of the future.

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AF97-083 TITLE: Elimination of Pulse Shortening in High Power Microwave Tubes

Category: Exploratory Development

OBJECTIVE: Develop and deliver a long pulse high power microwave tube that delivers a pulse that generates power of 1 GW or more that has more than 2 kilojoules of energy in a pulse more than 1 microsecond long.

DESCRIPTION: Advances in narrow band high power microwave (HPM) tubes has made possible the generation of intense pulses of RF energy with power in excess of 1 GW. However, the experience is that for a number of tubes that can operate at this power level (e.g. klystrons, MILOs), as the power of the tube is increased above 100 MW, the pulse becomes shortened, limiting the energy in the pulse to the order of 100 J. The goal of this SBIR project is to demonstrate that the processes that limit tube performance to short pulses at high power can be understood and controlled. The contractor shall study the mechanisms that lead to pulse shortening in a high power microwave tube and explore and develop means of overcoming the cause(s) of pulse shortening. The contractor shall design, build, and demonstrate the performance of the tube at the contractors plant, and deliver the tube to the Phillips Laboratory along with operating instructions and reports.

PHASE I: The contractor shall experimentally and if desired analytically investigate the causes of pulse shortening in a narrow band HPM tube. The contractor shall investigate potential methods for overcoming the phenomena causing pulse shortening and identify those that are effective in lengthening the pulses at high power. The contractor shall provide quarterly and final technical reports in contractor format with view graphs.

PHASE II: The contractor shall continue the effort begun in Phase I to develop a tube that incorporates the mitigation methods developed in Phase I and may continue to explore additional means with a view to being able to build the needed improvements into a tube that meets the requirements above with appropriate pulsed power to drive it. The effort will support the design of the long pulse HPM tube. The contractor shall build, test, demonstrate, and deliver a tube, and the pulser to drive it, at the end of Phase II to the Phillips Laboratory. The contractor shall provide quarterly and final technical reports in contractor format with viewgraphs to document progress. The tube design shall be incorporated into one of the quarterly reports, and the as-built drawings of the tube, appropriate operating instructions, and a parts list with recommended spares shall be included with the final report.

POTENTIAL COMMERCIAL MARKET: A successful Phase II effort can be expected to make it possible to build particle accelerators with a factor of ten fewer stages, cavities, and accelerator tubes. This will significantly impact synchrotrons for use in the semiconductor industry and nuclear research. Large $20M storage rings 20m in diameter could be replaced by linacs 2-3 m in length with savings of up to 90% in capital costs. In like fashion, linacs for X-rays could replace radioactive 60Co sources for food processing and eliminate the associated NRC licenses, regulating, operating, and capital costs. Similar machines could be competitive in sterilizing waste streams, such as treatment of waste from hospitals. The successful development of such tubes will also make markets in the use of linacs for making deep welds at high repetition rates and for radiology for inspecting deep welds in heavy industries including shipbuilding. US microwave tube manufacturers could capture a substantial increased share of the world market for high power tubes and spin off industrial applications.

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AF97-084 TITLE: Automated Vehicle Identification

Category: Exploratory Development

OBJECTIVE: Develop a system capable of identifying moving vehicles using electromagnetic radiation techniques.

DESCRIPTION: There is an increasing need to provide an automated system capable of identifying passing vehicles for law enforcement, base entry monitoring, and other security applications. Manual methods of reading license plates and other vehicle identification stickers can be both time consuming and labor intensive. They are also prone to errors and don't allow for unattended operation. A new approach based on electromagnetic technology is desired to provide this type of capability. Its ability to operate in varying weather and lighting conditions would provide advantages over optical methods. Characteristics of such a system should consider the use of some type of special license plate that can be attached to vehicles that would respond when illuminated by an electromagnetic field. The response would be in the form of a radiated electromagnetic field containing vehicle identification information. The license plate should be easily produced, low cost, and perform reliably. A passive (un-powered) license plate which has the capability to receive sufficient energy from the radiated interrogating field necessary to radiate the vehicle information in form of an electromagnetic field is preferred. Technical concerns include signal-to-noise-ratio limitations, radiated field levels, possible interference with other electronic systems and receivers, and directionality of the interrogating radiated electromagnetic fields. The coded response signal received from the vehicle should be capable of being decoded and transformed into digital computer format for automated storage and processing.

PHASE I: The contractor shall investigate various approaches during Phase I, and through modeling, analysis, and other means determine the feasibility of such a concept. The results of the Phase I effort should clearly demonstrate not only the feasibility, but establish a defined approach for a Phase II effort. Commercialization and dual-use applications should be developed and potential partners identified.

PHASE II: The contractor shall develop and demonstrate a prototype system capable of identifying moving vehicles under realistic highway and local traffic conditions. The system shall be capable of operating within applicable regulatory constraints, be cost effective, reliable, and produce a coded response signal output compatible with standard digital computers.

POTENTIAL COMMERCIAL MARKET: This technology will directly benefit civilian law enforcement needs for traffic surveillance and will support military needs to monitor base entry points and other security areas, thereby reducing labor requirements. Law enforcement agencies have identified this type of a capability as one of their needs.

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AF97-085 TITLE: Wideband Sources, Antennas and Mode Converters

Category: Exploratory Development

OBJECTIVE: Develop new concepts and enhanced capabilities in Very High Power Wideband and Ultrawide Band Transient electromagnetic energy production and propagation.

DESCRIPTION: Wideband and ultra-wideband (UWB) sources and emitters are of interest for a variety of potential applications that range from radar transmitters to jammers and communications systems. This technology is of current interest to the USAF Phillips Laboratory where research efforts have been underway for a number of years. Fast transient waveforms with high power and broad spectral content are of primary interest. Risetimes of interest are in the range of one nanosecond to 10s of picoseconds, and pulse widths as short as a few hundred picoseconds are desired.

Energy may be delivered from a high power wideband source on either a parallel plate or coaxial transmission line. In order to be useful, the energy must be transferred to an antenna to be radiated. This generally requires a mode convertor, especially in the case of coaxial sources. Extraction of energy from a coaxial source can be particularly tricky, especially at high voltages and short pulse times. The ability to extract and radiate high voltage energy with

very short rise times of 10's to 100's of picoseconds is an area of technology which is only just beginning to be explored. Innovative ideas for the generation, extraction, mode conversion, radiation and focusing of these wideband and ultrawide band signals are solicited.

PHASE I: The goal of this effort is to select promising applications for utilizing Phillips Laboratory's electromagnetic technology. Basic feasibility of the proposed applications will be investigated to determine the specific approaches, identify critical development requirements, potential risks, and provide a basis for determining the potential success of a Phase II effort.

PHASE II: Develop and fabricate a prototype system, conduct laboratory and other tests which will demonstrate a capability with clear commercial potential. Develop commercial partnership interests for a Phase III production and marketing program.

POTENTIAL COMMERCIAL MARKET: The civilian sector has similar requirements for locating buried objects such as pipes or underground cables and to perform inspections on concrete structures such as bridges or building foundations. Potential uses also include locating and identifying objects such as unexploded ordnance or other objects such as buried or hidden guns from a crime scene.

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AF97-086 TITLE: Electromagnetic Integration of Commercial-Off-The-Shelf (COTS) Equipment Into Military Systems

Category: Exploratory Development

OBJECTIVE: Develop methods that will allow electromagnetic integration of Commercial-Off-The-Shelf (COTS) equipment into existing and/or new military systems with the minimum of redesign and costs.

DESCRIPTION: Recent changes in DoD policies and goals have stressed the need to use COTS equipment in military systems to reduce costs and spin-on new technologies. To insure that these goals are met with minimum difficulties and costs, standard methods are needed to allow the integration of COTS equipment into military systems which are often required to operate in much more demanding electromagnetic environments than are normally seen in the commercial sector. With the advent of directed energy weapons such as High Power Microwave (HPM) and Ultra Wide Band (UWB), the potential operating environments can be significantly higher than the standard military communications, radar, and other high density electromagnetic conditions. Reduced budgets will place a greater emphasis on the need to retrofit existing weapons system platforms to improve performance while retaining operability and containing costs. Methods that will improve the electromagnetic protection of COTS equipment without the need for major redesign of either the COTS equipment or the weapons system are needed. Approaches that will identify specific retrofit protection requirements with easily modified standard electromagnetic protection methods that are both cost effective and easily maintained throughout the operational life of existing weapon systems are needed. Other approaches are also needed to effectively deal with the use of COTS in new system designs.

PHASE I: The contractor shall identify specific areas and concepts for implementing electromagnetic integration of COTS equipment into existing and new weapons systems. The first phase effort will scope the problem into a specific approach that can be expected to produce definitive results during Phase II.

PHASE II: The contractor shall pursue the concepts and approaches defined during the Phase I effort to demonstrate the adequacy of the methods to be used for electromagnetic integration of COTS equipment into a weapons systems. A specific military system incorporating COTS equipment shall be selected to demonstrate the effectiveness of the electromagnetic integration methods.

POTENTIAL COMMERCIAL MARKET: The ability to effectively use COTS equipment in military systems operating in hazardous electromagnetic environments has great commercialization potential and by definition is dual use.

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AF97-088 TITLE: Advanced Rocket Propulsion Technologies

Category: Basic Research

OBJECTIVE: Develop innovative components, manufacturing and processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities.

DESCRIPTION: There is a critical need for novel, innovative approaches in the development of technologies which can double existing rocket propulsion capabilities by the year 2010, and for bold, new, non-conventional aerospace propulsion-related technologies which will revolutionize aerospace propulsion in that century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either retaining or decreasing life-cycle costs. Specifically, technological goals include: 1) the

80% reduction of environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency; 2) increasing the payload capability of existing launch and upper stage propulsion systems by 7%; 3) a 50% decrease in the cost and time of manufacturing of solid rocket motors; 4) increasing the service life of cryogenic liquid rocket engines between overhauls from 3 to 100 flights; 5) reducing the number of parts for a cryogenic turbopump by 80%; 6) integrating high energy density matter into future rocket propulsion systems; and 7) advancing rocket propulsion capabilities through concerted government- and industry-based advances in Integrated High Pay-off Rocket Propulsion Technology (IHPRPT) efforts. Improvements in the operability, reliability, maintainability, and affordability of space launch applications, for example, might include development of novel systems which can be launched with short lead times for relatively low life-cycle costs. Such systems would need to demonstrate high reliability and maintainability levels. Subsets of advanced rocket technologies would have lengthy shredouts of potential research subjects, but are not stated here in detail. These technologies might include the need for combustion and plume diagnostics (i.e., application of electro-optical devices and sensors), performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination. Furthermore, bold, new, advanced propulsion and related technological concepts and products for space activities are solicited for development. These topics include revolutionary concepts in very advanced fuels and oxidizers, metastable high energy nuclear states, revolutionary energy devices, storage of antimatter in chemical matrices, nanotechnology products and techniques, and field propulsion thrusters. Research in these advanced rocket propulsion topics is included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technologies to prospective investigators.

PHASE I: The initial research in the effort will assess existing capabilities and demonstrate, through bench scale evaluation of the proposed new approach, the payoff to be derived by implementing the concept.

PHASE II: Phase II will demonstrate selected advanced rocket technological concepts beyond bench scale and conduct verification testing of those concepts.

POTENTIAL COMMERCIAL MARKET: Advanced rocket propulsion technologies will transition to the US commercial space launch industry, thus enabling the US industry to more favorably compete with foreign sources for space launch opportunities through reducing the life-cycle cost of inserting payloads to space orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability in remanufacture and maintenance of the US ballistic missile fleet.

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AF97-089 TITLE: Molded Polymeric Components for Combustion Systems and Extreme Temperature Applications

Category: Exploratory Development

OBJECTIVE: Design and fabricate components for the extreme temperature and pressure environments of advanced combustion and propulsion systems.

DESCRIPTION: The Propulsion Directorate of Phillips Laboratory is committed to infusing new materials technology into the very conservative rocket propulsion industry. The Polymeric Components group is striving to develop new preceramic polymers and polymer co-processing techniques that will allow components of all types to be manufactured more effectively and with less human labor. Polymeric materials have the highest probability of success in the low temperature regions of a combustion system, but it may also be possible to use high-performance polymers as lightweight substructures for combustion devices. New and innovative solutions are sought for the obvious technical challenges in manufacturing polymer-based components for the extremely high-temperature, cryo-temperature, and high-pressure environments present in advanced combustion and propulsion systems. Any combustion system successfully exploiting advanced plastics technology will be lighter, tougher, more corrosion resistant, and easier to

manufacture than conventional systems. These characteristics are highly desired in rocket propulsion systems which must be lightened and strengthened without loss of performance if the DoD is to reach the tactical and spacelift propulsion goals set forth by the Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) initiative.

PHASE I: Develop polymer-based materials (or materials combinations) and manufacturing suitable for extremely high- or extremely low-temperature applications. Show ability to manufacture components with the chosen materials.

PHASE II: Design and fabricate a liquid rocket engine component using the polymer materials and processing techniques outlined above. The component must be suitable for testing at Phillips Laboratory, Edwards AFB.

POTENTIAL COMMERCIAL MARKET: Mastering polymer processing and coprocessing for such hostile environments as those encountered in advanced combustion systems will open the way for applying high-performance plastics into any application where high-temperatures and pressures are a problem. Automobile and aircraft propulsion systems will benefit from the exploitation of this technology. Polymers are much easier to process than most materials and allow labor-intensive manufacturing processes to be automated. The advances in plastics processing achieved in this program will also increase the use of plastics in other high-temperature applications. Some potential applications: flame retardant materials and coatings, lightweight automobile structural parts, high-performance thermal insulation, and lightweight construction materials.

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AF97-090 TITLE: Innovative, Remote, Laser-Based Diagnostic Techniques for High-Pressure Combustion Applications

Category: Exploratory Development

OBJECTIVE: Develop unique and innovative diagnostic instrumentation to measure concentrations, temperatures, densities, and velocities in high-pressure combustion devices for defense and commercial applications.

DESCRIPTION: Innovative laser-based optical diagnostic methods are sought for application in high-pressure, multiphase combustion devices which provide reliable, accurate quantitative measurement of significant thermodynamic, chemical, and flow parameters. Future Air Force and Civilian propulsion systems will operate in high pressure combustion regimes for which there are almost no available diagnostic methods that are reliable and quantitative. Over the last 20 years, a broad spectrum of laser-based optical diagnostic techniques have been developed for remote, non-intrusive measurements in extremely harsh combustion environments, such as gas turbine engines, internal combustion engines, rockets and shock tubes. These proven methods can measure species concentrations, temperature, density, and flow velocity, in many cases acquiring a two-dimensional visualization. Unfortunately, these methods are semi-quantitative or qualitative at high-pressures. But it is precisely this pressure regime that is of critical importance to several strategic technology areas, both military and commercial. Pertinent examples are rocket propulsion, advanced gas turbine technology, internal combustion engines (gasoline and diesel) and supercritical chemical extraction and processing. Many devices would improve performance if operated at higher pressure, therefore, it is imperative that new technology be found to interrogate this difficult, nearly inaccessible regime.

The Phillips Laboratory is seeking new and unique diagnostic methods, or innovative application of existing methods such as (but not limited to) the following: emission spectroscopy, line-of-sight absorption, Raman (line-imaged and 2-D), Rayleigh-Brillouin, LIF and PLIF, CARS, Degenerate Four Wave Mixing and other laser-induced transient grating effects, and picosecond pulse methods. Other nonlinear spectroscopic and optical methods may be considered also. In appraising potential methods, particular attention to the exceptional problems unique to high pressure diagnostics, such as beam-steering and scattering, spectroscopic line-broadening and band collapse (encountered in Q-branch Raman and CARS), are considered. High sensitivity is not an overriding issue, rather, accurate measurement of major species, temperature, and density are paramount. An effort must be shown to reduce the size/weight/power demand/cost of the diagnostic instrumentation with the ultimate aim of onboard installation of the diagnostic on the combustion device. Similarly, consideration must be given to operation of the diagnostic under conditions of multiphase combustion and/or flow. Such multiphase considerations are necessary of liquid rocket engines and supercritical chemical processing.

PHASE I: Develop and demonstrate the potential of diagnostic methods for measurement of species concentrations, temperature and density of combustion reactants, intermediates, and products relevant to Air Force Propulsion and Energy conversion, under high-pressure, high-temperature, multiphase conditions in harsh environments, including supercritical conditions. An accurate, rapidly implemented measurement system is desired, which indicates an earnest endeavor to minimize size and complexity, and can be applied to both defense and commercial needs. A proof-of-concept demonstration of offeror's high-pressure diagnostic methodology is required.

PHASE II: Develop and demonstrate operation of prototype instrument for high-pressure combustion diagnostics investigated under Phase I. All hardware and software developed under this program shall be delivered. A well-documented strategy for implementation of this technology into Air Force Propulsion Systems and transfer into commercial applications shall be composed.

POTENTIAL COMMERCIAL MARKET: Diagnostic instrumentation that provides reliable, accurate data from devices operating at high pressure would impact countless commercial applications. Developers of this diagnostic instrumentation will be immensely successful because of these several marketing opportunities, and should easily foresee a multi-million dollar market potential. As an obvious example, this unique measurement technology is immediately and directly applicable to internal combustion engines and gas turbine propulsion. Stationary power plants provide another example. These vital measurements would be used to increase efficiency and reduce pollutant emission, and eventually may be employed to provide interactive control of operating conditions. The latter application would contribute to longer-lived engines, reduced fuel costs, and higher performance.

Another critical utilization for high-pressure diagnostics is in the chemical process industry where high-pressure reactors are routinely employed. Very little fundamental information concerning kinetics, reaction mechanisms, and product distribution for high-pressure reactions is available. Crucial thermodynamic and kinetic data gained from accurate diagnostics would lessen design time and system check-out and would provide better-informed operating strategy. A challenging new extension in this field, operating at very high pressures and high temperatures, is supercritical extraction and synthesis. One of the most important objectives of this technology is the safe conversion of toxic wastes into harmless products. Instrumentation that contributes critical measurements in these devices would improve performance through better design and process operation, making this industry more competitive in the worldwide marketplace.

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AF97-091 TITLE: Electric Propulsion (EP) Thruster for Low Power Small Satellites

Category: Exploratory Development

OBJECTIVE: Develop and validate innovative design concepts and components for low power electric propulsion thrusters applicable to small satellites.

DESCRIPTION: Small satellites are extremely mass and power limited. In addition, propulsion system requirements for this class of satellite will be high due to larger maneuvering requirements, higher precision attitude control, increased stationkeeping life, and higher drag make-up for low orbit satellites. Substantial improvements in both thruster performance and specific power are needed to provide this increased propulsion system capability while constrained by large mass and power limitations. The objective of this effort is to radically push the technological envelope in the field of electric propulsion. Proposed concepts must show promise of more efficiently utilizing the on-board electrical energy while maintaining high specific impulse operation. Projects proposing enhancements to existing systems will also be considered. The propulsion system should be sized for satellite masses from 500 lbm down to 10 lbm with satellite specific powers from 1 to 4 W/kg.

For Phase I efforts, a strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Both thruster components and complete thruster concepts will be considered for Phase I. One thruster component of interest is the cathode neutralizer, which is currently designed for Hall and Ion thrusters operating above 1 kW-potential advances include reduced cathode propellant and power usage, and reduced mass and size. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, thruster performance should be estimated and improvements quantified.

PHASE I: Develop and validate innovative electric propulsion thruster concepts or components for small satellite (500 lbm to 10 lbm) applications; primary interests are performance, thrust-to-weight ratio, minimal impact on spacecraft operations and systems, minimal spacecraft contamination, environmental compatibility, and lifetime. The focus of the effort should be on stationkeeping and orbit maneuvering applications.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of EP thruster performance capabilities. An interative thruster design process is expected, with the design and prototype that generates the best overall performance being reproduced and delivered to Phillips Laboratory upon completion of the Phase II technical period of performance.

POTENTIAL COMMERCIAL MARKET: Dual use commercialization would occur through the development of flight quality electric propulsion systems for small satellite and space experiment applications. The development of small satellites, and their propulsion systems, is one avenue for reducing satellite launch costs. The deployment of satellite constellations consisting of large numbers of satellites should create a large market for efficient low power thrusters. The higher performance thrusters will result in greater mission capability including both satellite life and

maneuverability, which are areas of interest to government and commercial customers. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace. The outlook for commercialization therefore appears very strong.

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AF97-092 TITLE: Solar Thermal Rocket Propulsion

Category: Exploratory Development

OBJECTIVE: Develop novel solar thermal propulsion components.

DESCRIPTION: The solar thermal rocket propulsion concept is to develop an Orbital Transfer Vehicle (OTV) to boost payloads from low earth orbit to geosynchronous orbit. Theoretically, this rocket has the capability of inserting about twice the payload of current OTV's into higher orbits and will be reusable. The OTV consists of two energy-collecting and focusing concentrators which direct sunlight into two small apertures. Within the apertures are heat exchanging media through which hydrogen gas, the propellant, flows. The hydrogen picks up heat, expands, and thrust is produced out the propulsive nozzle.

For AF missions we must keep the package volume and weight of the OTV to a minimum. This means using thin film inflatable concentrators and structural supports as much as possible. These items are made of thin film polyimides and, depending on the type, are shaped like clamshells or balloons. Both types have a clear light transmission area and a reflectorized light collection area. Micrometeoroids can penetrate the thin film materials easily, leaving larger holes upon exit than entrance. The concentrators' useful life will be of longer time duration if they can patch themselves instead of having to be replaced every other mission or so.

Other components required for the solar rocket include, but are not limited to: concentrators, thrusters, energy storage/propulsion bi-modal systems, propellant tankage, space sun-trackers, optical quality measurement devices, and laser beam power thrusters.

The latest technologies in Solar Thermal Propulsion concentrator components deal with: focusing laser light into apertures from ground-based systems; developing, designing, and fabricating foam inflation/rigidized structures for supports; and composite material telescoping supports that are light weight, packageable in small volumes, and self-deployable. For thrusters, the newest ideas are: matrices of small tubes that act like black body cavity receivers; and working, shaping, and applying new methods of manufacture to high temperature exotic refractory materials for use as solar absorbers.

PHASE I: Generate a list of components. Analyze them and perform tradeoffs. Some of the factors include, but are not limited to, the following: usefulness in space, effectiveness in closing holes or at least reducing their size (self-repairing concentrators), cost effectiveness, ease of use, environmental concerns, autonomy, distortion of the focal image, reliability, maintainability, vulnerability, and survivability. Develop preliminary designs and perform analyses to select most promising candidate. Laboratory demonstration of the selected concept is preferred but not required.

PHASE II: Further develop, design, fabricate, and demonstrate the chosen Phase I design/concept. The contractor shall deliver any hardware/software developed, document the work performed and develop a plan for technology transition and insertion into future systems and other commercial ventures.

POTENTIAL COMMERCIAL MARKET: Any inflated object, upon detecting a leak, could be repaired at reasonably low cost using the inflater technology developed under this effort. This is particularly true of tires and inflated pools. Any flat tire could be inflated and driven at reasonable speeds to the nearest repair facility. This would negate the necessity of even carrying a spare tire. A catastrophic blowout would not be helped, but since most tire problems are leaks, this could be of significant help. It is estimated that hundreds of millions of dollars could be saved if spare tires were eliminated from all new cars.

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AF97-093 TITLE: Turbine Blade Cooling

Category: Exploratory Development

OBJECTIVE: Develop methods to increase the turbine inlet temperature capabilities of rocket engine turbopumps.

DESCRIPTION: The turbine of a rocket engine turbopump is typically operated near the material thermal limitations. This limits the amount of power that can be extracted from the turbine, and this leaves little margin for safety in the operation of the turbopump. By cooling the turbine blades, either the turbine inlet temperature capabilities can be increased, or the safety margin can be increased.

In many cases rocket engines are expendable: the turbopumps are only expected to last the life of a single mission, so the thermal limits of the turbine materials is not a critical issue. However, in reusable engines, such as the Space Shuttle Main Engine, or new reusable concepts, the turbopump is expected to last several missions. Overcoming the thermal material limitations could dramatically increase the reliability of the turbines, and potentially decrease the cost.

A Phase I effort in this area would include investigating various cooling concepts for a rocket engine turbine blade. Phase I may entail building an experimental model to investigate whether the proposed concept was functional, and quantifying the benefits of the cooling method.

PHASE I: Produce a representative cooled turbine blade, or blisk, that will withstand the environment of a rocket engine turbopump.

PHASE II: Produce a turbine blade or turbine blisk which can be tested in a representative rocket engine turbine environment. Possibly use an existing design.

POTENTIAL COMMERCIAL MARKET: There are potential uses of cooled turbine blades in commercial and military high power gas turbines. These high powered small gas turbines have many of the same material thermal limitations as rocket engine turbopumps.

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AF97-094 TITLE: Magnetic Bearing for Rocket Engine Turbopumps

Category: Exploratory Development

OBJECTIVE: Develop methods to improve the capabilities of magnetic bearings to make their use in rocket engine turbopumps more attractive.

DESCRIPTION: There are several issues regarding magnetic bearings that inhibit their use in rocket engine turbomachinery. One issue is that, due to the weight of the magnets, the weight of a turbopump with magnetic bearings is usually greater than a turbopump with other types of bearings. Another issue is that magnetic bearings require a control system. This is a possible failure mechanism. A third issue is that the magnetic bearings may require an external power supply-another failure mechanism.

Despite their disadvantages, the Air Force is interested in magnetic bearings because of the possible benefits they may have. The advantage of magnetic bearing is that the bearing can compensate for off design loading conditions. With active control, fluctuations in the pump inlet conditions or the turbine condition, can be neutralized before they cause the turbopump to go unstable or cause damage.

A Phase I effort in this area would require optimizing a magnetic bearing for use in a rocket engine turbopump. The initial effort would require designing a bearing to optimize for lowest possible weight.

PHASE I: Design a magnetic bearing optimizing for lowest possible weight.

PHASE II: Produce a bearing based on a current turbopump design.

POTENTIAL COMMERCIAL MARKET: Although the Air Force is interested in magnetic bearings, industry would be more likely to capitalize on the benefits. Industrial turbomachinery is not subjected to the same weight limitations as the aerospace world. This allows for a backup power supply and physically larger magnets with higher load capacity, items which are typically weight prohibitive in the aerospace world.

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AF97-095 TITLE: Flight Weight Electro-mechanically Actuated Cryogenic Ball Valve

Category: Exploratory Development

OBJECTIVE: Develop a small, highly reliable, low torque, electromechanically-actuated ball valve.

DESCRIPTION: Rocket propulsion systems require highly accurate and reliable valves for control of engine thrust, engine startup, and engine shutdown. Because these valves must also fly with the launch vehicle, small size and mass are also extremely desirable attributes. Limited available power requires that these valves have a small power requirement as well. Traditional hydraulic valves and support systems in use have been larger in size and weight than desirable. Additionally, leaks and reliability have been persistent challenges. Recent technology advances in manufacturing techniques, materials, electrical systems design, etc., may allow for great improvements in the design and production of new types of valves.

PHASE I: a) Identify specific requirements for valves in rocket propulsion systems and reasons why present valves fail in rocket engine applications.
b) Identify ways to reduce size, weight, and power requirements for electromechanically actuated valves for cryogenic liquid rocket propulsion systems.
c) Develop conceptual designs for improved valves.
d) Rank order new concepts in terms of reliability, ease of manufacture, size, weight, cost, risk, etc.
e) Select the most promising concept for development and detailed design.

PHASE II: a) Design, build, and test the promising concepts developed in Phase I.
b) Demonstrate reliability, performance, small size and weight in realistic operating environment if possible.

POTENTIAL COMMERCIAL MARKET: Cryogenic fluid usage by the aerospace industry in the United States accounts for only 6% of the nation's total usage. Cryogenic ball valves have applications in many commercial industries which account for the remaining 94% of the nation's usage. During the hot summer months when natural gas is not in demand, the natural gas industry goes into peak shaving mode, in which vast quantities of natural gas are liquefied (to decrease storage volume) and stored until the winter months when demand skyrockets. Liquid nitrogen, a component of liquid air, is used extensively in the food industry to freeze food and hamburgers for fast food chains. A supermarket distributor for the city of Denver uses over 250 thousand gallons of liquid nitrogen each year for its fleet of refrigerated trucks. A single electronics manufacturing facility uses approximately 400 tons per day of liquid nitrogen to protect electronic parts from impurities during manufacturing. Half of all the liquid oxygen is used in the steel industry to remove carbon from molten iron. Considering the large commercial market for these valves, improvements such as lower cost, smaller size and weight, and reduced power requirements could save millions of dollars in annual operating costs each year.

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AF97-096 TITLE: Cryogenic Liquid Level Indicator #20

Category: Exploratory Development

OBJECTIVE: Develop a liquid level indicator that will give accurate level indications for turbulent flow conditions in various cryogenic liquids.

DESCRIPTION: In the rocket propulsion business, it is very important to know the amount of liquid contained in a storage vessel. Due to the extremely cold nature of cryogenic liquids (below -320F) used in rocket propulsion, these liquids easily boil off. The amount of boil off that occurs depends on the propellant used (liquid nitrogen, oxygen, or hydrogen) and the quality of the storage vessel. An accurate liquid level gauge is important in the realm of the boil off.

Conventionally, liquid level indicators use pressure measurements to determine the level of cryogen. Turbulent conditions that can occur during filling or a run condition oftentimes result in erroneous liquid level readings. Common practice in cryogenics dictates 5-10% ullage in the storage vessel after a fill. Due to the uncertainty in conventional gauges during turbulent conditions, the actual ullage space is unknown during a fill. During test operations, the pressure on the cryogenic vessel can be raised up to 6000 psi or higher. When this pressure is increased, along with evacuation of the liquid from the vessel, the level indication can read to a 30% error. Uncertainty of the liquid level in the tank could result in a gas flowing to the particular test hardware, damaging the systems, and incurring a large capital cost.

Due to the nature of testing, many different cryogenic liquids are used. The most common are liquid nitrogen, oxygen and hydrogen. Many times a single vessel can be used for all three of these liquids. Each liquid has a different specific gravity, and therefore either three gauges are required, or one gauge needs to be calibrated to the specific liquid at that time. This calibration of the gauge for the different liquids can be time consuming and costly.

Development of a cryogenic liquid level indicator that can function under turbulent conditions caused by filling, pressurization, and boil off condition would be beneficial. The system shall give accurate readings for liquid nitrogen, liquid oxygen, and hydrogen in all operational conditions. Furthermore, the system shall be self sufficient and shall not use additional tools for calibration. The indicator shall have the capability of zeroing the reading and the ability to be vented. Finally, the liquid level shall be displayed at the vessel in a non-glaring digital read-out and also be interfaced with today's standard data acquisition systems for remote read-out.

PHASE I: Develop a cryogenic liquid level indicator to operate in the turbulent flow conditions of filling, pressurization to 6000 psi, and boil off. Test and verify operational conditions in liquid nitrogen. In addition, the zeroing, venting and remote reading to a 4-20 mA or 10V data acquisition system shall be accomplished.

PHASE II: Refine the results found in Phase I and validate the system with liquid nitrogen, oxygen, and hydrogen to pressures up to 10,000 psi. The system shall be able to be calibrated to any of these three liquids and shall not require an additional calibration tool.

POTENTIAL COMMERCIAL MARKET: Cryogenic fluid usage by the aerospace industry in the United States accounts for only 6% of the nation's total usage. This liquid level can easily be accommodated into the other 94% of the cryogenic world, whether it be for natural gas, the food industry, steel industry, or the computer industry. During the hot summer months when natural gas is not in demand, the natural gas industry goes into a peak shaving mode, in which all of the natural gas is liquefied and stored until the winter months. Liquid nitrogen is used extensively in the food industry to freeze food for fast food chains. Half of all liquid oxygen is used in the steel industry to remove carbon from molten iron. In addition, liquid cryogens are used to increase the speed of specific types of scientific computers. Finally, the level gauge can be adjusted to serve in the petroleum industry.

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AF97-097 TITLE: Next Generation Atmospheric Turbulence Sensors

Category: Exploratory Development

OBJECTIVE: Develop a new generation of atmospheric turbulence measurement techniques. Both in situ and remote sensing methods are sought.

DESCRIPTION: Develop a new generation of atmospheric turbulence measurement technology capable of sensing atmospheric wind or temperature fluctuations with scales from millimeters to a few tens of meters. In situ methods (aircraft or balloon) and remote sensing approaches (passive, active or lidar) are sought. Approaches to atmospheric turbulence measurements have progressed little in recent decades. In situ methods used on balloons and aircraft continue to rely on wire probes. The most widely used remote sensing methods are based on Doppler radar which has limited range, spatial and temporal resolution. The promise of active optical techniques such as lidar has not been achieved and passive optical methods such as scintillometers or scidar have limited resolution. New approaches are sought to perform measurements of either mechanical (velocity) or optical (temperature) turbulence. These measurements are desired to probe the free atmosphere, that is, the troposphere and lower stratosphere. Such approaches include new sensors, miniaturization of existing techniques and advanced data and signal processing. Such approaches include, but are not restricted to, fiber optic technologies, laser diodes, eyesafe lasers, inexpensive miniaturized telemetry packages, new temperature sensors, compact ultrasonics. Remote sensing approaches include extension or improvement of traditional optical and radar passive methods, lidar, hyperspectral techniques and acoustic sounding. Mechanical turbulence sensors are needed for studies of atmospheric dynamics and aircraft safety while the optical turbulence sensors are needed for studies and modeling of laser and optical propagation through the atmosphere and for the design and performance of adaptive optics systems.

PHASE I: Develop preliminary design and perform performance analysis of turbulence sensor. Design includes not only the hardware but also the theory and data processing. Either laboratory demonstration and testing of the concept or detailed simulation is required.

PHASE II: Further development and engineering of the concept, including demonstration of the capability and performance in the atmosphere. The contractor shall deliver any hardware/software developed, document the work performed and develop a plan for technology transition and insertion into future systems and commercial ventures.

POTENTIAL COMMERCIAL MARKET: The turbulence sensors and technology developed under this program will have civilian as well as military applications. Remote sensing of wind turbulence has applicability to military and commercial aircraft as well as diffusion measurements for pollution monitoring and forecasting. There is also a market in the atmospheric research community studying atmospheric dynamics and change. The sensing of optical turbulence has its primary market in government sectors involved with ground-based space surveillance and laser beam propagation in the atmosphere. There is also a market in the academic and astronomical community for telescope performance and astronomical site selection.

REFERENCES:
References are not provided since this topic covers such a broad range of technology and is intended as a solicitation for new and creative ideas.

AF97-098 TITLE: Flight Track Clear Air Turbulence (CAT) Model

Category: Exploratory Development

OBJECTIVE: Develop and test a one-dimensional model that will predict probability of CAT at any point along a line connecting origin and destination of flight.

DESCRIPTION: There are no known numerical means of giving predictive guidance to aviators concerning the probability of encountering CAT at any point along a flight track. Current numerical models of the atmosphere can give general guidance on atmospheric conditions that may be encountered, but simply can't resolve small-scale turbulence. The idea here is to nest some type of one-dimensional high resolution model, aligned along proposed flight tracks of choice, within an advanced mesoscale meteorology model. Such a model could use temporal and spatial boundary conditions from the meteorology model. Run at high spatial resolution (~10m), the 1-D model would attempt to simulate the conditions to be encountered in the wind fields. Probabilities of CAT could then be deduced from the simulations.

PHASE I: Identify, host on workstation, and execute a suitable one-dimensional based model to simulate motion field on planes intersecting the flight track.

PHASE II: Nest successful 1-D model in mesoscale meteorology model on workstation, and produce real data motion fields on planes intersecting the flight track.

POTENTIAL COMMERCIAL MARKET: The commercial airline industry and the FAA would greatly desire the capability of a workstation-based flight track CAT model for pre-flight planning and air safety issues. This would greatly impact travel comfort and increase consumer demand for air travel

AF97-099 TITLE: Optical Sensors for Geophysical Remote Sensing, Environmental Monitoring and Target Characterization

Category: Exploratory Development

OBJECTIVE: Develop innovative visible/infrared remote-sensing instrumentation for geophysical research, environmental and target characterization.

DESCRIPTION: The Air Force conducts geophysical research to gain further understanding of the environment between the earth and the sun and to determine its effect on Air Force systems and operations. The Air Force also has the responsibility to measure the effect on Air Force operations on the environment. Phillips Laboratory has developed a variety of advanced remote-sensing instrumentation to aid in these efforts, but is interested in new sensors that leverage recent progress in commercial technology. Examples include passive optical systems such as visible or infrared radiometers, spectrometers, and imaging spectrometers. Many commercial technologies, such as those in detector arrays, electronics, and data storage and processing, are emerging that could be developed into innovative systems for remote sensing of the geophysical environment. The instrumentation will be utilized in ground-based, airborne, and space applications. Specific instrumentation of interest includes: imaging spectrometers, which simultaneously obtain both spatial and spectral characteristics of the background or target; imaging multispectral radiometers, which measure the spatial and temporal characteristics of a target or background simultaneously at two or more wavelengths; aerosol monitors, which can monitor and characterize aerosols deposited in the atmosphere by aircraft and missile engines; high-spectral-resolution infrared sensors having spectral resolution of 0.1cm-1 to 0.01cm-1 for middle atmosphere temperature profiling; very sensitive visible/near infrared spectrometers, covering the spectral range from 400 nm to 900nm, to be used, for example, to obtain spectral data of rocket plumes, to measure atmospheric pollution at levels as low as parts-per-trillion, and to observe emissions from the upper atmosphere during heating by ground-based, high-power, high-frequency transmitters.

PHASE I: An analysis shall be conducted which compares the candidate design to current technology in terms of sensitivity, spectral and/or spatial resolution, temporal resolution, size, weight, power consumption, etc. The effort should also include an investigation of how the new technology could be applied to other military and commercial applications.

PHASE II: Develop a working prototype and demonstrate operation in a laboratory environment. Tests shall be conducted to determine how effectively the design meets the requirements of the intended application.

POTENTIAL COMMERCIAL MARKET: The sensor developed under this program will also be useful for non-military applications, such as pollution monitoring, environmental change monitoring, process monitoring in manufacturing, and the remote sensing of earth resources.

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AF97-100 TITLE: Precision Orbital Microacceleromater (POM)

Category: Exploratory Development

OBJECTIVE: Develop miniaturized satellite sensor to accurately monitor atmospheric density and winds needed to update operational satellite drag and ionosphere models.

DESCRIPTION: The AF has flown accelerometers on selected satellites to measure satellite drag and neutral winds. Only a few instruments have been flown due mainly to their cost as well as size and power requirements. Routine, high-accuracy measurements are needed as inputs to initialize and validate operational ionosphere and neutral atmosphere space weather models. The drag data support satellite tracking requirements while neutral winds are an essential input to communications, navigation and radar ranging requirements. Advances in miniaturization are expected to permit development of accurate acceleration-sensing devices. A low-cost, small size and high reliability microaccelerometer will provide the capability to globally monitor satellite drag and winds on numerous satellites. The sensor required for space environment measurements must provide data in the along-track and cross-track directions. The instrument goal is a capability to accurately measure drag at the 0.05 micro-g level and cross-track winds at the 0.01 micro-g level. The dynamic range must also permit measurement of spacecraft orbital adjustment thrusts. Geophysical data are in the frequency range of approximately DC to 0.05 Hz. The sensor must be compatible with launch and space vehicle environment and operate reliably over a minimum period of one year.

PHASE I: Provide conceptual design of a space-qualified instrument. Include determination of achievable scale factor and bias levels, size, weight and power requirements.

PHASE II: Develop a prototype instrument as a proof-of principle device. Perform analyses and calibration to predict the performance, reliability and physical characteristics of production accelerometer design. Define compatibility with spacecraft integration.

POTENTIAL COMMERCIAL MARKET: There are very clear commercial applications for a high sensitivity, low cost microaccelerometer. Several areas are:
(a) Aircraft Navigation: There is currently an estimated $30-40M business in strapdown Inertial Navigation System platforms for airliners that would utilize improved designs that reduce cost and improve performance. There is also a need for the military industry to develop autonomous navigation for warfighting planes. The B2, F117, and F22 SPO's have requested enhanced inertial navigation systems. Gravity Gradiometers have been proposed to meet this need.

The Gradiometers consist of several accelerometers (4-8) mounted on a rotating platform. Consequently several microaccelerometers would be needed for each plane.
(b) Commercial Small Satellites: Applications include thrust dynamics, vibration sensing, attitude control and all navigation systems and all new inertial units. The market could include proposed large numbers of deployed systems such as the Iridium satellites. New accelerometers are also a technical need for the Navigation mission area.
(c) Exploration Geophysics (oil, gas, mining): Instrumentation is a large part of this big business. Applications include arrays of vibration sensors for seismic reflection studies, borehole logging of gravity signals and local seismicity. A new area that would exploit the new microtechnology is in airborne exploration. Bell Aerospace Corp. is evaluating the feasibility of mineral surveying from an airborne gravity gradiometer system-another area with tremendous growth potential in the civilian sector.
(d) Counterproliferation: Gradiometers are being planned to discriminate nuclear from non-nuclear warheads. For stationary monitoring in factories, current technology requires being within a couple of meters of the warhead. 3-D monitoring requires three sets of gradiometers. Since current technology requires large accelerometers, the large mass associated with these sensors means that the mass attraction of the gradiometer itself introduces an error. This error can be greatly reduced with the proposed small microaccelerometer. Mobile gradiometers that can detect underground structures are also being proposed. Closely related to this work are DOE applications which include detection of buried toxic waste sites.

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AF97-101 TITLE: High-Power, Doped Fiber Laser Amplifiers
Category: Exploratory Development

OBJECTIVE: Develop efficient fiber laser amplifiers with over 10 watts of output power, operating at room temperature.

DESCRIPTION: Currently, Erbium-doped optical amplifier technology is reaching maturity with many low power products commercially available. Two methods are used to achieve higher powers. In systems requiring high pump intensities, such as Erbium, power is scaled by using waveguide splitters to couple in more pump power in stages; in systems not requiring high pump intensities, such as neodymium, a large outer clad region can contain larger pump power in a single stage. Over 10 watts of power has been achieved by this method. Power scaling methods which combine these two methods are possible. The purpose of this topic is to encourage the optical fiber laser amplifier/oscillator community to further develop higher power fiber laser amplifiers and their applications. The fiber laser amplifiers should possess the following characteristics: 1) room temperature operation; 2) output power capability of over 10 watts; 3) efficiency; and 4) low cost.

PHASE I: The rare earth material system, the scale up methodology and the application chosen will be modeled. Test and demonstration of elements of the system, especially those necessary to achieve efficient operation, will be performed.

PHASE II: A prototype laser system will be built and tested. Applications testing will be performed.

POTENTIAL COMMERCIAL MARKET: The optical amplifiers/oscillators which will be developed under this program have a direct impact on the commercial photonics industry. With the wide range of wavelengths available from the Lanthanides, many product enhancements and potential new product development will occur. For instance, electronic printing, remote sensing, monitoring of airborne pollutants and ground water safety, and medical uses.

Development of this technology will also help DOD in several key problem areas. For example, such devices could have potential use for the "Fotofighter", Electro-Optical Counter Measures, Laser Communications, LIDAR, and pump sources for nonlinear optical systems. These DoD applications would create a huge commercial market for fiber amplifiers/oscillators.

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AF97-102 TITLE: Semiconductor Laser Technologies for Photodynamic Therapy (PDT) or Minimally-Invasive Surgery (MIS)

Category: Exploratory Development

OBJECTIVE: Develop cost effective, portable semiconductor laser systems or technologies for PDT treatment or other MIS surgical applications.

DESCRIPTION: In the past, most non-and minimally-invasive medical procedures have relied on large, inefficient and expensive laser systems. Use of such laser systems has been restricted to operating rooms, even for procedures that can be performed inside a physicians office. The benefits of semiconductor laser diodes include less expense and more compact laser delivery systems that can output substantial power. Semiconductor technology has the potential to provide wavelengths in the visible to mid infrared regions at powers over 50 watts. This capability opens doors for many minimally-invasive medical applications. Since specific applications have specific requirements, the increasing span of semiconductor diodes will accommodate their needs. Photodynamic therapy (PDT) is a very promising treatment technique for cancer that utilizes laser energy to eradicate cancerous cells. The procedure has recently been FDA approved for the specific treatment of esophageal cancer. The most commonly used drug in the procedure is photofrin, which requires wavelengths in the visible region (approximately 630 nm). However, there has not been an efficient and cost effective laser system in the market to deliver the required laser energy, nor has there been a way to monitor the effectiveness of the treatment. As other drugs that absorb different wavelengths are produced and other techniques are developed to administer PDT, there may be different parameter requirements. Semiconductor laser diodes provide the capability to accommodate different parameter requirements. With the existing capabilities of diode technology, innovative and advance laser systems for specific minimally-invasive procedures, such as PDT, are sought. Phase I proposals which involve animal or human testing will not be considered for award. Phase II or III proposals which involve or are expected to involve animal or human testing must be submitted to the Phillips Laboratory (PL) along with test plans and protocols prepared in accordance with the prescribed DoD format and, if appropriate, pertinent certifications.

PHASE I: The contractor shall address an innovative technique which would utilize a compact semiconductor laser diode system that can be used outside the operating room. The contractor shall identify the specific application of the system, which shall fall within the scope of PDT or minimally-invasive surgical procedures. The contractor shall be able to define, measure, and evaluate parameter requirements for their specific system and shall develop the parameters into a conceptual design. The conceptual design shall accommodate any specific requirements that the unit may request. The contractor shall also demonstrate the theory and/or feasibility of their conceptual design , and show that their system is an effective instrument that can be used in less threatening environments than the operating room. Final system requirements needed to produce an operational, FDA-approvable prototype during Phase II shall be

considered as well. The proposed Phase I effort shall not involve any animal or human testing. However, if Phase II plans will involve or lead to animal or human testing, the PL requires delivery of the "protocols" within three months after Phase I contract award.

PHASE II: The contractor shall develop a working prototype of the system as a proof-of-concept demonstration device. The contractor shall provide the means to test their system in its intended application, evaluate its performance based on their pre-defined criteria and redesign the system as needed in order to optimize performance. Furthermore, the contractor shall perform a system analysis to analyze the performance of their technology in comparison with any similar conventional techniques that are currently being used. Ultimately, the contractor shall have a well-developed system that is ready for FDA approval and extensive clinical investigations in the near future. Optimizing output performance and manufacturability shall be issues addressed as well. The working prototype shall be delivered at the end of Phase II. Phase II proposals which require animal or human testing, if selected for award, will involve somewhat longer leadtimes to satisfy all government requirements prior to award. Phase II contracts involving any animal or human testing will require additional data deliverables (such as "Annual Report to the Surgeon General") documenting all such testing, test plans, and animal care.

POTENTIAL COMMERCIAL MARKET: The laser systems developed under this program have great potential in both civilian and military realms because more manageable and affordable laser systems are needed in the medical field. Furthermore, they would enhance medical capabilities in the normal physician's office. They would greatly benefit private practioners who do not have the capacity to use larger existing systems. These laser systems will bring medical capabilities into the physician's office, where practical procedures can be performed. Military medicine would definitely have the same needs as civilian hospitals. Commercially, compact semiconductor laser systems have great potential to be mass produced at cost effective prices. These affordable laser systems will be a cost effective and efficient way to treat patients

AF97-103 TITLE: Direct Generation of Mid-IR Laser Wavelengths and Sensor Development

Category: Exploratory Development

OBJECTIVE: Develop solid-state gain media which lase in the 2-5 micron band and develop appropriate detector/receivers for operation in this band.

DESCRIPTION: Current fieldable techniques for generating light in the mid-infrared require nonlinear optical frequency conversion processes which reduce system efficiencies. One way to possibly increase the laser efficiency is to find solid-state materials which lase directly in the mid-infrared, particularly in the 3-5 micron band. Also of interest are research efforts which investigate the effects of mid-infrared wavelengths on optical sensors; of particular interest is sensor degradation caused by mid-infrared wavelengths. We are seeking proposals which address these topical areas. On-going research in the Air Force, other Government organizations, and in the remote sensing community can directly benefit from solid-state laser materials and sensors research in this wavelength band.

PHASE I: The Phase I effort should be directed toward researching the physics associated with solid-state materials which lase directly in the 2-5 micron band. Experiments, supported by theoretical analysis, should be performed which provide possible gain media candidates. Solid-state laser materials which can be diode-pumped are preferred. Attention should be paid to a particular market and application along with the implied performance criteria for source and detector/receiver.During Phase I, a preliminary design for the Phase II device/system should be developed.

PHASE II: Phase II should provide expanded proof-of-concept by fabricating a greater than 10 Watts average power, less than two times diffraction limited, laser source. Assembly and test of an associated detector/receiver should also be accomplished.

POTENTIAL COMMERCIAL MARKET: New 2-5 micron laser materials developed under this effort will have a direct impact on commercial solid-state laser applications such as lidar for wind shear and remote sensing, environmental monitoring, materials processing, surgical and therapeutic procedures in the health industry, and other

applications which require eyesafe laser wavelengths (greater than ~1.5 microns). Current lasers which are used for some of these applications usually use gas as the gain media or use nonlinear optical frequency conversion elements in conjunction with solid-state lasers to generate the mid-infrared wavelengths. Both systems are inefficient and usually are physically large, which limits their viability.

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AF97-104 TITLE: Applications of Smart Vision Systems

Category: Exploratory Development

OBJECTIVE: Develop smart vision chips for real time on board processing.

DESCRIPTION: In the last decade, significant progress has been made in understanding the first steps in visual processing. A large number of well-studied algorithms exist that locate edges, compute disparities along edges, estimate motion fields, and find discontinuities in depth, motion, color and texture. Several key problems remain. One is the integration of information from different modalities. Fusion of information is expected to increase greatly the robustness and fault tolerance of current vision systems, as it is most likely the key toward fully understanding vision in biological systems. In particular, "silicon retina" technologies are of interest.

Phillips Laboratory Lasers and Imaging Directorate is interested in the development of real time smart vision chips consisting of reconfigurable electronics for space-based platforms. Uplinking allows the on-board processor to be reprogrammed to handle changing mission requirements. Having adaptable on-board processing alleviates the downlinking of massive amounts of data for post-processing. We are interested in moving much of the standard image processing tasks onto the focal plane array using silicon retina, pulse couple neural networks and SPRITE- (signal processing right in the element) like technologies. The primary objective is for multispectral satellite image processing and passive remote sensing.

PHASE I: Address techniques to process the visual information reliably. Vision systems must be able to operate over seven to eight orders of magnitude of light intensity. Smart vision chips should have the ability to adapt rapidly to recent input and only signal abrupt changes away from the operating point. A large application field would open up if vision chips could combine not only image acquisition and processing, but also if the same chips could learn to extract features from scenes and store them or compare features from the currently viewed scene with stored ones.

PHASE II: Develop a prototype imaging system and evaluate its performance. Demonstrate the reliability and quality formation of components.

POTENTIAL COMMERCIAL MARKET: The results of a successful Phase II approach will lead to superior space-based imaging systems and other military and commercial applications. In particular, compact, low-cost smart vision systems have a tremendous commercial potential for biomedical and machine vision systems. According to Picker International, a leading manufacturer of biomedical hardware, the market for low-cost, compact smart vision systems has a billion dollar market in the biomedical field. According to Intel, a leading manufacturer of microprocessors, the market for automated VLSI chip inspection using the smart vision chip technologies is in excess of $100 million.

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AF97-105 TITLE: On-Chip Real-Time Wavefront Sensor Array Development

Category: Exploratory Development

OBJECTIVE: Develop a fast, accurate 2-D spatially resolved electronic full-field optical wavefront sensing device in which all sensing and processing is contained on a single IC chip.

DESCRIPTION: As applications of adaptive optics grow in the measurement and control of optical wavefront distortions produced by atmospheric and aircraft-induced turbulence and other highly dynamic spatially structured aberrating media, the need for high speed electronic wavefront sensing devices in the Air Force has increased. Examples of the kinds of sensors that are capable of measuring the amplitude and phase of an optical field are (but are not limited to) Hartmann sensing,heterodyne detection, and various holographic methods. On-chip measurement and processing of optical amplitude and phase data minimizes the need to transmit raw data from a remote sensor location to a processing center. Such on-board processing capability represents an important advance in the area of wavefront sensing for high speed and remote applications and for driving adaptive optics systems. We seek submission of proposals for development of a 2-D wavefront sensor array capable of measuring the amplitude and phase of incident optical fields at high speed and with 2-D spatial resolution in which functions such as sensing, signal conditioning, A/D conversion and signal output are resident on the sensor chip.

PHASE I: At a minimum, the results of the Phase I investigation should include: development of an amplitude and phase measurement and/or reconstruction algorithm; the receiving optical design optimized for sensor performance; circuit design to measure amplitude and solve phase reconstruction on chip; optics and microelectronics integration plan and packaging requirements; evaluation of the manufacturability of the device including the type of IC manufacturing process and cost of manufacture; estimates or simulations of device speed, sensitivity, spatial resolution, and noise characteristics. Existing integrated "smart sensor" technology, existing chip manufacturing processes, and low-cost optical fabrication techniques should be incorporated where possible for ease of manufacture and low cost.

PHASE II: Construct the wavefront sensing chip and demonstrate the full operation of the chip in a wavefront sensing application. Leveraging existing smart sensor technology with existing chip design and manufacturing processes is encouraged to maintain ease of manufacture and low cost. Demonstration includes integration of optical components, electronics, data acquisition hardware, and software for data management, processing and visualization as a package.

POTENTIAL COMMERCIAL MARKET: Results of a successful Phase II approach would lead to simplified fully-digital real -time testing of optical systems and improved devices for production line defect detection during manufacturing processes, process control, and product testing.

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AF97-106 TITLE: Semiconductor Laser Technologies for Fieldable, Diagnostic and/or General Medical Applications

Category: Exploratory Development

OBJECTIVE: Develop minimally-invasive, cost effective, portable, and self-contained semiconductor laser systems, enhancing real-time assessments of a patient's condition.

DESCRIPTION: The United States military has become increasingly involved in low intensity conflicts. Due to the types of operations that the US performs, such as peacekeeping and humanitarian efforts, there continues to be an urgent need to provide rapid trauma care to troops out in the field. In many cases, it is necessary to stabilize the patient at the site of injury because it would be too late to move him/her to a medical facility. Semiconductor laser technology offers great promise in the area of compact, portable, self-contained diagnostic and surgical devices. Since medical modalities have specific requirements and conditions, parameters such as wavelength and power will be dependent on the specific application. In general, semiconductor lasers provide a great source of energy between the visible and mid-infrared region for diagnostic imaging and spectroscopy. Diagnostic applications, which are currently lacking, will provide medical personnel with the capability to quickly assess vital conditions of the patient. Also, semiconductor lasers have the capability to provide energy for simultaneous cutting and coagulating, which would be a great benefit for rapid wound stabilization. Coagulation has been shown to work well at 810 nm. Therefore, innovative and advanced capabilities to enhance rapid assessment and stabilization of patients through the research and development of new and improved semiconductor laser systems are sought. Phase I proposals which involve animal or human testing will not be considered for award. Phase II or III proposals which involve or are expected to involve animal or human testing must be submitted to the Phillips Laboratory (PL) along with test plans and protocols prepared in accordance with the prescribed DoD format and, if appropriate, pertinent certifications.

PHASE I: The contractor shall address an innovative technique that involves the use of a compact semiconductor laser diode system to enhance the capability of field medical units. The contractor shall be able to define, measure, and evaluate parameters requirements for their specific system in order to achieve their intended application in the area of injury stabilization. The contractor shall accommodate any specific requirements requested by the unit and shall develop the parameters into a conceptual design. The contractor shall also demonstrate the theory and/or feasibility of their conceptual design, and show that it can contribute to the stabilization of patients in its intended manner. Final system requirements needed to produce an operational, FDA approvable prototype during Phase II shall be considered as well. The proposed Phase I effort shall not involve any animal or human testing. However, if Phase II plans will involve or lead to animal or human testing, the PL requires delivery of the "protocols" within 3 months after Phase I contract award.

PHASE II: The contractor shall develop a working prototype of the system as a proof-of-concept demonstration device. The contractor shall provide the means to test the system in a comparable field environment, evaluate its performance based on predetermined criteria, and redesign the system as needed to improve performance. Furthermore, the contractor shall perform a system analysis to analyze the performance of their technology in comparison with any similar conventional techniques that are currently being used. Ultimately, the contractor shall have a well-developed system that is ready for FDA approval and extensive clinical investigations in the near future. Optimizing output performance and manufacturability are issues that shall be addressed as well. The contractor shall deliver a working prototype at the end of Phase II. Phase II proposals which require animal or human testing, if selected for award, will involve somewhat longer leadtimes to satisfy all government requirements prior to award.

Phase II contracts involving any animal or human testing will require additional data deliverables (such as "Annual Report to the Surgeon General") documenting all such testing, test plans, and animal care.

POTENTIAL COMMERCIAL MARKET: Because medicine is such a universal field, the laser system developed under this program has great potential in both civilian and military realms. The markets on the civilian side would benefit mobile medical units such as paramedics. Furthermore, because time is critical, there would be a great need for such systems in emergency and trauma care units as well. Medical personnel can always benefit from advanced technology to make their jobs easier and more effective. Military medicine would definitely have the same needs as civilian hospital

AF97-107 TITLE: High Average Power Frequency Agile COIL (Chemical Oxygen Iodine Laser)

Category: Exploratory Development

OBJECTIVE: Develop high peak power and wavelength agile approaches for chemical oxygen iodine lasers (COIL).

DESCRIPTION: The Air Force Phillips Laboratory is seeking approaches for demonstrating high peak power, high rep rates, and frequency agile COIL (chemical oxygen iodine lasers) operating near 1.3 pm. The successful approaches must be capable of handling high average power levels above 10 kWatts. COIL devices have been operated with polarization dependent magnetic field induced gain suppression, (1) and have demonstrated (2) thar gain switching of these devices will be possible at high rep rates. Optical techniques for mode locking these gain-switched lasers are required and may include seeding with narrow band,tunable,pulsed laser sources and optical parametric oscillators. Furthermore, frequency tuning of COIL has also been demonstrated (3) using magnetic fields. Approaches for exploiting this tuning capability, coupled with the requirements for high peak power and high rep rates, are also desired by the Air Force. Alternatively, larger frequency tuning may be obtained with approaches that use nonlinear optics or Raman shifting and is also of strong interest to the Air Force. Any nonlinear process must be capable of handling the high average power of the COIL device.

PHASE I: Identify and design hardware for mode locking high power, gain switched, COIL devices. Demonstrate feasibility of the approach with modeling and /or in a breadboard experimental effort. The potential for frequency conversion will be defined in terms of frequency shift and efficiency possible.

PHASE II: Deliver hardware to the Air Force Phillips Laboratory necessary to convert existing COIL laser devices to mode locked and frequency agile capability.

POTENTIAL COMMERCIAL MARKET: In addition to Air Force applications, tunable narrow band sources that operate at high rep rates have commercial applications in remote sensing laser material processing and eye safe applications.

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AF97-108 TITLE: High Sensitivity Detection of Pulsed Laser Radiation for Differential Absorption Lidar (DIAL) Applications

Category: Exploratory Development

OBJECTIVE: Develop technologies which facilitate differential absorption lidar systems for space and high altitude aircraft applications.

DESCRIPTION: Differential Absorption Lidar, or DIAL systems measure absorption of chemicals in the atmosphere using a laser probe. Receivers for DIAL systems must operate while the laser rapidly tunes through a wide band of

laser lines. For CO2 systems operating in the LWIR, operation at wavelengths between 9 and 11 microns is foreseen. Tunability in the MWIR operating regime covers 3 to 5 microns. Direct detection receivers are the simplest to tune rapidly, but are currently detector noise limited. Background-limited, tunable, heterodyne systems are under development, but rapid tuning over a large number of lines is still out of reach. Heterodyne receivers have more components, and are therefore less compact and sensitive to alignment and vibration. Proposers should submit new concepts for DIAL receiver technology. These proposals should address one or more deficiencies with current systems and include new tunable detection schemes or enhancements to heterodyne detection. Proposals should be broad enough to facilitate a wide range of laser sources in at least one of the wavelength bands of interest. Commercial applications to this technology include environmental pollution monitoring and chemical leak detection warning systems.

PHASE I: Develop preliminary designs and perform analysis to select most the promising candidate. Laboratory demonstration of the selected concept is preferred but not required.

PHASE II: Further develop and demonstrate the chosen Phase I design/concept within the framework of existing Phillips Laboratory laser assets. The contractor shall deliver any hardware/software developed. Document the work performed and develop a plan for technology transition and insertion into future systems and other commercial ventures.

POTENTIAL COMMERCIAL MARKET: The receiver technologies developed under this program will be useful for many civilian applications. The remote sensing applications are pollution monitoring of industrial plants and waste sites, process monitoring in manufacturing, identification of agricultural and plant species and growth conditions, and oil surveys. Other spectroscopic techniques include medical applications such as glucose monitoring.

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AF97-109 TITLE: Hand-Held Visible Diode Laser Illuminator/Designator

Category: Exploratory Development

OBJECTIVE: Develop and demonstrate the effectiveness of a hand-held, self-contained visible laser and covert infrared (IR) laser capable of illuminating and designating targets up to a 1000 meter range.

DESCRIPTION: The devices sought are self-contained, variable focus laser illuminators to be used in law enforcement applications. There are distinct advantages to this approach. Providing IR illumination allows covert viewing of a suspicious subject without prompting flight or confrontation. Visible illumination provides rugged, low-power spotlighting for officers without night vision equipment. In the past, small laser diodes (670nm @ 15mw) have been used for targeting weapon systems and for designation. The pin-point spot is often hard or impossible to see at distance and is difficult to keep on a moving target. Law enforcement needs a variable spot size with more power, capable of covering the entire target in laser light, illuminating the target and designating it. For example: A target at 100 meters would require a 2 meter spot size, making the optical divergence of the source at 20mrad's. But at 1000 meters, a 2 meter spot would require optics with 2mrad's. The power required to effectively illuminate and designate a target with the aforementioned spot size is 300-500 milliwatts at 640-660 nanometers for visible, and 300-500 milliwatts at 808-880 nanometers for an IR laser. The IR laser would be used in conjunction with night vision devices. A self-contained flashlight-type package with easy-to-adjust optics is sought. Power will be supplied by off-the-shelf batteries that are easily changed out or recharged.

PHASE I: Address availability, efficiency, and durability of the different laser diode arrays which potentially could meet the specifications stated above. If no diodes exist that can meet the specifications as indicated by current PL research, development of such diodes will be performed. Research and develop high-efficiency power supplies for powering the laser diode array. Design and develop rugged supporting electronics that will control the temperature of the chosen diode array to maximize performance and longevity. Design an optical head that will adjust from 2-20 mrad's with a simple physical manipulation of the hand.

PHASE II: Demonstrate feasibility of system manufacturability by building 20 refined units (10 of each). Units will be field tested by operators in the field and need to be ruggedized and easily operated.

POTENTIAL COMMERCIAL MARKET: This system is a multi-use one, capable of providing law enforcement officers a means of illuminating darkened environments without giving away their position, and designating targets for other officers on the scene. The compact system allows use in a variety of environments (darkened buildings, alleys, night scenes). It enhances the ability of the officer to control the engagement with more safety. Operations from helicopters for apprehending or searching for targets on the ground would benefit from the application of a large visible and/or IR laser illuminator/designator. A large commercial potential exists: the darkened environment is one of the most stressful for law enforcement officers. Most squad cars and all helicopter patrols would covet this type of system. After a successful Phase I, field tests will be completed by operators so feedback on the packaging and performance of the systems can be collected. In addition, tactics for a large spot size laser illuminator/designator can be developed during the tests.

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AF97-110 TITLE: Scintillation Control for Imaging and Laser Propagation Systems

Category: Exploratory Development

OBJECTIVE: Develop spatial light modulator technologies for the high-speed control of amplitude fluctuations for imaging and laser propagation applications.

DESCRIPTION: The DoD has undertaken a large amount of research in adaptive optics for ground- and spaced-based imaging applications and in devices involving the propagation of lasers. Most of this work has involved the correction of phase aberrations. Correction of amplitude fluctuations (scintillation) is also important, especially for horizontal imaging near to the ground. Spatial light modulators are required which can control the intensity of light without inducing further phase aberrations. Furthermore, the devices must operate at high speeds (~KHz) and be capable of analog control. Innovative design and production is required to produce fast, analog spatial light modulator technology.

PHASE I: Design a spatial light modulator for the analog control light intensity at high temporal bandwidths (~KHz), which will not induce phase fluctuations across the beam as the device is switched. This will involve a detailed study of electronic addressing schemes for large (~128x128) arrays with ~8 bit control of the individual voltages. Assess the material properties of suitable technologies, such as switching speeds, optical quality, and reliability. Study the achievable specifications such as modulation depth, optical throughput, and power handling. Construct a simple array (~10x10) which demonstrates the above principles.

PHASE II: Following from the work of Phase I construct a large (~128x128) amplitude correction unit.

POTENTIAL COMMERCIAL MARKET: This work involves high speed analog intensity control of light with a high spatial resolution. There is commercial interest in this in order to extend the performance of compact TV displays (in particular for LCTVs). For example, a display constructed using such techniques could have individual pixels which display colors (current displays have 3-sub pixels) using the frame sequential color technique. Furthermore, they would require a lower digital control bandwidth. The second area is in optical correlators. A high speed analog correlator will show superior performance over the currently available bistable devices. These have applications in, for example, finger print detection and production quality control. In the astronomical community there is interest in scintillation correction for producing superlative imaging systems for the detection of extra-solar planets (refs. 1 & 2); this has been put forward as a "visionary goal" by NASA.

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AF97-111 TITLE: Optics Health Monitoring

Category: Exploratory Development

OBJECTIVE: Develop a portable instrument to monitor and indicate the condition of optical components in laser systems.

DESCRIPTION: Optical components and coatings used in laser systems are often damaged during laser beam operation and fail to perform after an extended period. Changes in the characteristics of these components may be indicative of degradation and/or impending failure. Potentially relevant characteristics include reflectance, transmittance, absorptance, scatter, dispersion, emissivity, temperature, stress, deformation, delamination, discoloration, haze, cracks, defects, and pits. A technique and subsequent monitor needs to be developed that will measure pertinent characteristics, accurately inform the laser operator of the condition of an optical component, and warn of impending failure. The technique must not interfere with normal laser operation, and the monitor must be lightweight, portable, automated, and low cost. The high energy laser wavelengths will range from the near-IR to the long wavelength IR.

PHASE I: Investigate promising techniques and determine the best technique(s) that satisfy the above constraints. Demonstrate the feasibility of converting the technique(s) into a reliable monitoring instrument.

PHASE II: Develop a prototype monitor and its associated controls and data processing. Plan and complete a testing program which demonstrates the reliability and accuracy of the monitor.

POTENTIAL COMMERCIAL MARKET: Application can found in the national inertial fusion program, the industrial laser cutting and welding market, or in any technology which requires that optical components work reliably during system operation. Monitoring technique can be broadened for use in remote sensing and control of automated industrial processes.

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AF97-112 TITLE: New Methods for Distributing Satellite Data to Users
Category: Exploratory Development

OBJECTIVE: Develop new methods for distributing data from small satellites to users by taking advantage of the numerous advances in the communications industry.

DESCRIPTION: Future advances in the communications arena will provide new opportunities for improving the way information is distributed to satellite data users. Currently, data is downlinked (e.g., from a small R&D satellite) to a ground station where it is stored on some sort of computer media (floppy, tape, hard drive). Operators then distribute the data to users manually (mail or couriers) or electronically (internet). As the communications industry advances in the electronic distribution arena, we would like to take advantage of these improvements to improve the speed, reliability, ease, and cost in which data can be transferred to users.

PHASE I: The contractor shall address new techniques to improve speed, ease, reliability, and cost of distributing data to users using new, innovative commercial-off-the-shelf (COTS) products wherever possible. Techniques should be electronic focused (i.e. internet). Considerations, at a minimum, should include hardware,

software, security, and data integrity improvements (successful transfers). Phase I should include a feasibility demonstration of the preferred technique.

PHASE II: Further refinement of the technique selected in Phase I. Phase II includes use of the product as part of the data distribution for an existing or new space demonstration program (e.g., MightySat).

POTENTIAL COMMERCIAL MARKET: The results from Phase I and II products can be used by the commercial sector as the demand increases for fast distribution of data as many of the communication constellations come on-line (i.e., Iridium).

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AF97-113 TITLE: Broad Area Technology Applications for Military Police Operations

Category: Exploratory Development

OBJECTIVE: Develop low cost systems to meet the needs of Military Police Operations.

DESCRIPTION: Integration of existing technology to develop low cost systems is preferred, as opposed to new development. Development with the civilian dual-use applications considered and integrated in the proposal is expected. To make the civilian applications viable, low cost solutions are necessary. Air Force-developed technology and some demonstration hardware can be made available for modification and commercialization.

PHASE I: Identify detailed military police operational needs in a specific area, and dual-use civilian needs. Develop preliminary design of system to meet those needs, with specific target performance goals. Develop commercial market assessment plan for the civilian application of proposed system, and perform initial market feasibility assessment.

PHASE II: Develop detailed design of system, and build a prototype for field evaluation. Perform performance testing and field evaluation testing by military and civilian organizations. The government can facilitate the field testing phase. Complete detailed market assessment. Based on field tests and market assessment, modify design and develop production plan.

POTENTIAL COMMERCIAL MARKET: Depending on specific system, dual-use applications should be significant. Most all military police needs are also pressing civilian law enforcement needs, or commercial security company needs.

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AF97-114 TITLE: Precision Reference Information State Error Measurement (PRISEM)

Category: Exploratory Development

OBJECTIVE: Develop real-time techniques for qualitatively characterizing reference systems state vector quality.

DESCRIPTION: Current and future military operational concepts emphasize the use of multi-platform operations and the sharing of resources within the theater of operations. This capability would allow many more users access to data from expensive resources and in some cases would help extend the operationally beneficial life of certain aging airframes. However, before the concepts for sharing such resources are operationally feasible, many technical issues must be resolved. Of particular interest and technical challenge are issues related to the processing and sharing of reference systems information (position, velocity, attitude, and pointing information from, to, and regarding the ownship, other friendlies, enemy operations, and targets). This research is intended to develop a capability to assess the quality of the reference state vectors used in the fusion process. These state vectors are generated by the reference system on each platform that provides or uses the information. The state vector information must be translated to each mission sensor on the information providing platforms. The real-time state vector quality assessment must provide both the quantitative and symbolic measures required to enhance the various levels of information and sensor fusion ranging from intraplatform to interplatform. These measures will range from probability distribution characterization to fuzzy sets, depending upon the fusion algorithms being supported. Technology that would enable consistently representing and reflecting the impact of characteristics of the reference systems data upon platform subsystems dependent upon that data would provide a capability to support theater-wide information fusion with predictable and reliable results. Assessment of technologies developed will be performed using such metrics as targeting error, errors indetecting and discriminating targets and threats, and computational improvements in fusion algorithms. Potential sources of data include E-3As/AWACS, E-8s/JSTARS, national assets, UAVs, reconnaissance platforms, and combat aircraft. Potential users of the information include combat aircraft, special operations aircraft, transport aircraft, ground based systems and personnel, ships missiles, and C2 nodes.

PHASE I: Using requirements determined under previous Theater-wide Reference Information Management programs (IMTRS, CORF, TRIM), Phase I of the Precision Reference Information State Error Measurement (PRISEM) program will consist of an assessment of current techniques for characterizing reference systems data and approaches to performing information fusion using that characterization to provide stability and coherence to the fusion process. Through the use of analysis and simulation, an assessment will then be performed of the applicability of various technologies to developing a coherent approach to this characterization and the sharing and using of that characterization by the gamut of levels of fusion required in the theater-wide environment. Potential technologies include modern estimation theory, symbolic reasoning, neural processing, and/or fuzzy processing.

PHASE II: Develop techniques, algorithms, and data structures using the applicable technologies identified under Phase I to produce real-time characterizations of reference state vectors. This demonstration system will consist of models of the sources and users of the information, and the information content of all data transmissions that would take place during a specific, realistic mission scenario. Other pertinent functions of the developed technology include error detection and system compensation.

POTENTIAL COMMERCIAL MARKET: Dual use applications include any process requiring correlation of information from disparate sources, each having its own degree of precision and reliability and its own approach for representing the quality of that information. Potential application areas would include those requiring immediate determination of "situation awareness" such as transportation, environmental or natural disaster monitoring, medical emergencies, dynamic business operations, and complex manufacturing or chemical processes involving multiple sources of instrumentation and observation for which fault elimination is of critical importance.

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To obtain this reference, contact Sandra Berning at (513) 255-2305

AF97-115 TITLE: Automatic Target Recognition (ATR) Technology Components

Category: Exploratory Development

OBJECTIVE: Develop new and innovative techniques for ATR algorithm design and performance evaluation.

DESCRIPTION: The Air Force is actively pursuing ATR technology for various reconnaissance and weapon delivery scenarios. Typical application scenarios demand robust approaches due to high clutter terrain environments or extensive use of camouflage and concealment or stealth. The Air Force is interested in new approaches to performing automatic target recognition with a variety of sensor modalities, examples of which include (but are not limited to) Synthetic Aperture Radar (SAR), Electro-Optic (EO) and Infra-Red sensors, 1D High Range Resolution (HRR) Radar-Frequency (RF) and laser sensors, and 3D laser radar or other 3D scanning sensors. Note that approaches which support fusion of sensor information across any or all of the above sensor modalities and with nonsensor data such as digital maps or object behavior models are highly desired, but not required. Examples of ATR technology components that are of interest include model and Physics-based, evolutionary computing, and behavior-based techniques. To promote understanding for potential respondents, a short explanation of these technology components are given below. Note that these are only examples, and any concept that shows promise for robust, adaptive ATR with remotely sensed data will be considered responsive to this topic solicitation. In addition to techniques for development of ATR algorithms, new and innovative approaches to improve existing ATR evaluation methodologies and tools, including both analytical and experimental approaches are also sought.

Model and Physics-based ATR - techniques that make explicit use of target object geometry models and/or the physics of the image or sensed data formation process. This could include explicit models of the 3D world-to-sensed data geometric transformation, the emitted or scattered radiation from the target object(s) and how this energy is sensed and processed to form the sensor output. Such approaches often include matching of predicted features to features extracted from sensed data.

Evolutionary Computing - this is characterized by a performance-driven selection process and a population of elements that undergoes reproduction with variation, in a manner similar to natural evolution. The motivation is to endow the computer with a capability to synthesize nonintuitive solutions to problems with minimal or no human interaction (other than in setting up the process). Key elements include a comprehensive representation domain for the problem, an intelligent search strategy and a performance evaluation methodology. Techniques which automatically or semi-automatically generate feature detectors or other algorithm components to create new pattern recognition systems are desired.

Behavior-based ATR - Behavior recognition can supply possible hypotheses for ATR that are not apparent from a direct analysis of the sensor information. Inferring the possible intent of a group of vehicles may often be the key to their identification, where purely visual-like processes may face difficulties. As examples, in air-to-air combat tracking the possibly threatening maneuvers of a group of aircraft may be the key to recognizing them as targets, or a vehicle that exhibits no unique sensor signature but moves in a particular fashion could be identified as a mobile missile launcher, but not otherwise.

WL/AAC has been supporting the KHORUS environment, which is a public-domain software environment for image and signal processing. KHORUS is the AAC preferred environment for developing ATR algorithms and evaluation techniques, and its use would greatly enhance the potential for Air Force application of any ATR research conducted under this solicitation. For more information, see the MBVLab WWW page - http://www.mbvlab.wpafb.af.mil/

PHASE I: Determination of ATR algorithm design or performance evaluation concept feasibility.

PHASE II: Development of dual-use ATR algorithm design or performance evaluation technique.

POTENTIAL COMMERCIAL MARKET: Object recognition technology is applicable to a wide array of commercial areas including vehicle navigation, security monitoring, industrial inspection, manufacturing automation, and satellite-based earth resource monitoring.

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3. Evolutionary Computing - L. A. Tamburino

AF97-116 TITLE: Sensor Management Across Multiple Platforms (SMAMPS)

Category: Exploratory Development

OBJECTIVE: Develop methodologies for on-board sensor managers to work cooperatively across platforms.

DESCRIPTION: Presently, there is on going research to determine multi-platform resource sharing through Cooperative Research And Development Agreement (CRADA) between the Avionics Directorate and Lockheed Fort Worth. This work is determining the feasibility, merit, and means of obtaining and using shared resources among multiple platforms to enhance tactical aircraft effectiveness. In addition to the CRADA work, research must be performed on the development of on-board sensor managers that will take advantage of the shared resources. This effort will investigate methodologies for managing sensors taking into account cooperative resources from multiple platforms within the same formation. The issues involved include resource control across aircraft, coordination of functions, and alignment challenges. The major function of the sensor manager is to supply useful data to the pilot; therefore, issues such as data formats, data latency, size of data shared, and accuracy of the data will be investigated. A major difficulty will be timing aspects which may utilize the high accuracy clock signals from GPS. Another aspect of a shared sensor manager is the data links necessary. This program will examine if present or proposed data links will provide the cooperative functions necessary, the actual development of a data link is out of the scope of this program. It is envisioned that some of the missions multi-platform sensor management can support are cooperative search, tracking, and identification. Multi-platform sensor management could also utilize active sensors on one platform to keep another platform covert. The sharing of information from different sensors across platforms will decrease costs of aircraft, utilize aircraft covertness, and provide sharing of important information.

PHASE I: Determine the issues involved in developing a cooperative sensor manager. Develop preliminary techniques to solve the major problems with sensor management across multiple platforms.

PHASE II: Develop the techniques further. Design a cooperative sensor manager, utilizing these techniques, and test this system through simulation with the intention of incorporating into major platform avionics.

POTENTIAL COMMERCIAL MARKET: The manufacturing industry will use the resource allocation methods in production planning and scheduling. These technologies are especially useful in manufacturing for automated multistep processes which use sensors to determine positioning, defects and other factors. Resource allocation problems for R&D projects having multiple, competing objectives in an uncertain environment is another dual use for this technology. Cellular phone technology can use some distributed technologies for emergency location systems. The automotive industry is an especially attractive dual use for this technology. The automobile manufacturers are being pushed to develop sensor management technologies with new car developments such as computer controls, GPS, onboard maps, and other intelligent features. Also, the technologies for sensor allocation and scheduling, and information sharing across multiple platforms will be a critical item for the Intelligent Vehicle Highway System being developed.

REFERENCES:
1. J. Diemunsch, "Wright Laboratory Sensor Management Efforts," 9th National Symposium on Sensor Fusion, 1996.
2. W. Bryan Bell, Multi-Path Resource Sharing CRADA Report, Advanced Mission Concepts, Lockheed-Fort Worth Company.

These references and additional references available by contacting Joe Diemunsch at (513) 255-4952

AF97-117 TITLE: Avionics Applications of Reinforcement Learning Systems

Category: Exploratory Development

OBJECTIVE: Develop methods to use reinforcement learning systems, utilizing residual algorithms, for the control and allocation of sensor resources.

DESCRIPTION: Utilize a residual reinforcement learning system to optimally manage/allocate sensor resources. The system is to be embedded in an airborne platform with a standard suite of sensor resources. Based on situational circumstances, the reinforcement learning system should learn the optimal allocation of sensor resources for the purpose of target identification. For example, the reinforcement learning system might control a low resolution sensor with a wide field of view for the detection of objects that might require further investigation. After detection, the reinforcement learning system should then position a high resolution sensor with a narrow field of view on these objects for the purpose of identification. Determine the scientific and technical feasibility of this approach, through analysis and simulation. Identify the possibilities of this approach for dual-use application to civilian problems.

PHASE I: Determine the scientific or technical merit and feasibility of the application of residual reinforcement learning to avionics sensor resource management/allocation.

PHASE II: Develop a product/process that utilizes residual reinforcement learning systems to optimally manage/allocate sensor resources.

POTENTIAL COMMERCIAL MARKET: The systems developed will be applicable to avionics problems in civilian aviation, and may be applicable to other optimal control and decision-making problems such as sensor management in cars or factories. For example, the automobile industry has an interest in robots that can perform more than a single function. The robot would decide the function to perform based on the object at hand. The process of object recognition and identification requires intelligent allocation of sensor resources. Another example of commercialization potential is in the home and business security industry. Security systems that utilize vision systems require the detection and identification of objects/people, and might use more than a single type of sensor. The technology developed in this SBIR would be directly applicable to foveal machine vision systems that are used in such security systems, as well as all other foveal machine vision applications.

REFERENCES:
1. Baird, L. C. (1995). Residual Algorithms: Reinforcement Learning with Function Approximation. In Armand Prieditis & Stuart Russell, eds. Machine Learning: Proceedings of the Twelfth International Conference, 9-12 July, Morgan Kaufman Publishers, San Francisco, CA.
2. Harmon, M.E., Baird, L.C., & Klopf, A.H. (1996) Reinforcement learning applied to a differential game. Adaptive Behavior, 4(1), 3-28.

These references and additional references available via World-Wide-Web: http://www.aa.wpafb.af.mil/~harmonme/

AF97-118 TITLE: Multiple Target Tracking for Avionics Platforms
Category: Exploratory Development

OBJECTIVE: Develop technologies to enhance avionics multiple target detection and tracking performance by sharing information between platforms.

DESCRIPTION: Innovative digital signal and image processing technologies which can be used to enhance the ability of Air Force avionics platforms ability to detect and track multiple targets are being sought. Some fighter aircraft systems share track file information between different platforms but better performance might be achieved by sharing detection information from sensors at different geometries and with different spectrum. This may particularly be true in scenarios where high false alarm rates occur because of low signal-to-noise ratios or ground clutter. The obvious approach of centralized fusion is impractical because of communication bandwidth requirements. Innovative approaches are needed which minimize communication requirements. The response should lead to significant improvements in one of the following areas where false alarms are a significant problem: detecting and tracking low signal-to-noise targets (detection false alarm rate - improve by 30% and tracking range - improve by 20%) e.g., F-16's tracking cruise missiles and tracking targets in clutter (improve false alarm rate by 30%) e.g., F-15 tracking low flying aircraft. The technology should be applicable to avionics sensors in development or on operational aircraft. This includes either active or passive sensors such as RADAR and Electro-Optical sensors.

PHASE I: As needed, reduce risk of proposed technology obtaining stated goals by developing necessary mathmatics and/or performing feasibility analysis. Make an initial assessment of implementation and trade-off issues. For instance, more fully develop the mathematical basis for an approach which reduces false alarms by fuzing detection data from multiple platforms. Analyze the on-board and off-board communication requirements for such an approach. Consider impact of alternatives. Develop the Phase II technology demonstration approach.

PHASE II: Demonstrate that the proposed technology can obtain stated improvements.

POTENTIAL COMMERCIAL MARKET: Potential application areas are distributed process-control systems used for vehicle and air traffic control.

REFERENCES:
1. Bar-Shalom and Fortmann, Tracking and Data Assocation, Academic Press, Inc., 1988.
2. Bar-Shalom and Li, Estimation and Tracking: Principles. Techniques and Software, Artech House, Inc., 1993.

AF97-119 TITLE: Biological and Cognitive Foundations of Holistic Information Fusion

Category: Exploratory Development

OBJECTIVE: Develop methods to employ Biological and Cognitive Sciences concepts to develop general-purpose, holistic information fusion algorithms and architectures.

DESCRIPTION: Information Fusion (a.k.a. Sensor/Data Fusion) is loosely defined as the process by which noise-corrupted data (potentially from disparate sources) is gathered, combined, reasoned-over, and new resource allocation decisions are made. In dynamic, uncertain, and high-stress warfare environments, information fusion is a formidable task--the dimensionality of the space of states and actions makes a comprehensive solution untenable for most realistic problems. Instead, the system designer typically invokes one of the fundamental tenets of systems engineering which we shall call "Divide and Conquer": A single, complex process is separated into subprocesses which are then solved independently. For information fusion systems this means that a single large, interrelated process involving gathering data (sensing), filtering data (kinematic and ID estimation), assessing situations, and deciding upon new information-effecting actions is separated into distinct sub-processes with predefined interfaces. Unfortunately, this approach can lead to suboptimal performance resulting from the requirement to contend with complex interactions between the subprocesses. Further, significant computational and communication burdens can be incurred by ensuring that the subprocess interfaces are robust enough to account for all of the complex interactions. Taken together, these problems work to limit the types of information a working system can accommodate. Presumably, the benefits of a holistic approach would include more robust performance with more efficient use of communication/computation assets. This would enable a wide variety of information, including sensor readings, contextual information, and pilot assessments, to be integrated into a single computational framework. Such an approach could also impact attempts to formulate a general-purpose information fusion processing model which currently does not exist.

This effort shall seek to broaden the technology base for intelligent information fusion systems by leveraging theoretical results from the biological and cognitive sciences toward developing a holistic, robust information fusion algorithm/architecture (algotecture). In the past, efforts to develop intelligent systems based upon biologically-inspired concepts have led to significant advances and new paradigms (such as reinforcement learning, various types of neural networks, generic algorithms, etc.). These continue to be fruitfully exploited by the research community. The vision of this work is to develop novel, biologically-inspired paradigms for holistic information fusion systems with comparable utility.

PHASE I: Under the first phase of this research, the contractor would develop a theoretical approach to holistically address the information fusion challenge in the most robust and efficient manner possible. The basis for the paradigms developed shall be inspired from biological and cognitive theories/models. These paradigms may be developed by reworking existing biologically-inspired models, or completely new models may be developed for this effort. The contractor would conduct simulation-based research to evaluate trade-offs between various paradigms. The specific information fusion problem to be addressed should reflect the environment of a tactical fighter in a high-stress situation. General details shall be decided upon by mutual concurrence at the kickoff meeting.

PHASE II: Under the second phase of this work, the contractor shall perform studies to evaluate theoretical and implementation trade-offs for the paradigm(s) developed under Phase I. The simulations used shall be of higher-fidelity than those used in Phase I.

POTENTIAL COMMERCIAL MARKET: The proposed effort will extend the theoretical foundations of information fusion. Since this research proposes to impact information fusion technology at a fundamental level, it is more likely to have a far-reaching effect. Aside from DOD applications involving military aircraft, ground and sea warfare, a variety of non-DOD applications are also envisioned; these include robotics, traffic control systems, industrial planning and control, flexible manufacturing, financial planning, and the "information superhighway."

REFERENCES:

1. E. Waltz, J. Llinas, MultiSensor Data Fusion, Artech House, Norwood, MA 1990
2. R. C. Luo and M.G. Kay, "Multisensor Integration and Fusion in Intelligent Systems," IEEE Trans. Syst. Man, Cyber., vol 19, no. 5, pp. 901-931, Sept./Oct. 1989
3. R.R. Murphy, "Biological and Cognitive Foundations of Intelligent Sensor Fusion," IEEE Trans. Syst. Man, Cyber., vol 26, no

AF97-120 TITLE: Solid State RF Electronics Applied Research

Category: Exploratory Development

OBJECTIVE: Explore innovative RF device and component technologies, and demonstrate concept feasibility.

DESCRIPTION: Investigate promising new microwave and millimeter wave circuit and component technologies with the potential to reduce the cost, weight, and volume, and increase the reliability/performance of military RF systems. Candidate technologies include microwave and millimeter wave solid-state and vacuum electronic devices, monolithic integrated circuits, computer aided design/characterization techniques, device and circuit fabrication, power and low noise amplifiers, signal control components, and mixed mode ICs. Emphasis will be placed on the development of technologies which reduce size, weight and cost through improved fabrication and higher levels of integration, and which are amenable to accurate modeling for improved design and simulation.

PHASE I: Determine the initial feasibility of the concept through design, physical analysis, mathematical modeling and analysis.

PHASE II: Develop key processes, validate the model experimentally, explore critical parameters, and optimize the design.

POTENTIAL COMMERCIAL MARKET: Commercial applications that will benefit from innovative electron device technological advancements include high temperature RF transmitters and mixed mode ICs for personal communications, and automotive collision avoidance/warning, and radiometric sensors for the medical industry.

REFERENCES:

1. D. Hill, A. Khatibzadeh, W. Liu, T. Kim, P. Ikalainen, "Novel HBT with Reduced Thermal Impedance," Microwave and Guided Wave Letters, Vol. 5, No. 11, Nov 1995.

2. B. Bayraktaroglu, J. Barrette, L. Kehias, C.I. Huang, R. Fitch, R. Heidhard, R. Scherer, "Very High Power Density CW Operation of GaAs/AlGaAs Microwave Heterojunction Bipolar Transistors," IEEE Electron Dev. Lett., Vol 114, No. 10, Oct 1993.

AF97-121 TITLE: Innovative Molecular Beam Epitaxy (MBE) Growth and Semiconductor Characterization Components and Techniques

Category: Exploratory Development

OBJECTIVE: Develop components and techniques to enhance the growth capability and understanding of MBE

DESCRIPTION: This effort will involve the ability to improve MBE semiconductor crystal growth capability by the design of innovative crystal growth and/or characterization components and techniques. These innovative components or techniques may either fit directly on an MBE machine, as in an effusion source, or support the MBE system in material characterization, as would a scanning tunneling microscope. The characterization may be either optical and/or electrical in nature. If the component is to go directly onto the MBE, it must fit on a Varian (GEN II-like system). The component or technique must emphasize nitride (wide bandgap) or antimonide (narrow bandgap) based III-V semiconductors.

PHASE I: Emphasis will be on the design and prototyping of the component or technique to determine feasibility.

PHASE II: Emphasis will be on the fabrication of the innovative component or technique with a demonstration of the capability and delivery to the Air Force.

POTENTIAL COMMERCIAL MARKET: Potential applications would be the growth, characterization and development of heterostructure lasers, microwave and millimeter wave transistors, infrared detectors and high temperature electronic components. Potential users would be military and commercial component vendors; MBE manufacturers: EPI, SVT and MBE machine users: Defense contractors (TRW, Hughes, Raytheon and TI), Government Labs (WL, ARL, NRL, NIST) and Commercial companies (HP, AT&T and Bellcore).

REFERENCES:
1. K.R. Evans, R. Kaspi, J.E. Ehret, M. Skowronski, and C.R. Jones, J. Vac. Sci. Tech. B, 13 1820 (1995).
2. J.F. Zheng, J.D. Walker, M.B. Selmeron and E.R. Weber, Phys. Rev. Lett. 72, 2414 (1994)

AF97-122 TITLE: Innovative Electro-Optic Device Technology

Category: Exploratory Development

OBJECTIVE: Develop electro-optic device technologies which offer expanded or new electronic functionality and/or improvement of electro-optical sensor capabilities.

DESCRIPTION: To meet the stated needs for future Air Force systems, further development of electro-optical component performance and functionality is required. Not only are these needs stated in terms of increased or new operational specifications, but there is also an expressed emphasis on achieving this performance at the lowest possible cost. The objective of this topic is to develop new and/or improved materials, devices, small to medium scale integrated circuits, and/or models or concepts which address: (1) detector or focal plane array sensors, expecially in the ultraviolet and infrared spectral regions; (2) focal plane array sensor readout/multiplexer circuitry to allow increased signal processing at the focal plane array itself; (3) low power light emitters/lasers for integrated circuit optical interconnect and associated applications; (4) optical switching devices, directional couplers, and related concepts; (5) modulation control devices and techniques, especially for microwave frequencies; and (6) other electro-optic techniques for increasing the speed, reducing the cost, size, and weight of icrowave/millimeter-wave or high speed digital electronics and integrated circuits which enhance current electronic functions.

PHASE I: Determine the initial feasibility of the concept through design, physical analysis, mathematical modeling, crystal growth, preliminary device fabrication and/or measurements.

PHASE II: Develop key processes, validate the model/device experimentally, explore critical parameters, optimize design, and fabricate demonstration devices, circuits, or interconnects.

POTENTIAL COMMERCIAL MARKET: Commercial applications that will benefit from innovative electro-optic device technological advancements include: (1) optical sensors for applications such as environmental monitoring and night vision; (2) high speed elctronics for computers and communication systems; and (3) diagnostic tools for the medical industry such as thermal imaging and miniaturized probes.

REFERENCES:
1. D.L. Smith and C. Mailhiot, "Proposal for Strained Type II Superlattice Infrared Detectors," J. Appl. Phys. 62(6) 2545 (1987).
2. R. H. Miles, D. H. Chow, J. N. Schulman, and T.C. McGill, "Optical Properties of InAs/GaInSb Superlattices," Appl. Phys. Lett. 57, 801 (1990)

AF97-123 TITLE: Support Technologies for Multichip Modules

Category: Exploratory Development

OBJECTIVE: Develop the support technologies required to produce affordable multichip assemblies.

DESCRIPTION: To meet the ever expanding need for increased functionality in advanced military systems requires the use of advanced IC technologies closely coupled to advanced packaging techniques such as multichip modules, chip on board and three-dimensional packaging. Many of these assemblies contain both analog and digital devices operating in close proximity to one another and must meet stringent size, weight, and power requirements while being able to operate over a wide range of temperatures (-55 degrees C to 125 degrees C). The objective of this topic is to develop the support technologies required to produce affordable multichip assemblies. Areas of interest include, but are not limited to design tools for mixed mode assemblies, including electromagnetic modeling and simulation tools; known good die; low parasitic interconnects, including microwave dielectric materials for three-dimensional packaging; protective coatings; thermal management techniques; testing methods; and improved assembly techniques.

PHASE I: Determine the initial feasibility of the concept through design, physical analysis, mathematical modeling, measurements, and, if possible, a prototype.

PHASE II: Develop key processes, validate models experimentally with hardware, explore critical parameters and optimize the design/assembly.

POTENTIAL COMMERCIAL MARKET: Commercial applications that benefit from innovative packaging technology advancements include high performance digital, analog and mixed mode assemblies such as found in computers, wireless communications, automotive and miniaturized diagnostics for the medical industry.

REFERENCES:
1. R.R. Tammale, "Microelectronic Packaging Handbook," 1989, Van Nostrand Reinhold.
2. Semiconductor Industry Association (SIA) "The National Technology Roadmap for Semiconductors

AF97-124 TITLE: Innovative Microelectronics Device Development

Category: Exploratory Development

OBJECTIVE: Develop innovative semiconductor device technology and demonstrate concept feasibility.

DESCRIPTION: Explore revolutionary new device concepts and conduct feasibility demonstration efforts on devices with potential for high frequency microwave/millimeterwave and high speed electronics applications, e.g., novel ideas for greatly increasing the speed of analog to digital converters with device cutoff frequency greater than 200 GHz and power consumption less than 1 uw/gate. Examine new device approaches to logic and electronic processing, ultrahigh speed digital switching devices and advanced semiconductor fabrication technology. Investigate promising microwave and millimeterwave solid-state devices such as microwave power device with power density greater than 20 mW/um2, monolithic integrated circuits and computer-aided design/fabrication. The intention of this program is to examine new device approaches, including existing devices such as Heterojunction Bipolar Transistors (HBTs), III-V Complementary Heterostructure Field Effect Transistors (C-HFETs), Metal Semiconductor Field Effect Transistors (MESFETs), and other very high performance devices (HEMTs, RTDs, etc.). Consideration will be given both to those technologies that promise reproducible circuits, and to the application of III-V nitride compounds to the device fabrication. Selection of the demonstration vehicles shall be based on customers future needs and the availability of suppliers transferring these technologies from a research to a production environment.

PHASE I: Device concepts, including material growth, characterization, and device development shall be completed, and fabrication feasibility, shall be demonstrated.

PHASE II: Functional demonstration vehicles and design of potential products shall be completed.

POTENTIAL COMMERCIAL MARKET: Commercial applications for low power, high density, high frequency IC technology include mobile communication equipment and networks, high density logic/memory components, and consumer electronics.

REFERENCES:
1. S.C. Binari, "GaN FETs for High Temperature and Microwave Applications," Proceedings of the Symposium on Wide Bandgap Semiconductors and Devices and the 23rd State-of-the-Art Program on Compound Semiconductors, Vol 95-21.
2. Semiconductor Industry Association (SIA) "The National Technology Roadmap for Semiconductors.

AF97-125 TITLE: Adaptive Computing for RF Device and Component Modeling

Category: Exploratory Development

OBJECTIVE: Investigate innovative RF device and component computer-aided engineering technologies, and demonstrate concept feasibility.

DESCRIPTION: Explore novel microwave/millimeter wave computer-aided engineering technologies. The goal is to achieve a major reduction in the cost of and time required for designing microwave/millimeter wave devices and monolithic integrated circuits. Candidate technologies include, but are not limited to, various computational intelligence methods encompassing: neural networks, fuzzy logic, genetic algorithms, evolutionary programming, and adaptive reasoning systems. Emphasis will be placed on the development of technologies that enhance areas which currently limit the efficiency of the microwave/millimeter wave computer-aided engineering design cycle.

PHASE I: Determine the initial feasibility of the concept through the development of prototype implementations and identification of opportunities for insertions into microwave/millimeter wave computer-aided engineering tools.

PHASE II: Develop and demonstrate prototype by insertion into microwave/millimeter wave computer-aided engineering tool, validate the implementation, identify candidate insertions into mainstream commercial microwave/millimeter wave computer-aided engineering tools to enable broad market access.

POTENTIAL COMMERCIAL MARKET: Commercial applications that will benefit include microwave/millimeter wave computer-aided engineering tools.

REFERENCES:
1. J.M. Zurada, "Introduction to Artificial Neural Systems," West Publishing Co., St. Paul, MN, 1992, pp 186-190

AF97-126 TITLE: Highly Sensitive Imaging Detectors for Laser Radar Systems

Category: Exploratory Development

OBJECTIVE: Develop highly sensitive imaging detectors for laser radar transceivers that operate at wavelengths longer than 1.4 micrometers.

DESCRIPTION: Laser radar systems have significant potential for imaging and targeting applications. The desire to use such systems to image unknown objects requires that the imaging function be performed at wavelengths that are eye safe; in other words, the wavelength should be longer than 1.4 micrometers. Such wavelengths are beyond the responsibility of typical silicon detectors. It is desired that the detectors operate at a minimum in the wavelength region from 1.5 micrometers to 2.5 micrometers, though operation out to longer wavelengths (5 micrometers) is desired. The detectors must operate uncooled or with moderate cooling at most (no cryogenics). Additional requirements include the ability to gather the entire image on a single pulse from the laser transceiver; therefore, the

receiver must contain multiple pixels. Minimum pixel counts would be 32 x 32, with greater than 64 x 64 desired. Another consideration is that the laser radar transceiver will image objects at long ranges, perhaps in excess of 20 kilometers. Because the return signal from objects at such ranges will be extremely small, it is desired that the detectors have some form of gain which would allow them to operate at or near the shot noise limit. A final consideration is to obtain full three-dimensional imagery the detector must be capable of being coupled to readout circuitry that will provide a range counter per pixel. Such circuitry is being developed by Wright Laboratory, WL/AAJT, and is described in the reference listed below. Approaches such as the use of avalanche photodiodes and fiber amplifiers have been considered in the past and are described in the reference below. Extensions of these approaches to single pulse imaging or other approaches that meet the requirements specified here are solicited.

PHASE I: Design and assessment of receiver architecture and critical detector component technologies. The approach to achieving single pulse, highly sensitive imaging of eye-safe laser energy will be defined. Critical issues associated with fabrication of the detector and integration with the appropriate readout circuitry will be defined and approaches to fabrication will be developed.

PHASE II: Fabricate and quantitatively evaluate an eye-safe detector with limited number of pixels. Critical issues associated with fabrication of the detector would be addressed and fabrication approaches would be demonstrated. Coupling of the detector to appropriate readout structures would also be accomplished.

POTENTIAL COMMERCIAL MARKET: Sensitive laser radar detectors at eye-safe wavelengths would greatly increase the potential applications of laser radar systems. Imaging in factories for process control, imaging for nondestructive testing, and imaging for surveillance and security are examples where this technology can be applied.

REFERENCES:

1. R.D. Richmond and R. Stettner, "Laser radar focal plan array for three-dimensional testing," Proc. SPIE Vol. 2748 (Apr 96).

2. J. A. Overbeck, M.S. Salisbury, M.B. Mark, and E.A. Watson, "Required energy for a laser radar system incorporating a fiber amplifier or an avalanche photodiode," Appl. Opt. 34(33), 7724-7730 (1995).

AF97-127 TITLE: Architecture and Components for Modular, Multifunction Electro-Optical (EO) Avionic Systems

Category: Exploratory Development

OBJECTIVE: Develop and define compact and affordable integrated multifunction open architecture EO systems.

DESCRIPTION: The ultimate desired EO system would perform a variety of mission-critical functions, including target detection and recognition, precision weapon delivery, covert communication with friendly aircraft, missile and laser warning, and countermeasures against IR and EO threats. The successful integration of multiple EO functions into a compact, low cost system will revolutionize battlefield awareness and precision engagement. Architectures and critical component technologies leading to this ultimate sensor are of interest in this effort. Areas of interest include:

a) Conformal optical apertures that will rapidly, agilely, and precisely steer, with no gimbals, both the incoming image information and outgoing laser radiation. A broad spectral range as well as a large steering angle capability is required for both the image and laser radiation.

b) Multifunction laser sources capable of target designation, of imaging at eye-safe wavelengths for target recognition, of covert optical communications, and of infrared countermeasures. These sources may be required to be sepctrally agile and coherent to increase the number of dimensions used in the target recognition space.

c) Sensitive infrared and laser receivers for target imaging and threat detection with high resolution and with multiple wavelengths.

d) Optical "backbone" for distribution of laser energy and connection/integration of optical apertures with common central processing.

PHASE I: Design and assessment of system architectures and critical components. Multifunction EO components will be designed, and detailed cost and risk assessments will be made. Methods of component integration will be defined.

PHASE II: Fabricate and quantitatively evaluate multifunction components at brassboard level. Develop detailed plan for integrated product in Phase III.

POTENTIAL COMMERCIAL MARKET: The multifunction technologies developed will have broad application to more conventional federated systems in military, medical and commercial arenas. The optical aperture technologies will find application in all surveillance sensors such as for facility security as well as for machine vision in robotics. The source and receiver technology will be directly applicable to remote sensing for pollution monitoring. Optical interconnection and distribution technologies development will support all manner of products in the fiber-optic communication industry, including phone line interconnects and chip-to-chip communications in computers.

REFERENCES:

1. P.F. McManamom, T.A. Dorschner, D.L. Corkum, L.J. Friedman, D.S. Hobbs, M. Holz, S. Liberman, H.Q. Nguyen, D. P. Resler, R.C. Sharp, and E.A. Watson, "Optical Phased Array Technology," Proc. IEEE Vol. 84(2), 268-298 (1996).

AF97-128 TITLE: Robut Multi-Function Laser Sources

Category: Exploratory Development

OBJECTIVE: Develop robust, multi-function laser sources which are insensitive to environmental changes.

DESCRIPTION: A robust, multifunction, compact laser source is needed for airborne applications where extremes in temperature, pressure, and vibration are present. Thus the laser source must be rugged and reliable with minimal maintenance. In particular, device performance in terms of beam quality and operating efficiency must be either insensitive to optical alignment or automatically aligned. A device with few or no moving parts is also highly desirable since every part in a laser device adds to its complexity and the possibility that malfunctions will occur. Maintaining high quality optical coatings over long periods of time under adverse operating conditions is also a reliability problem for laser sources; innovations which could make optics repeatedly exhibit greater than 10,000 hours between failure is needed. Finally, while the number of airborne applications for lasers increases, the available volume and power on an aircraft do not. A different laser for each application is not going to be viable. A laser source which is flexible in terms of repetition rate (10 Hz to 10 kHz), output pulse energy (joules to millijoules) and wavelength (1-12 microns) is needed to meet diverse needs in the areas of target designation, obstacle avoidance, laser radar, and infrared countermeasures. A multifunction laser source must also operate reliably under the environmental extremes experienced aboard a jet fighter aircraft.

PHASE I: Demonstrate the feasibility of an innovative technique, concept, or device which would lead to a major improvement in reliability, reduced maintenance, or multifunctionality.

PHASE II: Demonstrate a complete device suitable for flight testing which incorporates the innovation demonstrated in Phase I. Device performance will be tested under a full suite of environmental extremes including lifetime, failure modes, and multifunctionality.

POTENTIAL COMMERCIAL MARKET: A reliable, rugged, low maintenance, simple-to-operate laser source is needed for many commercial applications as well as military ones. A number of important commercial applications, especially environmental monitoring, are basically not being pursued because the available laser sources are too complex and expensive to operate. Other commercial applications, currently not even contemplated, would also appear once a simple and reliable laser source was available.

REFERENCES:
1. OSA Proceedings on Advanced Solid-State Lasers, Bruce H.T. Chai and Stephen A. Payne, eds. (Optical Society of American, Washington DC 1995) Vol. 24.

AF97-129 TITLE: Nonlinear Optical Frequency Conversion of Ultrafast Sources

Category: Exploratory Development

OBJECTIVE: Develop schemes for efficient nonlinear frequency conversion of ultrafast solid-state, fiber, and diode lasers.

DESCRIPTION: Ultrafast laser sources are enjoying a period of significant development and application. This work has been spurred by the emergence of practical ultrafast laser designs based on solid-state, fiber, and diode lasers. The short pulse characteristics of these lasers make them important tools for spectroscopic, remote sensing, and scientific uses. The high intensity of short pulses make them particularly useful in situations where high peak power is required. Thus in nonlinear frequency conversion, efficient interactions are obtainable with the high peak powers that are generated in ultrafast lasers. This topic will develop efficient nonlinear frequency conversion techniques using ultrafast laser pump sources while mitigating temporal dispersion effects. Applications for ultrafast sources can be found in all regions of the UV, visible, and IR spectrum. The use of conventional birefringently phasematched materials is

acceptable, but the new quasi-phasematched materials are of particular interest because of their capability to tailor the spectral properties of the phasematching.

PHASE I: Demonstrate a concept for nonlinear frequency conversion of an ultrafast solid-state, fiber, or diode laser, and establish the feasibility of the design and its potential utility.

PHASE II: Build a prototype system and demonstrate its applicability.

POTENTIAL COMMERCIAL MARKET: The commercial applications of this technology include environmental sensing systems for industrial process monitoring and pollution control. For example, the sensing of hydrocarbons is important in these applications, and it is a constituent of vehicle exhaust that may be used as a detectable signature by a multispectral sensor. Spectrophotometers and spectro-ellipsometers are optical instruments used in the characterization of material reflection/absorption and in measuring thin film thickness and refractive index. Coherent versions of these devices will be important for high accuracy measurements. The same spectral activity that makes the multispectral sensor of such interest ot the Air Force also makes these devices of great utility in spectroscopic applications. The monitoring of film deposition during semiconductor processing is a promising commercial application of a spectroscopic system using this technology.

REFERENCES:

1. "Advanced Solid-State Lasers," 1996 Technical Digest, Optical Society of American, Washington DC (1996).

AF97-130 TITLE: Coherent Spectroscopic Instrumentation

Category: Exploratory Development

OBJECTIVE: Develop coherent spectroscopic instruments such as spectrophotometers, spectroellipsometers, and environmental monitors.

DESCRIPTION: Present nonlaser based spectroscopic instruments have low brightness light sources (low power per unit spectral bandwidth) which limit measurement sensitivity and provide poor absolute accuracy. High brightness laser sources would provide better signal-to-noise ratio and hence allow for more accurate measurements. However, lasers generally operate at fixed wavelengths or have limited tuning over the technologically important spectral regions. Nonlinear frequency conversion, for example, optical parametric oscillators and difference/sum-frequency generators can produce a high brightness source with wide tunability. The objective of this project is to develop a coherent spectroscopic instrument which uses nonlinear frequency conversion to generate tunable wavelengths. The emphasis is the development of compact, practical sources suitable for scientific instrumentation or environmental sensing over distances typical of industrial facilities. Measurements of interest include transmission/reflection of low loss coatings and mirrors, accurate absorption and dispersion values for optical materials, precise thickness and index of films deposited or grown on substrates, and remote detection of environmentally sensitive gases in industrial processes and hazardous chemicals in military situations. Nonlinear frequency conversion using the new materials for quasi-phasematching may result in particularly efficient and widely tunable designs.

PHASE I: Develop a concept for a coherent spectroscopic instrument and demonstrate key technical aspects to establish its feasibility.

PHASE II: Build a prototype system of the coherent spectroscopic instrument and demonstrate its measurement capability.

POTENTIAL COMMERCIAL MARKET: The Air Force applications of this technology are primarily in new sensor systems. For example, innovative methods of propagation through the atmosphere have been demonstrated with ultrafast lasers, and nonlinear frequency conversion of these sources can be used to shift the wavelengths to that required for Air Force missions (e.g. >1.5 um for eye-safe operation, or 3-5 um for penetration of haze). Another example is the use of an ultrafast laser combined with a nonlinear frequency converter in the sensor receiver for efficient upconversion of the return signal.

Commercial application of this technology lies in making ultrafast laser sources available at wavelengths where direct laser devices do not operate well. This will broaden the market potential for the newly emerging ultrafast lasers.

REFERENCES:
1. "Advanced Solid-State Lasers," 1996 Technical Digest, Optical Society of America, Washington DC (1996)

AF97-131 TITLE: Digital Multifunction Sensor

Category: Exploratory Development

OBJECTIVE:Develop and design a digital multifunction sensor system for advanced airborne platform.

DESCRIPTION: Avionics sensor systems are on the verge of revolutionary advancements, due to, advancements in apertures, miniature filters, direct digital synthesis, analog/digital converters, amplifiers, and mixers. These advances are due to materials, packaging, interconnect, sealing, chip compaction and process control improvements due in large part to transmit/receive module development and commercial processor chip developments. This program will explore applications of new technologies based on sensor requirements and constraints to meet our far-term vision of multifunction digital RF sensors. Enabling Sciences have advanced from Material, Engineering and Mathematical sciences such as Statistics (Estimation Theory), Numerical Techniques (Adaptive Processing), and Communication Theory (IF Sampling). Thus, the combination of enabling science and technology gives hope/confidence that an all digital multi-function RF sensor suite will be accomplished and that this effort allow us to begin to understand the research required and technology needs associated with this vision.

1. Conformal Multifunction Array: Airborne antenna apertures of the future must be low cost, broad band, low radar cross section (RCS) and multifunction in nature to earn their way onto platforms where space is at a premium. To achieve these requirements, radically new aperture technologies need to be cultivated. This research explores a) pattern control for an aperture that is conformal to a doubly curved surface which has never been done before. Electromagnetic computational codes will be developed to rigorously predict the phenomena associated with scanning a beam on a generally doubly curved aperture, and b) the potential for generating multiple simultaneous beams on a general double curved surface which has never been done before. Electromagnetic computational codes will be developed to predict the phenomena associated with formation of multiple beams on a doubly curved surface.
2. System and Concept of Operation: 1) strategies for developing those technologies required to achieve an all digital multifunction RF system, 2) system and concept of operation studies to determine the benefits of potential off-board cues or bi-static operations, and 3) the benefit of multifunction waveforms to timeline loading and survivability through simulation analysis. These studies and analyses will attempt to balance the cost of ownership (i.e., acquisition, operating, and support costs), installation, and performance constraints.
3. Wideband Digital Antenna Electronics: Current antenna electronics at present assumes conventional Nyquist A/D technology. RF (at the microwave band of interest) is converted to IF and finally to baseband. This research explores the emerging Delta-Sigma A/D technology which presents an opportunity to modify the architecture to incorporate a set of dynamically tunable A/Ds that hop, digitize and filter signals at RF. This sampling technology could allow for the reduction of size, weight and cost of a sensor while increasing sensor performance and flexibility.
4. Advanced Spread Spectrum Filter Technology: Current sensor approach to acquire long pseudo-random sequences uses many parallel correlators to simultaneously search multiple Doppler windows. This research will determine the feasibility of using a new innovative signal processing approach which integrates the best frequency and time domain processing algorithm technology with monolithic microwave integrated circuit technology to implement a very cost effective matched filter.

PHASE I: Research and define a digital multifunction system or Subsystem including applicable technology trades, performance and cost trades.

PHASE II: Define systems interfaces for platform applications and build and test a critical sub-system.

POTENTIAL COMMERCIAL MARKET: Resulting technology applicable to automobiles or commercial aircraft for low-cost antenna, high performance antenna, or ultra-low noise communication system.

REFERENCES:
1. M.J. Povinelli, A Planar Broad-Band Flared Microstrip Slot Antenna, IEEE Trans. on Antennas and Propagation, Vol. AP-35, No. 8 Aug 1987, pp. 968-972.
2. K.M. Pasala, E.M. Friel, Mutual Coupling Effects and Their Reduction in Wideband Direction of Arrival Estimation, IEEE Trans. on Aerospace and Electronic Systems, Vol. 30, No.4, Oct 1994, pp. 1116-1121

AF97-132 TITLE: Digital Frequency Modulation

Category: Exploratory Development

OBJECTIVE: Develop digital frequency modulation capabilities for advanced active electronic attack (EA) techniques.

DESCRIPTION: Advanced coherent EA exciters require frequency modulation capability to effectively defeat certain threat radars. Current analog modulation schemes are counter productive to the digital advances being made in coherent exciters. Digital radio frequency memories (DRFM) have significantly enhanced the time domain performance of coherent EA subsystems. However, many modern threat systems are able to reject deception signals which only produce time domain perturbations. A critical need exists in these systems to provide coordinated time and frequency domain techniques. Having the capability to produce frequency modulations on the signal while in digital form has the potential to significantly reduce size, weight, cost, and power as well as enhance the time-frequency coordination of EA systems. Digital frequency modulation will also afford advanced coherent EA subsystems the capability for spectral content deception techniques that provide platform type "signatures." Limited past research has produced various digitally fed analog implementations where the digital modulation signal is converted to analog prior to mixing with the desired signal. The objective of this effort is to design, develop, and analyze a frequency modulation algorithm entirely with digital hardware.

PHASE I: Design a novel, advanced digital frequency modulation subsystem based on current Wright Laboratory performance requirements for EA applications. The design must be based on amplitued sampled digital words and impose the shift by digital manipulation. Consideration must be given to minimize the impact to data throughput time.

PHASE II: Develop prototype hardware and evaluate the proposed design in context of coherent digital EA systems for ability to provide coordinated time/frequency modulations and spectral content deception.

POTENTIAL COMMERCIAL MARKET: The developed digital frequency modulation has potential use in a variety of commercial applications such as digital communications, data packet coding, cellular telephones, cable and standard data modems, intelligent highways, and signal instrumentation.

REFERENCES:
1. A Digital Single-Sideband Modulator for A Digital Radio Frequency Memory, AFIT Thesis, Capt Thomas M. Foltz, USAF, Dec 1988.
2. Signature Development For A Digital Radio Frequency Memory Jammer Signal, AFIT Thesis, Capt Vicki M. Sundberg, USAF, Dec 1990.

References can be obtained by calling Marvin Potts at (513)255-4322

AF97-133 TITLE: Combinted Ultrawideband Radar/Communications Avionics

Category: Exploratory Development

OBJECTIVE: Develop an ultrawideband transceiver capable of performing short range radar and communication functions.

DESCRIPTION: Current avionics systems have been developed to provide only a single function. The large number of functions required from today's avionics and the shortage of payload volume and load carrying capability, especially in unmanned air vehicles (UAVs), necessitate the combining of functions and sharing of resources. Some missions, such as those of Special Operations Forces, require low-probability-of-intercept (LPI) radar and communications for formation flying and rendezvous. Hence, there is a need for a single avionics package that can perform radar ranging to a distance of 15 to 20 nautical miles (nm) and can transmit and receive digital communications at a maximum range of 100 nm with a data rate of 16 kilobits/second using featureless waveform technology. Such a system can be used for rendezvousing and communicating with refueling aircraft and other aircraft within a formation. It can also be used for navigation and radar altimetry by fixed and rotary wing aircraft, and for station keeping and control of UAVs. Use of spread spectrum, featureless waveform for both radar and communications will greatly enhance the survivability of the using vehicle.

PHASE I: Investigate various means of generating and receiving an LPI waveform that can be used for both radar and communications functions. Investigate beam steering methods that can be used for radar and communications. Develop a functional architecture for such a system. Determine military and commercial applications.

PHASE II: Design, fabricate and test a system in accordance with the Phase I functional architecture. Determine the suitability of using such a system on helicopters, light aircraft and UAVs.

POTENTIAL COMMERCIAL MARKET: This system has potential uses in commercial and general aviation for ground proximity warning, collision avoidance, and communication functions.

REFERENCES:

1. G.E. Prescott, D. Connolly, L. Gutman, "A Modulation Quality Factor for Low Probability of Intercept (LPI) Communication Systems," AGARD, Avionics Panel Symposium, Fall 90, Munich, Germany, 1-4 Oct 90.

Reference available by calling Dave Pleva at (513) 255-5565

AF97-134 TITLE: Chaff Dispenser Location Computer Model

Category: Exploratory Development

OBJECTIVE: Develop a model to determine the optimum aircraft location for chaff/expendables dispensers.

DESCRIPTION: Create a computer based model for Air Force and Navy application to assist in determining the optimum location for chaff/expendable dispensers. This program would model the 6 degree-of-freedom characteristics of the air flow across aircraft surfaces, vortices, jet engine exhaust, rotor or blade effects, winds, chaff pyrotechnics, type of chaff and dispenser location and position. With detailed models of the aircraft, the program will allow relocation of the dispenser or dispensers to any location on the aircraft. This effort will also assist in creating a chaff database to represent chaff RCS and Doppler for specific types of chaff. This program would be written such that it will run on a PC or workstation and will be incorporated into the existing MARCS (Missile, Aircraft, Radar, Countermeasures Simulation) electronic countermeasures simulation.

The utility of this type of computer program is to allow the user to run the program either as a stand-alone program or within the computer simulation MARCS to evaluate countermeasures effectiveness. The program would be available to the Tri-Service community, aircraft manufacturers and integration engineers for chaff dispensers, foreign countries and NATO.

Contractor performing work would have to be familiar with chaff/expendables, chaff/expendables dispensers, computer model generation and programming, and modifying the source code of MARCS (including the modeling chaff in MARCS data files).

PHASE I: Determine the initial feasibility of the concept through design, physical analysis, computer based modeling and analysis.

PHASE II: Develop validated computer model, explore critical parameters and design means of implementation.

POTENTIAL COMMERCIAL MARKET: There is potential commercial application of these models to aircraft such as Air Force One and for DOD contractors working on aircraft such as the F-22.

REFERENCES:
1. NAVAIR-16-1-539, "NAVAIR Expendable CM Directory."

AF97-135 TITLE: Global Positioning System (GPS) P(Y)-Code Acquisition

Category: Exploratory Development

OBJECTIVE: Develop and evaluate innovative techniques that utilize RF/EO technologies for GPS Direct P(Y)-Code acquisition.

DESCRIPTION: GPS acquisition is currently accomplished using Coarse/Acquisition (C/A) Code. C/A Code is 1 MHz Gold Code sequence that repeats every 1 msec. These properties make the C/A-Code easily acquired with relatively simple hardware. However, these same code properties make acquisition using C/A-Code vulnerable to jamming and spoofing. Acquisition of GPS using 10 MHz P(Y)-Code pseudo-random (PN) sequence greatly improves system acquisition jamming and spoofing immunity but makes acquisition of the code much more difficult. The difficulty stems from the fact that the jamming requires a large number of chips be integrated for each correlation. The P(Y)-Code chipping rate requires that a large number of correlations must be performed to search even small time uncertainties. Also large Doppler windows have to be searched for frequency uncertainty due to oscillator and doppler uncertainties. These factors create a two dimensional (time and frequency) area that must be searched to acquire the P(Y)-Code. The problem is further compounded by operational considerations which require this search be accomplished with affordable low power/small hardware, in a short period of time, and in a jammed environment. The current Direct P(Y)-Code acquisition approach uses a large number of parallel correlators and/or precise clocks. These approaches can achieve reasonable time-to-first-fix (TTFF) (several minutes) when searching time uncertainties on the order of 50 msec and frequency uncertainties of several hundred hertz for J/S ranging from 35-40 dB.

PHASE I: Investigate/develop RF/EO technologies and search techniques that have the potential to greatly improve the speed at which large time and frequency uncertainties can be searched. The acquisition time goal for this effort is less than 15 minutes for time uncertainty of 2 seconds, frequency uncertainty of +/- 300Hz and J/S of 43 dB. The approach and technologies chosen must have cost, size, and power consistent with the constraints of most GPS applications.

PHASE II: Optimize the design of the acquisition technique developed under Phase I and characterize the techniques performance using analysis, simulation and hardware demonstration.

POTENTIAL COMMERCIAL MARKET: This technique can provide commercial GPS receivers with a C/A code rapid acquisition capability. This technique can also be exploited by any real time signal processing application performing signal correlations such as spectrum analyzers, image/speech processing or coded telecommunications.

REFERENCES:
1. O. Brazzi, R. Torguet, C. Bruneel and J.C. Kastelik, "A Compact acousto-optic correlator for rapid GPS signal processing," IEEE Ultrasonics Symposium, Maryland, 1993.

2. O. Brazzi, R. Torguet, C. Bruneel, M. Gazalet and J. Rouvaen, "Space-integrating acousto-optic processor for rapid Global Positioning System signal acquisition," Optical Engineering, September 1994, Vol. 33 No. 9, pp. 2931-2935

AF97-136 TITLE: Avionics Modeling and Simulation Technology

Category: Exploratory Development

OBJECTIVE: Develop realtime and non-realtime simulation technology for collaborative engineering and virtual prototyping of avionics systems.

DESCRIPTION: The contractor will develop simulation technologies to enhance DoD productivity and commercial sector competitiveness by advancing real-time and non-real-time desktop collaborative virtual prototyping processes and applications. Proposals should build on the significant technology base existing for electronic systems design (VHDL, AHDL), Joint modeling and simulation (M&S) standards, and other commercial/industry modeling standards. Collaborative Virtual Prototyping (CVP) involves the application of advanced distributed modeling and simulation over a geographically disperse area using an integrated simulation environment to support design, performance, and producibility trade-off analyses throughout the entire life cycle of system development. The high-leverage Joint standards and M&S initiatives include the DoD High Level Architecture, Joint Simulation System (JSIMS), the Joint Warfare Simulation (JWARS) and the Joint Modeling and Simulation System (J-MASS). Using CVP, a simulation model, developed in parallel with the hardware or technology development, allows the scientist, engineer, or end user to refine system requirements early in the engineering process. A virtual prototype allows the engineer on the desktop to see the impact of design changes. Trade studies using the model can then be performed throughout development as an essential part of the systems engineering process. The Joint M&S Standards emphasize models based on reusable components. The virtual prototyping tools necessitate research in areas such as simulation engineering based on visual programming and visual assembly with domain specific icons and browsers, automated test, automated verification and validation, model based software requirements development, parallel automated documentation, automatic code generation with multiple language support, embedded configuration control, multimedia help and on-line documentation, domain specific toolkits for component developers to populate libraries, application developer toolkits to define requirements and compose model software from components, expert system assistants and domain specific software structural models.

PHASE I: The desired products of Phase I are 1) identification and development of applicable desktop M&S processes and requirements for avionics, 2) identification of the enabling realtime or non-realtime technologies for avionics M&S based upon employing J-MASS as the underlying modeling system, and 3) conduct of specific experiments to verify critical aspects of the defined concepts, 4) development of a system specification, implementation approach, and demonstration plan.

PHASE II: Design and develop the prototype technology and demonstrate the proposed technology in the appropriate Wright Laboratory System Concept and Simulation Division simulation facility. The contractor shall also detail his plan for his Phase III effort.

POTENTIAL COMMERCIAL MARKET: M&S is an enabling technology and a change in the way of doing business that will have major implications for the commercial and defense sector. Desktop M&S will become a mainstream concept in the design and production of commercial systems. The commercial marketplace will increase for generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in financial industries, manufacturing, industrial process control, biotechnology, health care, communication and information systems. Boeing demonstrated the success of integrated computer assisted design with supporting modeling and simulation in bringing to market the 777 airliner. Similarly, the automotive industry has used CAD and modeling for years. Advances in software and computer technology is making CVP and desktop M&S possible and affordable for the small to medium business. Software development itself is a manpower intensive endeavor. Requirements definition remains a problem area where the user is unable to verbalize what he/she wants in detail. Virtual prototyping of software requirements and modeling of the software is a future growth area in which simulation is used to review completeness of software requirements and functionality.

REFERENCES:
1. "J-MASS and Concurrent Simulation in the Laboratory Environment," NAECON Conference Paper, February 1996, Public Release Case Number ASC 96-0138.
2. "Avionics Wind Tunnel, Laboratory Interface Development," NAECON Paper, May 1993.

These references plus additional references are available at the WL/AASE Technical Information Center, contact William McQuay at (513) 255-4511 for additional information

AF97-137 TITLE: Electronic Design Automation

Category: Exploratory Development

OBJECTIVE: Develop electronic design automation tools and methods which support the design of complex analog and digital electronic systems.

DESCRIPTION: The Air Force continuously develops complex electronic components and systems for its weapons. Significant cost savings can be achieved if design times and design errors are reduced and the appropriate factors are considered during the initial design of this equipment. Electronic Design Automation (EDA) or Computer Aided Engineering (CAE) technologies play a key role in achieving a successful weapon system design while reducing its cost. The AF's primary interests are tools that a) allow technology independent, parameterized, automated generation of analog building blocks (i.e., op-amps, filters A/D converters etc.) b) allow high level synthesis of analog circuits from VHDL-A (the emerging IEEE standard), c) support the design of low power electronics (e.g., asynchronous logic or multivalued logic) d) dramatically reduce system design and verification time, e) help a design team view and manage complex designs, or f) that help a designer work with commercial-off-the-shelf parts. Inputs to a tool should be either an industry standard format such as VHDL or VHDL-A, libraries of design choices, or some other natural format that is intuitive to the design team member that is targeted to use this tool. Outputs should be compatible with other tools that are used in follow-on stages of the design process. The tool must have interfaces to the CAE or enterprise framework and data bases on which it is intended to operate. Duplication of capabilities that are already commercially available or that are already receiving significant investment by the DOD are strongly discouraged.

PHASE I: The preliminary design of the tool will be performed. The functionality, user interface, and design environment interface will be completely specified.

PHASE II: The tool will be constructed, evaluated, and demonstrated. Reference manuals and user guides will be developed.

POTENTIAL COMMERCIAL MARKET: All tools developed under this topic will be inherently dual-use. This is because the same methods used to design military electronic systems are applicable to commercial systems, although military systems design often includes additional requirements such as legacy system support and adverse operational environment support.

REFERENCES:
1. Antao and Broadersen, "ARCHGEN: Automated Synthesis of Analog Systems," IEEE Transactions on VLSI Systems, VOL. 3 No. 2, June 1995, pp. 231-244.
2. ANSI/IEEE 1076 VHSIC HARDWARE DESCRIPTION LANGUAGE (VHDL) REFERENCE MANUA

AF97-138 TITLE: Single-Mode Reliable Optical Card-Edge Connector

Category: Exploratory Development

OBJECTIVE: Develop, design and test a reliable, rugged, blind-mate single-mode optical connector for avionics modules.

DESCRIPTION: For decades research has been performed on solving the problems associated with optical connectors for avionics applications. Efficient and reliable bulkhead connectors have been in use for several years. However, blind-mate connectors for avionics line replaceable modules (LRM) need to be developed to reduce problems associated with fiber optics and photonics. The connector problems include the inability to maintain optical alignment, excessive damage under shock and vibration, contamination of exposed fiber ends, and degradation of the alignment sleeves and fiber surfaces. Other concerns result from transitioning from light emitting diodes (LED) to laser transmitters such as eye safety. To help alleviate these reliability and maintainability problems with optical networks in weapon systems such as the Air Force F-22 tactical fighter, a reliable, blind-mate optical connector using multimode fiber has been developed. A prototype was built, tested and transitioned to the F-22 program. This connector is fine for most digital applications. The next technology step is to develop a single-mode reliable optical connector. There are many benefits of developing this connector so that it can be used in optical systems with laser transceivers. Higher power margins can be achieved. Greater bandwidths than that of LED systems will be attained.

PHASE I: Will involve 1)establishing a preliminary connector design (either a new design or enhanced existing design), 2) providing a mock-up of this innovative design, and 3) creating a development plan for the chosen concept.

PHASE II: Will involve the detailed design, prototype development, and testing of this single-mode optical connector. This will include any demonstration applicable to a commercial application of this technology concept. The testing will include the rigors of the severe military environment and maintenance procedures to which the avionics and connector will be subjected.

POTENTIAL COMMERCIAL MARKET: Commercial avionics have become more sophisticated and faster, using laser transmitters. This connector can be used for sensor to processor data transfer and airline seat monitor and entertainment bus connections. Ground-based super computers with optical networks will require these for connecting peripherals, central processors, and monitors. Commercial space applications such as satellite and medical payloads require rugged connectors that operate in a harsh environment.

REFERENCES:
1. "Single-Mode Reliable Optical Card-Edge Connector (SROC)," IEEE/AIAA 13th Digital Avionics Systems Conference, Oct 30 - 3 Nov 94, Phoenix AZ

AF97-139 TITLE: Missile Warning System Scene Projection

Category: Advanced Development

OBJECTIVE: Develop an EO scene projection technology for missile warning system evaluation.

DESCRIPTION: The development and evaluation of missile warning system technology/enhancements have required extensive flight tests. Recent breakthroughs in digital IR scene generation capability developed for the Wright Laboratory Integrated Defensive Avionics Laboratory (IDAL) was transitioned to WR-ALC to provide a capability to perform hardware-in-the-loop simulations for developing algorithm/software enhancements for the AAR-44 missile warning system. This capability allows the development and evaluation of these enhancements prior to flight test. This capability significantly reduces the required flight tests and significantly increases WR-ALC's ability to respond to the warfighter's evolving missile threats. The current capability provides a digital scene that is injected into the missile warning system processor. Current EO scene projection technology is expensive and does not provide the required capability converting digital scenes to optically projected scenes that could be used to stimulate the missile warning system's sensor optics. This requires innovative research to define/develop EO scene projection technology that can interface to digital scene generators and provide an optical scene to stimulate missile warning receivers such as the AAR-44, AAR-47 and the joint service Common Missile Warning System (CMWS). This scene projection

technology would be demonstrated and utilized in the IDAL for the development of missile warning system technology.

PHASE I: Define the key technical requirements/issues, develop a preliminary concept/design and provide an implementation approach including feasibility and cost tradeoff analysis. Performance demonstrations of critical aspects of the design are desired to evaluate risk in proceeding with Phase II.

PHASE II: Develop, fabricate, demonstrate and document proposed concept/design. Based on the Phase II results, provide recommendations on how the resulting technology can be applied to fulfilling commercial needs.

POTENTIAL COMMERCIAL MARKET: This SBIR topic has dual use potential for the laboratory development of IR camera technology. The conversion process for transforming digital scene information into optically transmitted scene information has potential application to the television industry for quick response flat screen technology. The projection technology also has application to the commercial airlines industry for crew training using projection technology to stimulate the forward-looking infrared (FLIR) autonomous landing system being developed for category III landings (minimum ceiling visibility of 50 feet).

REFERENCES:

1. "Joint Modeling Simulation System 1995," NAECON Conference Paper, May 1995, Public Release Number ASC 95-0167.
2. "Avionics Wind Tunnel, Laboratory Interface Development," NAECON 1993.

These references and additional references are available from the WL/AASE Technical Information Center. For additional information, contact Roderic Perry at (513) 255-4264.

AF97-140 TITLE: Innovative Electron Beam (EB) Cured Structures

Category: Exploratory Development

OBJECTIVE: Develop a new class of low cost, highly efficient composite structures enabled by EB cure.

DESCRIPTION: The Air Force seeks to exploit the unique processing and tooling allowed by EB cured composite materials to develop new, low cost, highly efficient aircraft structural concepts. EB cure combined with advanced fiber reinforcement textile products and low cost processing techniques such as resin transfer molding (RTM), vacuum-assisted resin transfer molding (VARTM), and fiber placement shall be employed. Highly efficient structural concepts that are unproducible and/or unaffordable with two-dimensional lay-up and thermal autoclave cure materials shall be developed. Low cost tools made of wood, cardboard, plaster, and/or plastics shall be employed to fabricate the concepts. Highly unitized structural concepts with low part and fastener count featuring efficient load transfer through joints and intersections such as integral sin and substructure shall be developed. Highly efficient substructure concepts such as truss and geodesic webs shall be considered.

PHASE I: Small subcomponents shall be built to demonstrate the feasibility of the fabrication process and evaluated to provide the initial demonstration of structural efficiency.

PHASE II: Full size structural components shall be designed, fabricated, and tested to demonstrate the structural design concept and validate the manufacturing and tooling approach.

POTENTIAL COMMERCIAL MARKET: Low cost EB cure composites will create new multi-million dollar markets for high performance composite materials in cost driven commodity type products. The use of high performance composites is currently limited to premium cost products. EB cure composites could enable a significantly greater use of composites in commercial automobiles, trucks, buses, and trains leading to significant weight savings and improving fuel efficiency thereby reducing consumer energy costs. EB cure composites will enable application to an array of economical consumer products from lightweight appliances and bicycles to fishing poles and power tools. A great

market potential also exists for application to lightweight, long life, corrosion free composite building components such as columns, beams, and girders for public bridges and buildings.

REFERENCES:
1. "Electron Beam Curing of Composite Materials," WL-TOPS-07, Delivery Order 07-00, Report Volume 1.

AF97-141 TITLE: Distributed Actuation for Aircraft Maneuver and Performance Enhancement

Category: Exploratory Development

OBJECTIVE: Develop innovative concepts in actuation, distributed throughout the structure, to achieve aircraft maneuver and performance enhancement.

DESCRIPTION: Innovative concepts are solicited in the use of smart/distributed actuation as applied to flight vehicle structures. The employment of such concepts can effect both the performance characteristics and the total weight of aircraft. The elimination of the need for conventional, discrete control surfaces can have major impact on flight vehicle weight, drag, and signature. Other distributed actuation concepts can be applied to structural problems such as buffet alleviation, flutter suppression, vibration isolation critical components, and anti-icing. (The results of a recent SBIR feasibility study in the area can be found in the reference.)

PHASE I: Perform a feasibility study (primarily analytical) of employing the selected concept to either a current operational vehicle or to a new vehicle design. Determine the payoff of using the concept in terms of vehicle performance or in solving light vehicle structural problems. Estimate the weight impact of the new concept versus conventional designs.

PHASE II: Perform ground or wind tunnel tests (or both) to validate the concept developed in Phase I.

POTENTIAL COMMERCIAL MARKET: Distributed actuation can be used to design lighter weight commercial aircraft. In addition, many of the concepts (distributed actuation for vibration suppression, for example) have nonmilitary, nonaerospace uses and can benefit from concept feasibility studies.

REFERENCES:
1. Lazarus, Kenneth B., Saarmaa, Erik, and Agnes, Gregory S., "An Active Smart Material System for Buffet Load Alleviation," Proceedings of the 1995 North American Conference on Smart Structures and Materials, "Industrial and Commercial Applications of Smart Structures Technologies," SPIE Vol. 2447, 2-3 March 1995.

AF97-142 TITLE: Structural Integrity of Aging Aircraft

Category: Exploratory Development

OBJECTIVE: Develop methodologies for determining, assessing, and predicting the effects of various forms of aging aircraft damage.

DESCRIPTION: A variety of critical service problems are currently plaguing our aging aircraft fleets and threatening them with grounding or shortened service lives because accurate methodologies for prediction and assessment do not exist today. These problems include but are not limited to corrosion fatigue, widespread fatigue damage (WFD), fretting fatigue, fretting corrosion, joint debonding, composite delamination, and composite impact damage. Research efforts should involve generating analytical methodologies, validating these methodologies through experimental testing, and integrating these methodologies with existing aging aircraft computer codes. These models shall be suitable for integration into PC or workstation based deterministic fatigue crack growth, probabilistic risk assessment, and/or repair design and analysis computer programs. Emphasis areas are (1) fretting fatigue and fretting corrosion including testing techniques for validation (e.g. correlation of fretting corrosion and fatigue data produced in laboratory

environment with data from aging aircraft by developing the appropriate transformation functions), (2) deterministic fatigue crack growth analysis model (e.g. in the plastic zone), (3) advanced life extension techniques (e.g. laser shock processing, ion implantation), (4) advanced analysis methodologies of composite repairs on metallic structures, (5) low velocity impact damage of bonded composite repairs on metallic structures, and (6) concept of equivalent initial flaw size.

PHASE I: Develop computer code modules suitable for integration with existing deterministic, probalilistic, and/or repair analysis computer programs as well as advanced life extension techniques.

PHASE II: Methodologies and techniques developed in Phase I will be validated by experimentation.

POTENTIAL COMMERCIAL MARKET: The methodologies and techniques are directly applicable to aging commercial aircraft as well as to new commercial aircraft. Also, the potential for use is extremely high in the automotive, shipping, railroad, nuclear and space industries.

REFERENCES:

1. Waterhouse, R.B. "Environmental Effects in fretting, Fatigue, and Fretting Fatigue," 10th International Congress on Metallic Corrosion., undated.
2. Buhler, K and Grandt, A.F. "Analysis of Multiple Site Damage With Implications for Nondestructive Evaluation." Twenty-first Annual review of Progress in Quantitative NDE, Snowmass Village, CO, July 31 - August 1994.
3. Sun, C.T. and Arendt, C. "Analysis of Cracked Aluminum Plates Repaired with Bonded Composite Patches," Proceedings of the 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference (SDM), New Orleans LA, 10-14 April 1995.
4. Rohrbaugh, S.M., Hillberry, B.M. and D. Ruff, "A Probabilistic Fatigue Analysis of Multiple Site Damage: Influence of the Number of Fastener Holes," ICAF '95, International Committee on Aeronautical Fatigue, 18th Symposium, Melbourne, Australia, 3-5 May 1995.
5. Granadt, A.F. "Analysis of Multiple Site Damage in Aging Aircraft, "Symposium of Aging Structures, Joint Applied Mechanics and Materials Summer Conference, ASME, Los Angeles CA, 28-30 June, 1995.
6. Szolwinski, M.P. "Mechanics of Fretting Fatigue Crack Formation," M.S. Thesis, School of Aeronautics and Astronautics, Purdue University, August 1995.
7. Arendt, C. P. and Sun, C.T. "Bending Effect of Unsymmetric Adhesively Bonded Composite Repairs on Cracked Aluminum Panels, " FAA/NASA International Symposium on Advanced Structural Integrity Methods for Airframe Durability and Damage Tolerance, Hampton VA, 17-18 May 1994.
8. Arendt, C.P., "An Efficient Plate Finite Element Model for Analysis of Cracked Metallic Plates Repaired with Composite Patches," M.S. Thesis, School of Aeronautics and Astronautics, Purdue University, July 1994.
9. Gallagher, J.P., Dhar, S., Berens, A.P., and J.G. Burns. "A Comparison of Fracture Criteria for Crack Coalescence and Other Observations Based on residual Strength Calculations," Paper Presented at the U.S. Air Force Structural Integrity Conference, San Antonio, Texas, December 1993.
10. Mar, J.W. "Structural Integrity of Aging Airplanes: A Perspective," Structural Integrity of Aging Airplanes, S.N. Atluri, S.G. Sampath, P. Tong, Editors, Springer-Verlag, Berlin, Heidelberg, 1991.
11. Mar, Park, J.H. and Alturi, S.N. "Fatigue Growth of Multiple-Cracks Near a Row of Fastener-holes in a Fuselage Lap-Joint," Paper Presented at the U.S. Air Force Structural Integrity Conference, San Antonio, Texas, December 1992.
12. Denney, J.J. "Fatigue Response of Cracked aluminum Panel with Partially Bonded Composite Patch, " M.S. Thesis, Air Force Institute of Technology, Wright-Patterson AFB OH, December 1995.
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AF97-143 TITLE: Flight Control Technology

Category: Exploratory Development

OBJECTIVE: Develop affordable flight control technology to support Air Force Global Reach, Global Power objectives.

DESCRIPTION: The Air Force is interested in the development of one or more of the following advanced flight control technologies for future air vehicles: a) computation based implicit air data systems, b) scalability of flight control test results between air vehicles lacking geometric similitude, c) closed-loop flight control of tactical aircraft with flexible structures, d)miniature actuators using smart materials for high response changes in wing shapes, e) virtual channel real-time fault tolerant computing architectures/techniques, f) multiple frequency optical multiplexing for fault tolerant flight control communication, g) domain based graphical software that automates and integrates redundancy management, mode logic, and interface programming with control law development, h) real-time optimization algorithms for engagement solutions for cooperative uninhabited air vehicles (UAV) and multiple target, i) optimization of UAV formation flight between aerodynamic benefits (reduction of induced drag) and sensing benefits (resolution of distributed aperture radar), j) development of an electronic, retrievable stability and control data base for various aircraft configurations based on both linear and nonlinear wind tunnel data, and k) development of flying qualities guidelines and criteria based on quantitative pilot workload assessment methods.

PHASE I: Expectations include determining the feasibility, preliminary concept identification and requirements definition. Some specific examples are photonic interface module design, control software interface design description.

PHASE II: Expectations include hardware fabrication, ground testing, simulation or flight testing, and validated, executable software code. Some specific examples include photonic interface fault tolerant communication elements built and lab tested, complete flight control software design tool built and demonstrated.

POTENTIAL COMMERCIAL MARKET: All of the items in this SBIR topic are generally applicable to both the civilian and military aircraft sectors. The technology developed will provide for greater integration at the system level, more affordable configurations, more efficient and supportable flight control architectures, and the ability to operate air vehicles safely and effectively in an internetted environment. All commercial aircraft manufacturers, suppliers, and airline would benefit from this technology.

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AF97-144 TITLE: Tactical-Uninhabited Air Vehicle (T-UAV) Operator Station Simulator

Category: Advanced Development

OBJECTIVE: Develop, design, and demonstrate an operator station simulator for T-UAVs.

DESCRIPTION: Future DOD plans envision a T-UAV operator controllingmultiple vehicles. Operators require a simulation station to effectively train to control these platforms. Technology development personnel need a facility for research, testing, demonstration, and evolution. It is envision that a two-person station could control up to eight T-UAVs. A simulated operator station would provide operator trinees the means to monitor the vehicles' operation from both a strategic and tactical point of view. Such a station would also allow for control of the simulated vehicles through an interactive interface. The station would interact with other advanced flight management systems such as decision iaides and situation assessment systems. The aim of this program, then, is to research and design a T-UAV operator station simulator that allows for strategic and tactical displays and interactive control, considering human

factors wngineering issues. An innovative approach is sought that takes into account advanced display hardqare technology, informtion display formats and controls, decision aides, and operator/vehicle interfaces.

PHASE I: Simulation station requirements definition to include an analysis of available advanced display technologies, mission definition and analysis, and T-UAV operationa requirements. Design an operator simulation station based on requirements analysis. Design should identify hardware and software requirements needed to implement prototype station and should include an interface control document. Limited prototype demomstation and evaluation of key design features.

PHASE II: Implement a prototype capability based on the design defined in Phase I. Demonstrate prototype operation ofr several T-UAV missions. Integrate prototype with established operator/vehicle interface technology deelopment facility.

POTENTIAL COMMERCIAL MARKET: The commercial potential of this work includes air traffic control, land surveys, drug interdiction, search and rescue, and, forest fire control.

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18. Fulghum, David, A. "Air Force Prepares New UAV Acquisition, Operations," Aviation Week and Space Technology, v 143, p. 52, 27 November 1995

AF97-145 TITLE: Full-Color Autosterographic True Three-Dimensional Displays

Category: Exploratory Development

OBJECTIVE: Develop an autosterographic true 3D display that is fully addressable, interactive, operator position independent, without special user equipment.

DESCRIPTION: Current technology portrays the world through the limitations of two-dimensional displays. These limitations restrict the perception of depth and viewing angles in complex scenes and object interactions. A true three-dimensional display will yield a more realisitic representation of the world that will simplify its understanding to a human observer. This will be especially useful t support control of multiple remotely operated air vehicles in complex, high workload environments. The objective of this effort is to develop the technology for a true three dimensional, full color autosterographic display system that produces images in true three dimensional space. This display will define a fully addressable, high resolution array of XYZ points in space for drawing solid surfaces, stick figures, and readable text. The display system will be high speed and capable of real time operation with a minimum of 60 3D frames per second. It must supply means for user interaction and a complete lookaround viewing capability. The design must include provisions for safety, considering a naked-eye operator/viewer, with no speacial equipment requirements.

PHASE I: Generate a design for an autostereographic full color, true three-dimensional display system. Detemine display's maximum display volume, spatial resolution in XYZ space, refresh rate, number of colors, brightness, contrast, and graphics performance (e.g., 3D vectors, polygons). Define the display's specifications e.g., RGB input, RS-170A input) and requirements (e.g., input voltage), as well as its programming and user interfaces. Produce an analysis on how to integrate such design with WL/FIGP's laboratory facilities.

PHASE II: Design and build a working prototype 3D display system based on the results and conlusions of Phase I.

POTENTIAL COMMERCIAL MARKET: Three dimensional displays (3D) have wide applications in commercial ad military markets. Three dimensional displays have the potential of replacing current two- dimensional displays. Commercial applications include television, NMRI medical displays, air traffic control, remote vehicles operation, robotics, and remote telepresence operations.

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AF97-146 TITLE: Global Diagnostic System for Unsteady Flow Fields

Category: Engineering Development

OBJECTIVE: Develop a nonintrusive flow diagnostic instrument capable of making off-body, global measurements of unsteady flowfields.

DESCRIPTION: Substantive advancements in both military and commercial flight vehicles hinge on understanding and exploiting unsteady flow phenomena. Wind tunnel tests require detailed quantitative measurements of flow variables (velocity, pressure, density, temperature) throughout the flow field to understand the flow phenomena and to validate computational fluid dynamics codes. Since probes inserted into the flow field may disturb the flow, these data must be taken by nonintrusive means. Furthermore, to allow detailed investigation of unsteady flow fields, these methods must allow simultaneous measurements on entire planes or volumes in the flow field. Some planar methods, such as Doppler Global Velocimetry (DGV) are capable of making global velocity measurements in the flow field. Others, such as Planar Laser Induced Fluorescence (PLIF) are capable of making density measurements. All these methods face limitations in unsteady flow fields because of the amount of data which must be acquired at high speeds. These methods also have limited dynamic range. A new method to augment these techniques or extend the dynamic range or accuracy typical of these techniques is desired. Ideally, this method would simultaneously provide information on multiple flow variables throughout the flow field. Furthermore, the dynamic range of an ideal technique would allow measurements of velocities ranging over at least 3 orders of magnitude in subsonic flows. This method must provide nonintrusive measurements and would most likely be optically based. The technique must be usable in wind tunnels with limited optical access. The technique should account for distortions due to nonoptical quality wind tunnel windows (e.g. plexiglass). Any seeding material used must be environmentally nonhazardous. The data acquisition hardware required to provide temporal resolution of unsteady flow fields for such a method may also need to be developed. This would require shutter speeds of less than 0.1 millisecond and frame rates of approximately 1kHz.

PHASE I: Phase I activity would identify a new diagnostic system or substantial advancements or improvements to existing techniques. The optical requirements, wind tunnel modifications, computer requirements and data reduction techniques applicable to this task would be identified and the feasibility of the technique wold be demonstrated.

PHASE II: Phase II would design and build the diagnostic system, including any specialized data acquisition hardware and data reduction software and install the system in the Subsonic Aerodynamics Research Laboratory (SARL) wind tunnel in Wright Laboratory, or other facility, as suitable.

POTENTIAL COMMERCIAL MARKET: Significant advances in flow-field diagnostics have the potential of making a tremendous impact in the commercial aircraft, automotive and trucking industries. Improved fuel economy due to decreased vehicle drag might be achieved cost effectively by using enhanced diagnostic systems. Commercial wind tunnel tests may become simpler and less expensive while yielding orders of magnitude more data than are possible using existing testing techniques.

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2. Beutner, T.J., Baust, H.D., Meyers, J.F., "Doppler Global Velocimetry Measurements of a Vortex-Tail Interaction," Proceedings of the Seventh International Symposium on Flow Visualization, Seattle, WA, pp 428-423, September 1995.

AF97-147 TITLE: Cost Estimating Methodology for Advanced Air Vehicles

Category: Advanced Development

OBJECTIVE: Develop cost estimating model for advanced air vehicles.

DESCRIPTION: Affordability is a major factor in the development of advanced air vehicles technologies. The emphasis in developing affordable advanced air vehicles requires proper measurement of the impact of new technologies in the cost of developing advanced air vehicles. The Air Force Scientific Advisory Board new World Vistas Study "recommends that research efforts be established to define fundamental principles for cost determination and that all S&T projects consider the proper balance between life cycle cost and capability." Trade-off studies used to determine which new technology may give the best return on investment are limited due to the lack of existing cost estimating tools that do not address the impact of new technologies on air vehicle designs. Parametric cost estimating relationships (CERs) relying on historical, as-built data, cannot capture effects of advanced materials and technologies. Weight-based CERs only address existing materials mixes and do not take into account the functional complexity of a system, which in some cases drives the cost. Engineering build-up methods are labor intensive, manufacturer specific, and with a show turnaround. The development of a cost estimating tool that will address new technologies impacts in a more realistic manner is desired. Ideally, this development would take into consideration the favorable characteristics of parametric cost estimating relationships and engineering build-up methods, to provide a cost estimating tool that would yield a more reliable, realistic conceptual level life cycle cost estimate of the impact of new technologies in the development of advanced air vehicles. It is desirable that this tool would be developed to be used by design engineers and technical cost analysts.

PHASE I: Phase I would identify a new cost estimating tool and its feasibility, or major improvements to existing tools.

PHASE II: Phase II would develop and test the tool. This phase would include baseline testing for correlation purposes, as well as integration with existing conceptual/advanced design tools to provide a complete suite of tools that would be available to the design community.

POTENTIAL COMMERCIAL MARKET: Air Force, Navy, and industry have expressed interest in developing a cost estimating tool that would properly address advanced technology insertions and their impacts in conceptual and advanced air vehicle design. Affordability will dominate development, procurement, and operation of future weapon systems. Cost prediction is essential to the determination of affordability. The commercial sector would benefit from the development of a cost estimating tool that would provide more realistic estimates of the impact of new and advanced technology insertion in future (post JAST) advanced air vehicle systems. This will result in development of affordable, high performance advanced air vehicle systems.

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2. Beltramo, M.N.; "A Critical Look at the Development and Application of Airframe Cost Models," Society of Allied Weight Engineers, Annual Conference, 41st, San Jose, CA, May 17-19, 1992.
3. Lamar, W.E.; "A Review and Assessment of System Cost Reduction Activities," AGARD CP-289, "Design to Cost and Life Cycle Cost," Flight Mechanics Panel Symposium on Design to Cost and Life Cycle Cost, Amsterdam, Netherlands, 1980.
4. Marks, K.E.; "An Appraisal of Models Used in Life Cycle Cost Estimation for USAF Aircraft Systems," Report R-2287-AF, Rand Corporation, October 1978.

AF97-148 TITLE: Aeromechancis for Future Aircraft Technology Enhancement

Category: Exploratory Development

OBJECTIVE: Develop aeromechanics technology to achieve affordable fighter aircraft with advanced maneuverability, extended range, and high survivability.

DESCRIPTION: The Air Force has a vital interest in the development of manned and unmanned aircraft with significant advancements in flight performance and mission effectiveness These advanced air vehicles will rely on innovation in aeromechanics technology to achieve new levels of speed, maneuverability, range, payload capability, low life cycle cost, and rapid design development. Advancements are needed in the following areas: a) accurate engineering design methods for determining aerodynamics characteristics and flight performance of unconventional aircraft, b) rapid efficient computational fluid dynamics methods to describe the airflow about air vehicles in rapidly maneuvering flight, c) flow control devices such as MEMS and active compliant surfaces which can be used to reduce drag or prevent flow separation, d) methods to improve the accuracy and reduce the cost of wind tunnel experiments through more accurate measurements and extrapolation of subscale results to flight, e) efficient integration of inlets and nozzles, and f) innovative aircraft configurations which produce advanced performance capabilities.

PHASE I: Define the proposed concept, outline the basic principles, establish the method of solution. Present an example of the advanced performance which will result from the technology. Determine the risk and extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions.

POTENTIAL COMMERCIAL MARKET: Improved performance and safety of commercial and private aircraft will be realized with application of this technology. New areas of commercial growth will result from aircraft design tools which allow fast and accurate development of vehicles to respond to aircraft needs throughout the world. Examples are devices which allow aircraft to operate from remote fields, carry large payloads at low cost, and are economical to produce and operate. New aerodynamic analysis tools will improve education methods and allow industry to produce with lower initial investment. Advanced experimental methods are applicable to more efficient ground transportation systems.

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AF97-149 TITLE: Fire Detection/Suppression Systems

Category: Basic Research

OBJECTIVE: Develop advanced firefighting technologies that can significantly improve fire detector efficiency and increase fire suppressant performance.

DESCRIPTION: The Air Force has a critical need for improved fire protection capabilities. Firefighting is being revolutionized by increasing environmental concerns. Front-line fire extinguishing agents caused environmental concerns. Similarly, firefighter training with hydrocarbon fires has been severely restricted. Current fire detection

systems cannot discriminate against all potential false alarm stimuli and have resulted in the loss of vital Air Force resources and costly cleanup operations. New environmentally safe and effective fire detection/suppression systems are required. Some of these areas include but are not limited to the following:

1. High Speed Suppression via Cold Inert Gas Generation - Fire extinguishment by inert gases is an effective means of protecting electronic and electric equipment. Large volumes of inert gases can be generated by thermochemical means to suppress potentially dangerous fires rapidly and effectively. This proposed research will develop a system that rapidly generates cold inert gases for rapid extinguishment of electronic/electric fires.

2. Optical Pre-warning Gas and Flame Detection - Current fire detection technologies generally depend on the presence of a flame before corrective action can be taken. An open path gas detection system that can provide early warning of flammable or toxic gas presence will significantly improve fire protection, safety.

3. Computational Fluid Dynamics Fire Suppression Systems Design Tools - The high cost of new fire suppression agents emerging from laboratory development makes medium and large scale testing of these agents in fire suppression delivery systems prohibitively expensive. This research will produce a set of design tools that can be used to design, at low cost, fire suppression delivery systems that incorporate current and future Halon 1301 and Halon 1211 replacements.

PHASE I: Development of preliminary design of cold gases and path detectors.

PHASE II: Build and test prototypes for field testing using results obtained in Phase I.

POTENTIAL COMMERCIAL MARKET: All commercial facilities and industries where rapid fire detection and suppression would increase the survivability of people and resources, including but not limited to the automotive industry, commercial cruise lines and/or other sea transportation, and any other industry where the use of high speed turbine engines are the primary source of power.

REFERENCES:

1. "Computational Fluid Dynamics Modeling of Fire Suppression Events," National Research Council (Canada), June 1993.

2. Fire Extinguishing Pyrotechnics "Proceedings of the Eighteenth International Pyrotechnics Seminar," Breckenridge, Colorado, p. 701, July 1992

AF97-150 TITLE: Innovative, Localized, Autonomous Cooling Systems

Category: Exploratory Development

OBJECTIVE: Develop localized, autonomous cooling system capable of dissipating large power densities with moderate cooling capacity.

DESCRIPTION: The increased performance, compact packaging, and variable operation cycles associated with future aircraft systems and retrofits of existing fleet aircraft systems lead to both increased power densities and transients. Additionally, these systems, which include actuators and electronic components, are being positioned in the extremities of future high performance aircraft. These trends necessitate the advancement of the state-of-art in localized or distributed cooling concepts that can meet the power densities associated with future electronics and the thermal transients pertaining to "on demand" systems. The cooling system must be "environmentally friendly" and compatible with lightweight aircraft structures and avionic equipment. It must also have affordability benefits and good producibility for practical application. It shall be capable of dissipating large power densities of up to 100 W/cm2 with moderate cooling capacities of up to 2 kW while being exposed to aircraft environments1.

PHASE I: During Phase I, analysis and conceptual design work will be performed to evaluate the heat transfer effectiveness and energy dissipations capability of the proposed localized, autonomous cooling systems. This analysis and conceptual design will also address the concepts compatibility with aircraft and electronic systems. The design will show sufficient technology maturity for orderly development into aircraft systems with compatible environmental factors. The Phase I work will produce a competent technical report and plans for experimental development in a proposed Phase II effort.

PHASE II: This phase continues the necessary analytical work and provides experimental verification of predicted heat transfer capability for the localized cooling system. Laboratory simulation of typical operating conditions will evaluate performance at different temperature and power conditions. Any environmental restrictions will be assessed. Benefits to be gained from the use of the heat transfer system will be quantitatively established for different potential applications to prepare for possible commercial development of the system. A competent technical report will document all of the work conduct, a final optimized designed will be completed, and an optimized localized cooling system will be fabricated.

POTENTIAL COMMERCIAL MARKET: Dual use commercialization will be considered in all phases of this effort. Commercial markets could include commercial aircraft, large machinery for agriculture and transportation, electronics, and automobiles.

REFERENCES:
1. Mil-Std-810D, "Military Standard Environmental Test Methods and Engineering Guidelines."
2. "The Development of Advanced Cooling Methods for High Power Electronics," T.J. Bland, et al., SAE Paper 9011962, Presented at the SAE Aerospace Technology Conference and Exposition, Long Beach CA, October 1-4, 1990.
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4. "Cooling of Electronic Boards using Internal Fluid Flows," K.E. Herold, S. Sridhar, and S. Hu, Proceedings from the First Joint ASME/JSME Conference on Electronic Packaging, Milpitas CA, April 9-12, 1992, pp. 285-290.

AF97-151 TITLE: Spall Fragment Field and Surface Deformation Characterization System

Category: Exploratory Development

OBJECTIVE: Develop a quantitative spall fragment field and surface deformation system.

DESCRIPTION: This effort involves the development of a quantitative means of recording the spall fragment field and surface deformations produced by projectile penetration of composite materials. The system will be used by Wright Laboratory to characterize the fragment field's kinetic energy distribution (i.e., particle size and velocity vector distributions) and threat-target interactions resulting in surface deformation. Required system capabilities include quantifying the dynamics of selected individual fragments over a protracted period of time, together with characterizing the deformation (or velocity) history of target surfaces. Spall fragments having cross-sectional dimensions in excess of 10 microns and lengths in excess of 100 microns must be discernable. Fragment velocities are dependent on proximity to the impact location and can be as high as 3 km/s. Surface observations must span a minimum area of 100 square centimeters, with a lateral (spatial) resolution of 1 mm (i.e., 10,000 measurement locations per time step). The axial resolution requirement, with respect to the shotline, is 100 microns over a deformation range of 1 centimeter. Several user-selected time steps are desired. Time step intervals will vary from 1-500 microseconds. Quantitative measurements will be used to validate first-principles-based algorithms for composite penetration.

PHASE I: A prototype system will be designed to quantify impact-generated surface deformations and spall fragment fields. The design will be supported numerically and through proof-of-concept tests.

PHASE II: A turn-key prototype system will be developed, tested, and delivered. The system will be capable of quantifying the dynamics of selected individual fragments over a protracted period of time and characterizing the deformation history of target surfaces.

POTENTIAL COMMERCIAL MARKET: As composites are introduced into commercial and consumer products, a system that characterized energy dissipation mechanisms and mass loss (as a result of collision, impacts, and/or explosions) is need ed to characterize the hazard and evaluate safety issues. Targeted commercial organizations are damage resistant material manufacturers serving the optical, automotive, marine, and aviation industries.

REFERENCES:
1. Nebolsine, P.E., et al., "Shadowgraphic Holography Analysis for Debris Characterization," SPIE Conference 2214, Space Instrumentation and Dual Use Technologies, Orlando FL, April 1994

AF97-152 TITLE: Engineering Research Flight Simulation Technologies

Category: Engineering Developmentment

OBJECTIVE: Develop innovative flight simulation techniques which support research for advanced aircraft.

DESCRIPTION: The Air Force is interested in new flight simulation technologies which support flight control or aircraft system development for advanced aircraft. The Air Force seeks simulation technologies that support a small number of high fidelity entities interacting in a virtual research environment. Technologies that optimize aircraft fidelity between local and long haul network entities are needed to support training applications. Novel display technologies, lower life cycle cost simulation techniques, or improved techniques for conducting research using networked simulation are of interest. Application of commercial virtual reality technologies to simplify research simulation is encouraged so long as simulation can be maintained at a high fidelity. Innovative approached for the use of large High Definition Television (HDTV) Cathode Ray Tubes (CRTs) or flat panel displays in flight simulator instruments and projection systems for visual displays are of interest. Improvements will be considered for any technology, hardware device, or software program/architecture that shows potential for flight simulation advancement.

PHASE I: Shall define the proposed concept, investigate alternatives, and predict performance of the proposed design. Demonstrations of high-risk portions of the design are encouraged, but not required.

PHASE II: Shall fully implement, demonstrate, and test the Phase I design. Results of the test and recommendations for improvements and/or alternatives shall be documented.

POTENTIAL COMMERCIAL MARKET: Improvements in flight simulation technology have application to flight simulators used by the airline industry to satisfy FAA training requirements. Flight simulation technologies can also be applied to the expanding fields of virtual reality, medicine, manufacturing, and entertainment.

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AF97-153 TITLE: Innovative Damping Concepts for Extreme Environments

Category: Exploratory Development

OBJECTIVE: Develop damping concepts for structures subjected to high temperatures, centrifugal loading, and other extreme environments.

DESCRIPTION: Although there are a number of relatively mature technologies associated with damping non-rotating structural components at temperatures below 500 degrees Fahrenheit, there is a critical need for damping concepts appropriate for applications that are subjected to high temperatures, centrifugal loads, and other extreme environments. Existing polymeric viscoelastic damping materials are only effective over narrow temperature range, and become susceptible to creep when exposed to elevated temperatures and/or when subjected to large steady state loads. For extreme environments, damping concept using polymeric materials must include some sort of innovative scheme to address these problems. Alternative approaches to the use of polymeric viscoelastic materials may be identified for the damping concept, and damping treatments that are relatively insensitive to temperature would be very useful in may applications. An analytical model that can be used in the design of the damping treatment is required so that the

damping design will not be based on an empirical "trial and error" approach. The damping treatments may be designed for specific extreme environment applications of interest to the Air Force, including engine nozzles, hypersonic or exhaust washed structures, and rotating components within air vehicle engines. One application of special interest is the damping of aircraft turbine engine blades, which supports research to reduce the effects of high cycle fatigue (HCF) in aircraft engines.

PHASE I: Must demonstrate the feasibility of the damping concept, including its compatibility with elevated temperatures and/or sustained steady state loads. If the damping treatment is intended for a specific Air Force application, the feasibility study should include analytical studies of the concept that predict the level of damping to be seen in the component and an evaluation of the effectiveness of the damping treatment in the system environment.

PHASE II: The damping treatment must be fabricated and then tested to demonstrate its effectiveness in the application considered. The testing must effectively demonstrate the damper's durability in the environment for which it is designed. The Phase II must also demonstrate that the treatment can provide effective damping without adding excessive weight, cost, or maintenance requirements.

POTENTIAL COMMERCIAL MARKET: There are several commercial markets for damping technologies that are capable of withstanding elevated temperatures and large steady state loading, including vibration isolation devices for heavy machinery. Damping concepts can also be used in the commercial aircraft and automotive industries to reduce undesirable vibration in structures and engines. Added damping reduces resonant response, which reduces requirements for maintenance and enables the development of lighter weight, higher performance turbine engines. Large turbines are also used in the power generation industry, which could realize similar benefits.

REFERENCES:

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AF97-154 TITLE: Bare Base Operations

Category: Exploratory Development

OBJECTIVE: Develop lightweight, air transportable Bare Base support systems that significantly improve existing and/or new Bare Base capabilities.

DESCRIPTION: The Air Force has a critical need for improved mobile, air transportable support systems to expedite and sustain aircraft operations and personnel beddown during contingency operations. These new systems must be smaller in size, lighter in weight, rapidly deployable, and provide capabilities to improve system operations, reduce operating cost and manpower. These new systems must be smaller size, lighter in weight, rapidly deployable, and provide capabilities to improve system operations, reduce operating cost and manpower. There are significant opportunities through application of advanced technologies to achieve measurable results in many key areas. Some of these areas include but are not limited to the following:

1. Efficient Waste Processing and Disposal Plant - Currently Bare Base waste is disposed of by liquid waste pumpers. This poses severe penalties in airlift volume in deployments, such as Desert Storm, Guantanamo and Somalia. This proposed novel research is to develop an air mobile waste disposal plant which minimizes weight and volume of current waste systems.

2. Advanced Integrated Mobile Power Generation Systems - Existing Bare Base power generation systems are heavy, bulky, and require significant airlift. Use of new cryogencially cooled superconducting materials will enable the development of a generator one-quarter the size and weight of current assets. The application of superconductivity technology can revolutionize mobile power generation.

3. Hybrid Dual-Fluid Environmental Control Units - Mobile base environmental control units (ECUs) protect personnel from harsh climates. Present day ECUs use banned ozone depleting chemical (ODC0) R-22. The proposed

research will develop a new generation of ECUs that replace ozone depleting fluorocarbon refrigerants on both fixed and mobile AF installations.

4. Pavements Creation From In-Situ Materials - Air Force forward and contingency bases require additional parking capability to meet mission requirements. The proposed research will develop methods to rapidly create aircraft operating surfaces using insitu solid materials. Target time-frame for construction of a 150ft by 150ft parking apron is 8 hours.

5. Air Mobile Shelters - The Air Force has requirements for innovative concepts for a new generation of air mobile shelters. The shelters must minimize weight, packing volumes, and assembly times, support snow loads, wind loading, and be capable of long term storage. Life cycle costs, energy efficiency and potential for chemical/biological protection are also areas of interest.

PHASE I: Identify and laboratory test a proof of concept.

PHASE II: Will include the transition of individual components into an optimization process whereby a module assembly will be fabricated and tested.

POTENTIAL COMMERCIAL MARKET: Technologies used to develop improved Bare Base equipment will be developed jointly with industry and have direct application to DoD and commercial sectors (utility, transportation and aircraft industries).

REFERENCES:

1. Bare Base Conceptual Planning Guide, AFPAM 10-219, 1 February 1995.

AF97-155 TITLE: Advanced Aircraft Coatings Systems

Category: Basic Research

OBJECTIVE: Develop approaches for a fundamental understanding leading to advanced aircraft coating systems capable of satisfying operational requirements over a service life of 30 years.

DESCRIPTION: Aircraft painting/stripping/repainting processes and handling the associated hazardous waste is one of the highest cost maintenance activities in the Air Force. As a result, in late 1993 a USAF Paint Technology Task Force was chartered to establish a strategy for the Air Force paint removal and coating systems of the future. The Air Force Coating System Strategy applies to almost all operational aircraft and identifies aircraft coating system requirements from now until beyond the year 2003. In addition to environmental compliance, the strategy clearly defines long term coating system performance parameters significantly beyond the current state-of-the-art. An advisory panel of internationally recognized experts in the fields of coating technology and corrosion science and engineering, from industry and academia, was chartered to study the potential of a basic research contribution to ameliorate the aircraft paint issue leading to recommendations for a programmatic course of action. As result of that study, the following four areas of basic research activity were identified as enabling for the Air Force to meet its stated objectives by the year 2003.

1. Investigation of synthesis/structure/property relationships for surface treatments, primers and matte topcoats.
2. Identification of degradation mechanisms of polymers in matte coatings and subsequent development of appropriate models for performance predictions.
3. Synthesis of advanced materials (polymers, additives, pigments, inhibitors) for new coating systems.
4. Development of nondestructive evaluation (NDE) for under-coating inspection and coating health monitoring.

The Air Force plans to establish basic research programs in each of the above enabling technology areas with participation by the top researchers in the country. Although there are ongoing activities to address environmental compliance, AF requirements are unique in the areas of 30-year life and removal/reapplication of topcoats. Current

national and international research activities in the above areas lack a "fundamentals" approach, are somewhat unfocused and do not address requirements unique to the Air Force. Research and development programs are sought which address the unique operational requirement of 30-year life.

PHASE I: The establishment of viable approaches to addressing key elements of the above enabling technologies are sought in Phase I.

PHASE II: Follow-on efforts in Phase II will further develop and optimize the elucidation of mechanisms, development of models, synthesis of advanced materials and/or development of NDE techniques using the approaches established in Phase I.

POTENTIAL COMMERCIAL MARKET: The commercial aircraft industry will benefit because much of the technology developed will be directly applicable. The auto industry also has a great need for corrosion protection as well as a need for predicting and extending the life of coatings for cars and trucks.

REFERENCES:

1. Report, "AF Blue Ribbon Advisory Panel on Aircraft Coatings, Part 1, Basic Research," prepared by Universal Technology Corporation for WL/ML and AFOSR, November 1995

AF97-156 TITLE: Environmentally Compliant Aircraft Coatings

Category: Exploratory Development

OBJECTIVE: Develop low/zero-VOC materials and/or application techniques suitable for aircraft coatings.

DESCRIPTION: The Air Force is interested in conducting exploratory development of aircraft coatings with a minimal detrimental impact on the environment. Most coatings now used by the Air Force release large amounts of volatile organic compounds (VOC's) into the atmosphere, producing smog or other air pollution. Some coating formulations include hazardous components (EPA 17, lead, chromates, etc.). Some of the new coatings for low speed and high speed aircraft, which meet the environmental standards, suffer an unacceptable loss of properties such as adhesion, durability, cleanability, optical signature control, and affordability. The Air Force has a durability goal of 8+ years. New materials and/or application systems that can greatly reduce or eliminate VOC's and other undesirable materials, while controlling the aircraft's spectral and diffuse infared signature, are necessary in order to comply with stringent environmental regulations, either currently in effect or likely to be enacted in the near future. Relevant technologies for low/zero-VOC coating development include, but are not limited to, high solids coatings, waterborne coatings, powder coatings, plasma/thermal spray systems, and appliqués.

PHASE I: Phase I will address initial formulation, fabrication, evaluation, and application techniques of specific subjects for proof of concept.

PHASE II: Phase II will further develop and optimize the material and/or application techniques, and produce larger samples for a full spectrum of evaluations.

POTENTIAL COMMERCIAL MARKET: The requirement to comply with environmental regulations applies equally to the commercial coating industry. As such, much of the technology developed for compliance of military coating systems could be extended to commercial applications. Commercialization of the technology would involve scale-up to production capacity, and production of sufficient quantities of material to coat aircraft or other large objects using an environmentally compliant and commercially viable application technique. Additionally, opportunities for commercialization in the solar energy field exist.

REFERENCES:

1. AFWAL-TR-86-1028, "Camouflage Handbook," April 1986.
2. Title I of the Clean Air Act Amendments of 1990 (CAAA).
3. California South Coast Air Quality Management District Rule 112

AF97-157 TITLE: Affordable Composites

Category: Exploratory Development

OBJECTIVE: Develop low cost materials and processes for carbon fiber composites.

DESCRIPTION: The Air Force is seeking new and highly innovative concepts for affordable carbon fiber composite materials and processes utilizing polymeric and/or carbon matrices. These concepts are for aircraft, spacecraft, automotive, and/or electronic applications. Concepts on near net-shape manufacturing, integrated structure, low cost coatings, and low cost raw materials and processes are sought. A large cost driver in producing parts from advanced composites is from machining after the part is processed. Near net-shape manufacturing can help to reduce costs due to machining. The cost of labor to assemble many parts to build a structure affects composite costs. Integrated structure would reduce part count, thereby reducing assembly time. For some composite materials, a faster processing time or reduces step processing would eliminate some composite costs. Low cost coatings for use in the 1000 or 1200°F temperature regime could greatly increase the number of applications utilizing carbon fiber composite materials. Finally, high material costs keep carbon fiber composites from being fully utilized in applications such as automobiles and electronics. Low cost raw materials can help to expand the use of carbon fiber composites.

PHASE I: The Phase I program must demonstrate the feasibility and cost savings of the proposed concept sufficiently to justify further development and/or scale-up in a Phase II effort. Proof-of-concept subcomponents should be fabricated and tested.

PHASE II: The concepts demonstrated in Phase I will be scaled up and developed in detail. The payoffs and benefits of the technology will be demonstrated by fabrication and testing a component.

POTENTIAL COMMERCIAL MARKET: Affordable carbon fiber composites will provide technologies for commercial transportation vehicles, sporting goods, electronic modules, and civilian infrastructure such as composite bridges. Extreme environment composite technology (high temperature, stress, and/or vibration) will have extensive applications for internal combustion, turbine engines, nuclear reactors, and incinerators.

REFERENCES:
1. 40th International Society for the Advancement of Materials and Process Engineering (SAMPE) Symposium, Anaheim CA, 1995

AF97-158 TITLE: Polymer/Inorganic Nanocomposites for Substructure Applications in USAF Rockets and Aircraft

Category: Exploratory Development

OBJECTIVE: Develop a new generation of polymer-matrix nanocomposites for use in substructure applications in USAF rockets and aircraft.

DESCRIPTION: New high-use temperature, lightweight polymeric materials shall be required in future airframes and rockets to enable the optimum performance characteristics of the systems. Recently, a new generation of polymer-matrix nanocomposites has been developed based on the molecular-level dispersion of highly anisotropic, inorganic nanoscale rods or plates, such as mica-type layered silicates, in a thermoplastic polymeric resin. These new polymer-matrix nanocomposites exhibit superior mechanical characteristics (e.g. 100% increase in the heat distortion temperature) and chemical resistance (e.g. ~ 10 fold decrease in 02 and H20 permeability) compared to the neat resins. These property improvements raise the use-temperature and extend the potential use-environments of the polymeric material. Additionally, in contrast to conventional filled-polymer systems where inorganic loadings are greater than 30 wt%, these nanocomposites contain less than 10 wt% of the inorganic. Thus, the overall weight of the nanocomposites is less than that of conventional composites and the impact strength of the nanocomposites is less than of conventional

composites and the impact strength of the nanocomposites is not drastically decreased with respect to that of the neat resins. These impressive properties are believed to be related to the homogenous nanoscale dispersion of the highly anisotropic nanoscale inorganic phase. In contrast, conventional filled resins and composites utilize inorganic fillers on the micron or larger scale, such as talc, kaolinite, carbon black, glass fiber and carbon fiber. This technology has yet to be explored for potential Air Force applications. These materials may replace current composites and filled polymer materials in substructure applications, such as trusses, in rockets and aircraft resulting in a weight and cost savings. Also, these nanocomposites could replace nonpolymeric materials in some noncritical structural applications such as fuel-line brackets, stirred combustion chambers and cryogenic storage containers, again resulting in weight and cost savings. New economically-viable, preferably nonsolvent based processing techniques are sought which retain or improve the nanoscale dispersion and global alignment of the inorganic phase and result in polymeric-matrix nanocomposites with superior mechanical, thermal and chemical properties. Additionally, the development of new economically-viable inorganic constituents that are dispersible as nanoscale plates or rods in a variety of commercially available thermoplastic resins and that are more thermally stable than current commercial material will also be considered.

PHASE I: The goal of the Phase I effort is development of at least two potential thermoplastic resin/inorganic constituent nanocomposite systems. Emphasis should be placed on potential nanocomposite systems from (1) elevated use-temperature thermoplastics (i.e > 175°C, long term) and (2) ultra high use temperature resins (i.e. > 250°C, long term) such as aromatic heterocyclic rigid rod polymers.

PHASE II: The polymer-matrix nanocomposite with the most promising combination of mechanical, thermal and chemical properties will be selected, and continued technical work shall require the fabrication of commercially viable specimens in the form of films, fibers and molded components.

POTENTIAL COMMERCIAL MARKET: Commercial applications would include structural components in automobiles, replacement of current filled polymer systems in automobiles, replacement of conventional fiber composites such as fiber glass, and packaging materials such as films and containers for foods which require low permeability and recyclabilty.

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2. Maxfield, M., et al., International Patent (PTC), C08K3/34, c08L77/00, 23/02, (1993).
3. Vaia, R.A.; Tse, O.; Giannelis, E.P., U.S. Patent pending, Serial # 08-158,249 (29 Nov 1993).
4. Kojima, Y., et al., J. Polym. Sci: Part A: Polym. Chem. 1993, 31, 983.
5. Vaia, R.A., Ishii, H., Giannelis, E.P. Chem. Mater., 1993, 5, 1694.
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7. Burnside, S.D., Giannelis, E.P., Chem. Mater., 1995, 7, 1597.
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9. Wang, M.S.; Pinnavaia, T.J., Chem. Mater. 1994, 6, 2216.
10. Messersmith, P.B.; Stupp, S.I., J. Mater. Res., 1992, 7, 2599

AF97-159 TITLE: Improved Tribological Systems for Spacecraft

Category: Advanced Development

OBJECTIVE: Develop methods to extend spacecraft useful life up to 15 years from limits imposed by existing tribological systems.

DESCRIPTION: Existing spacecraft utilize lubrication systems that have not been optimized for long life and low torque and wear. There is a general reluctance to change a lubricant and/or bearing surface finish to new materials that are known to be superior, but have not been "space proven." However, as the size of spacecraft is getting smaller and the time in space is lengthened, more severe demands are placed on the tribological systems. Lubrication failure is more and more often the cause of satellites becoming useless in space as the bearings and other mechanical parts lock

up following lubricant depletion. NASA Lewis Research Center has been organizing the tribological experiences of spacecraft in the form of a handbook, but the ranking of the needs for tribological research and development needs to be established with the highest payoffs targeted for testing and improvement. Materials Directorate, Wright Laboratory has been conducting R&D on new base fluids and on additives for these and existing base fluids and on new tribological coatings for wear surfaces. Base fluid general classes of interest (because they are in existing systems) include hydrocarbons and perfluoropolyalkylethers. Silahydrocarbon base fluids offer excellent improvement in reduced torque and low volatility compared to other hydrocarbons. Low volatility additives have been found to reduce friction and wear over the base fluid. Greases made from silahydrocarbon are needed to take advantage of the excellent properties of the base fluid. Materials Directorate has also developed improved coating materials, including WS2, Cfx, CNx and TiN, applied by different state-of-the-art techniques, including magnetron sputtering, pulsed laser deposition and cathodic arc deposition. These are improved bearing/race coatings to potentially improve the life of space bearings. Improvements in currently used familiar materials will have greatest acceptance to potential uses of new technology. The greater the involvement of Aerospace Corporation, NASA, satellite and spacecraft component suppliers, satellite and spacecraft manufacturers, tribological experts and government agencies, the greater anticipated acceptance by the space community.

PHASE I: Identify most critical needs in space system tribology. Incorporated improved base fluids and additives and coatings from Materials Directorate programs and from industry into optimized lubricants, greases and coatings. Develop a standard for liquid/grease "outgassing" to overcome the shortcomings of current methods developed for structural materials.

PHASE II: Based on input from the space community, fabricate an operating mechanism to demonstrate the various lubricants and coatings to simulate the life characteristics of a space mechanism. Thoroughly assess the strengths of various lubricant systems identified in Phase I towards the goal of up to 15 years life in spacecraft mechanisms.

POTENTIAL COMMERCIAL MARKET: Since many spacecraft are commercial as well as military, the knowledge gained and demonstrated from this program on extension of mechanical system life and weight reduction through elimination of redundant mechanisms will easily transfer to commercial spacecraft.

REFERENCES:

1. "Research and Development of Low Volatility Silahydrocarbon Based Liquid Lubricants for Space," C.E. Snyder, Jr., L.J. Gschwender. K.J.L. Paciorek, G.J. Chen, Lubrication Engineering, 48, 4, 325-328 (1992).
2. "Acidic Attack of perfluorinated Alkyl Ether Lubricant Molecules by Metal Oxide Surfaces," NASA TM-10192, M.J. Zehe and O.D. Faut (1989).
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4. "Synthesis and Tribological Properties of Carbon Nitrite as a Novel Superhard Coating and Solid Lubricant," M.Y. Chen, X. Lin, V.P. Dravid, Y.W. Chung, M.S. Wong and W.D. Sproul, Tribology Transactions, STLE, 34, 491-495 (1993)

AF97-160 TITLE: Paint Stripping Methods

Category: Exploratory Development

OBJECTIVE: Develop innovative process for stripping paint -- completely and selectively -- from aircraft.

DESCRIPTION: The Air Force is interested in new innovative ways to strip aircraft. The primary method of removal was application of methylene chloride which was a labor intensive process and under current regulations is environmentally unacceptable. Currently, plastic media blast materials and water technologies have been emerging at Air Logistic Centers, but there is still concern over disposing of spent materials, cost of systems and their operations, and strip rates. New technologies are sought that will eliminate environmental concerns, reduce labor, and be nondestructive to the skin of the aircraft over its lifetime. The technology should be able to strip the coating system

completely (primer and topcoat), but also be able to demonstrate selective stripping as well (topcoat only leaving primer intact). The stripping process should focus primarily on aluminum 2024-T3 alloy as the substrate with a small emphasis on composite materials, and the system should be a feasible and realistic transition to existing Air Logistic Center's support facilities. Some technologies sought but are not limited to are new water technologies, energetic stripping methods, newly developed plastic blast materials or wheat starch materials. These systems must reduce or eliminate HAZMAT disposal fees, be cost competitive in production of the apparatus and in its operation, be able to strip a majority of the aircraft, and meet/exceed current strip rates.

PHASE I: Phase I will entail the initial design and development of the paint stripping method with some preliminary evaluation on strip rates and ability to completely and selectively strip paint systems.

PHASE II: Phase II will further develop and optimize the stripping process and produce a prototype stripping apparatus. Larger parts representing aircraft components will be stripped to evaluate strip rates, selectively of stripping process, and ease of application used.

POTENTIAL COMMERCIAL MARKET: This has the potential to be used commercially due to the impending environmental regulations. Stripping of aircraft is essential in inspecting the skin of the aircraft and this process must be done faster, cheaper, and more environmentally responsible than what we use in current practice. All aircraft operators and manufacturers will have a vested interest in this technology if they plan on keeping aircraft more than 7 years.

REFERENCES:

1. WL-TR-94-4106 "Evaluation of the Effects of Chemical and Plastic Media Blasting Paint Removal," August 1994

AF97-161 TITLE: Gap Treatment Materials for Low Observable Aircraft

Category: Exploratory Development

OBJECTIVE: Develop a rapid-cure conductive sealant for gap treatments.

DESCRIPTION: Many of the Air Force's current and planned aircraft employ low observable or "stealth" technologies. One critical component of these technologies is the treatment of the gap formed at the surface of the aircraft between structural components and access points. The nature and function of the gap requires a material that is flexible and electrically conductive, properties which are mutually exclusive. Due to the physical requirements, current gap materials tend to have low reliability, are difficult to apply and repair, and have special storage requirements. The Air Force is seeking to develop a gap treatment material which is reliable, has a short cure cycle, is easily stored and applied, and can be easily repaired. The traditional approach has been to fill an elastomeric sealant with conductive particles. Unfortunately, achieving a minimal cure time for a highly filled conductive sealant is very difficult due to the solvents required to process the system. Potential approaches to meet the rapid-cure concept include ultra-violet light, induction heating, and electron-beam curing matrix systems or other methods that use little or no solvents.

PHASE I: The Phase I program must demonstrate the feasibility and cost savings of the proposed concept sufficiently to justify further development and/or scale-up in a Phase II effort. Proof-of-concept subcomponents should be fabricated and tested.

PHASE II: The concepts demonstrated in Phase I will be scaled up and developed in detail. The payoffs and benefits of the technology will be demonstrated by fabrication and testing a component.

POTENTIAL COMMERCIAL MARKET: Reliable and maintainable gap treatment materials could readily be used in many areas where conductive caulks or sealants are required. Markets include electronic shielding, dissipation of electrostatic charge in computer assembly, flexible attachment for wiring and hybrid circuitry, and construction.

REFERENCES:

1. J. Jones-Meehan, "Corrosion Resistance of Several Conductive Caulks and Sealants from Marine Field Test and Laboratory Studies with Marine, Mixed Communities Containing Sulfate-Reducing Bacterial," NRL/PR-92-094-333, ASTM, Vol 27, pp 217-33, 1994

AF97-162 TITLE: Affordable Multi-Material System Alternatives

Category: Exploratory Development

OBJECTIVE: Develop thermal, mechanical, and /or chemical process design of alternative near net-shape processes for difficult-to-form materials.

DESCRIPTION: Materials insertion applications and spare components for aging aircraft systems offer tremendous opportunity to introduce innovative methods, processes and material systems to reduce weight and costs while improving wear, temperature and strength performance. The need is for material process design methods which consider alternative processing which lead to significant reduction in design and fabrication times. Of particular interest is the design and fabrication of precision tooling to enable materials substitution or replacement components that are lighter, stronger and less expensive than might be otherwise attained through conventional forging, casting and machining operations. Demonstration of reduced part turnaround and delivery with cost savings of 50% are a targeted goal. Methods, processes and materials should be functionally integrated via a feature-based design environment allowing selection and optimization of manufacturing methods, processes, and materials for structural aircraft and engine components.

PHASE I: Demonstrate feasibility of embedding analytical models of basic transport phenomena such as thermal, mechanical, and chemical processes into computer-aided design system with geometric modeling and feature-based design environment capability. Develop a protocol for adding material and process models and a design feature library for storing them. Using an aircraft component such as a turbine blade, verify process design system capabilities by evaluating and comparing different manufacturing methods.

PHASE II: Develop a prototype design system for exploring different thermal, mechanical, and/or chemical processes for effectively producing near net-shape components composed of difficult-to-form materials. Verify the process design system by comparing the feasibility and cost benefits of alternative types of physical processes, namely hot forging, investment casting, reaction-based forging, and reaction-based squeeze casting for certain turbine engine and structural components.

POTENTIAL COMMERCIAL MARKET: Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance metals, ceramics and polymers. Aircraft and automobile propulsion system vendors providing tooling for forming new higher temperature alloys.

REFERENCES:

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AF97-163 TITLE: Gradient Materials Interface Design

Category: Exploratory Development

OBJECTIVE: Modeling and simulation of the interface design of gradient bulk and thin-film materials.

DESCRIPTION: The widespread application of gradient materials in areas ranging from biomimetic and mechatronic materials for nondestructive sensing and micro-actuation, to nonlinear optical properties for threat and detection, and to multilayer films for unique combinations of properties is limited by the lack of a design environment. Future material systems will require a design environment for modeling and simulating gradient thin-film interfaces including thin-film to bulk materials interfaces across monolithic and composite materials. Of particular interest is the ability to enable the integrated design of bulk components comprised of monolithic alloys and/or polymer, metal, and ceramic matrix composites whose properties are enhanced by interfacial effects and/or multilayer thin-film coatings. Although computational materials science approaches offer the potential for such a design environment, innovative approaches are sought to mitigate computational complexity and cost issues.

PHASE I: Demonstrate the tractability of approach relative to the design of the structure and composition for a given performance envelope (thermal, strength, magnetic and electro-optical properties) of multilayer film interfaces, i.e., inter-layer and film-to-substrate. Materials of immediate interest are replacement components for aging aircraft to include high temperature intermetallics, composites, and inorganic and polymer based electro-optical materials.

PHASE II: Develop a generic capability to design the structure and composition of a multi-layer film together with the ability to evaluate the performance (thermal, strength, magnetic and optical properties) of the combined film and substrate.

POTENTIAL COMMERCIAL MARKET: Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance aerospace metals, ceramics and polymers. Aircraft and automobile propulsion system vendors providing multilayer films for component thermal and wear protection.

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AF97-164 TITLE: Advanced Materials & Processes for Aging Aerospace Systems

Category: Exploratory Development

OBJECTIVE: Develop novel materials and processes to extend service life of aging weapon systems.

DESCRIPTION: The many aerospace weapons systems in the Air Force inventory are being asked to perform ever-longer periods of service as the number of new weapons systems is reduced. Examples of these systems include aircraft structures, propulsion, electronics and optics, hydraulics, seals, sealants, and coatings. Novel materials and processes are needed to extend the life and reduce the cost of operating these systems. Due to the large variety of

weapons systems, technical approaches should focus on concepts that would address more than one if possible. This is an exploratory development effort that would result in a materials and process feasibility demonstration with a clear path provided for further development to commercialization. Materials systems of interest would include both metallics and nonmetallics, monolithic and reinforced, and the related processes to produce, inspect, and simulate the effects of long-term aging.

PHASE I: A limited scope, concept verification phase that gathers enough experimental information to allow the original concept to be validated. Where possible the Phase I efforts shall utilize and compare findings with those obtained utilizing current materials and processes. The contractor shall include an engineering analysis of potential uses of the new technology for applications in various aging systems both military and civilian.

PHASE II: This phase will conduct much more extensive exploratory development materials and process verification efforts with heavy emphasis on comparisons through aging studies with existing materials and processes being used in the depot of field. Where possible, actual hardware and processing methods shall be utilized to validate the Phase I predictions. Lab level NDE and testing will be conducted on both the as-developed and artificially aged materials and related processes.

POTENTIAL COMMERCIAL MARKET: This effort should have significant dual use commercialization potential due to the extensive nature of aging infrastructure in the civilian economy. Improved metal alloys, composites, coatings, and other materials and processes should be broadly applicable to civil components.

REFERENCES:

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AF97-165 TITLE: Novel Nondestructive Evaluation Technology for Aerospace Components & Systems

Category: Basic Research

OBJECTIVE: Develop new nondestructive evaluation (NDE) techniques that permits the detection and tracking of life limiting flaws in structural components.

DESCRIPTION: The Air Force is interested in research and development projects directed toward potential applications of new and novel NDE techniques to detect and quantify flaws in a range of components. Such a program should address the types of nature of a particular class of flaws and offer a method for their detection and quantitative assessment. Examples of the flaw types that are of interest include the very small flaws that result during high cycle fatigue, corrosion of aluminum aircraft structure, and the mapping of wide area fatigue damage in older aircraft. Another long standing NDE problem deals with the assessment of adhesively bonded components. Any work in this area must show that NDE measurements are applicable to well known models of adhesive joint performance. Such work must not be a simple correlation of performance with an NDE signal. An investigation of the trade-offs involved in the use of any proposed technique should lead to a rational engineering use philosophy for the technique. Special consideration will be given t those proposals that address materials that have both military and civilian applications, i.e., dual usage.

PHASE I: Programs in these areas should address the requirements and goals of the proposed efforts, as well as initial formulation, testing, and evaluation required for proof of concept.

PHASE II: The process or design concepts from Phase I would be developed through optimization and scale-up efforts to establish feasibility for manufacture and wide scale use of any instrument proposed. Either process or design concepts would lead to a marketable product after a Phase III program.

POTENTIAL COMMERCIAL MARKET: With the world wide emphasis on reliability and initial quality, the potential applications of new NDE techniques could be conceivably quite large.

REFERENCES:

1. The Nondestructive Testing Handbooks, Second Edition; Vol. 1, Leak Testing, Ed. R. C. McMaster; Vol 2, Liquid Penetrant Testing, Ed. R. C. McMaster; Vol. 3, Radiography and Radiation Testing, Ed. L. E. Bryant; Vol. 4, Electromagnetic Testing, Ed. M. L. Mester; Vol. 5, Acoustic Emission, Ed. R. K. Miller; Vol. 6, Magnetic Particle Testing; Ed.s J. T. Schmidt & K. Skeie; Vol. 7 Ultrasonic Testing, Ed.s A. S. Birks & R. E. Green, Jr.; Vol. 8, Visual and Optical Testing, Ed.s M. W. Allgaier & S. Ness; Vol. 9, Special Nondestructive Testing Methods, Ed. R. K. Stanley; American Society for Nondestructive Testing, Columbus, OH.
2. Nondestructive Evaluation, A Tool for Design, Manufacturing, and Service, D. E. Bray and R. K. Stanley, 1989, McGraw-Hill Book Co., New York, NY.
3. Nondestructive Testing Handbook, 2nd Edition, R. Halmshaw, 1991, Chapman & Hall, London.
4. Metals Handbook: Nondestructive Evaluation and Quality Control, Vol. 11, 1976, The American Society for Metals, Metal Park, OH.
5. Nondestructive Characterization of Materials, R. A. Kline, 1992, Technomic Publishing, Lancaster, PA

AF97-166 TITLE: Metallic Structural Materials for Air Force Systems

Category: Exploratory Development

OBJECTIVE: Develop, characterize, and model metallic structural materials.

DESCRIPTION: New approaches are requested to (a) develop and characterize gamma titanium aluminide intermetallic materials (up to 1800°F); (b) characterize, understand, and model damage initiation and growth in metallics used in or proposed for use in turbine engines; and (c) develop continuous filament reinforced Ti-matrix composites with improved mechanical properties. For gamma titanium aluminide intermetallic materials, research is limited to (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control; (b) methods of synthesizing gamma titanium aluminide to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale; and (c) methods for environmental protection of gamma (both monolithic and composites) aimed at providing long life under cyclic oxidation conditions. For damage initiation and growth in turbine engine metallics, proposals must describe new, innovative experimental test techniques and/or analytical modeling approaches for the characterization of life-limiting mechanical properties such as low cycle fatigue (LCF), fatigue crack growth, and creep/fatigue interactions. Special emphasis is placed on damage tolerance and high temperature, often time-dependent, properties, leading to the development of life prediction models. For continuously reinforced Ti-matrix composites, proposals must describe approaches for producing improved mechanical properties (damage tolerance, creep, and environmental resistance are mechanical properties of specific interest) and should focus on methods or concepts for control of interface properties of reinforcement, or control of matrix composition and microstructure.

PHASE I: This program will focus on the critical issues which when solved, will provide proof of concept for developing the materials, approach or methodology.

PHASE II: This program will be structured to develop and refine those feasible concepts to the point where an assessment could be made of the ultimate potential to help meet Air Force advanced materials needs.

POTENTIAL COMMERCIAL MARKET: The developed approach could have broad commercial applicability due to the large number of commercial aircraft and engine systems that have materials requirements of a very similar nature to those faced by the DoD. Various energy conservation applications, e.g., radiant burners, heat exchanger, and power turbines, are also pertinent.

REFERENCES:
1. D. B. Miracle, P. R. Smith, and J. A. Graves; "A Review of the Status and Development Issues for Continuously-Reinforced Ti-Aluminide Composites for Structural Applications," in Intermetallic Matrix Composites III, (J. A. Graves, R. R. Bowman, and J. J. Lewandowski, eds.), MRS Proceedings, Vol. 350, pp. 133-142, (1994).
2. D. M. Dimiduk, M. G. Mendiratta, and P. R. Subramanian; "Development Approaches for Advanced Intermetallics Materials - Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J. J. Lewandowski, C. T. Liu, P. L. Martin, D. B. Miracle, M. V. Nathol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale PA (1993) pp. 619-630

AF97-167 TITLE: High Temperature Structural Materials for Advanced Air Force Systems

Category: Exploratory Development

OBJECTIVE: Develop and characterize advanced high temperature structural materials.

DESCRIPTION: New approaches are requested to develop and characterize (a) advanced high temperature structural ceramic composites (1800°F to 3500°F, excluding carbon-carbon composites), (b) intermetallic materials and composites (1800°F to 3000°F, excluding nickel aluminides) and (c) model forming processes for advanced structural materials. For ceramic composites, research is limited to continuous ceramic fiber reinforced ceramic matrix systems and may include the following: (a) new, unique ceramic composite development, (b) novel matrices suitable for continuous fiber reinforcement, (c) fiber/matrix interface treatments engineered for toughened behavior and stability, (d) continuous ceramic fiber development, (e) test techniques to determine mechanical and physical behavior (such as failure modes, crack and void growth, oxidation, stress-strain, cyclic stress-strain, etc.) as a function of temperature and loading history, and (f) analytical modeling of composite behavior. For intermetallic materials, research is limited to (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control, (b) methods of synthesizing intermetallics to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale, and (c) methods for environmental protection of intermetallics (both monolithic and composites) aimed at providing long life under cyclic oxidation conditions. For modeling of forming processes, research may include modeling of (a) the unit forming process, (b) the material behavior in response to the demands of the unit process, (c) the interface between the work piece and the die or mold, and (d) novel methods for obtaining physical property data and constitutive equations for insertion in models.

PHASE I: This program will focus on the critical issues which, when successfully addressed, will provide proof of concept. Proposals should demonstrate reasonable expectation that proof of principle can be attained within Phase I.

PHASE II: This program will be structured to develop and refine those feasible concepts to the point where performance is demonstrated on a scale sufficient to permit an assessment of the ultimate application potential to help meet Air Force advanced materials needs.

POTENTIAL COMMERCIAL MARKET: The developed approaches would have broad commercial applicability due to the large number of commercial aircraft and engine systems that have materials requirements of a very similar nature to those faced by the DoD. Various energy conservation applications, e.g., radiant burners, heat exchangers, hot gas filters, and power turbines, are also pertinent.

REFERENCES:
1. "Ceramic Engineering & Science Proceedings: 19th Annual Conference on Composites, Advanced Ceramics, Materials, and Structure," 16 [4-5], The American Ceramic Society (1995).

2. R. J. Kerans and T. A. Parthasarathy, "Theoretical Analysis of the Fiber Pullout and Pushout Tests," J. Am. Ceram. Soc., 74 [7] 1585-96 (1991).
3. A. G. Evans and D. B. Marshall, "The Mechanical Behavior of Ceramic Matrix Composites," Acta Metall., 37 [10] 2567-83 (1989).
4. D. M. Dimiduk, M. G. Mendiratta, and P. R. Subramanian; "Development Approaches for Advanced Intermetallic Materials, - Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J. J. Lewandonski, C. T. Liu, P. L. Martin, D. B. Miracle, M. V. Nathol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale, PA 619-30 (1993)

AF97-168 TITLE: Design and Synthesis of New Bichromophore Laser Protective Materials

Category: Exploratory Development

OBJECTIVE: Develop, design and synthesize new bichromophore laser protective materials

DESCRIPTION: The expanded use of lasers in many applications, including range finders and target designators, necessitates the protection of assets from accidental exposure. New linear and nonlinear materials are sought for use in protection schemes for use in the visible to near- infrared spectrum (0.4 to 2 microns). We are interested in new chromophores containing an optimized donor and acceptor, and a linking molecule with energy transfer between them. Indeed, recent recognition of the importance of advances in absorbing dyes and combinations thereof to address specific requirements and shortfalls, necessitates the application of predictive tools that address various aspects of advanced design, synthesis and characterization. Such a predictive capability is provided by an extensive application of computational methods ranging from ab initio quantum mechanical approaches, also including solvent effects, to semi-empirical techniques, and molecular mechanics/dynamics of large molecular systems for determining the structure of the linking molecule, and also with necessary modifications to address processability and solubility. The objective is therefore to apply computational-chemistry/materials science methods to predict structure and properties of existing and improved absorbing dyes, followed by synthesis and characterization. This objective is intended to lead to significant advances in bichromophore materials synthesis and processing, thereby permitting crucial changes in the design of optical systems that prevent damage during accidental or exposure to hostile laser radiation. Companies having both computational chemistry, dye synthesis and laser characterization expertise are encouraged to apply.

PHASE I: During this phase the proposer will design, synthesize and demonstrate material that has potential for laser protection.

PHASE II: Design, synthesize and characterize an expanded series of bichromophores based on proof of principle studies in Phase I.

POTENTIAL COMMERCIAL MARKET: This technology will have broad commercial applications involving lasers and will provide needed safety devices for worker protection. Materials would be commercialized by manufacturers specializing in laser protective eyeware.

AF97-169 TITLE: Advanced Liquid-Crystal Materials Development

Category: Exploratory Development

OBJECTIVE: Develop new liquid-crystal materials and processing technology to enhance their performance and utility.

DESCRIPTION: Devices based on liquid-crystal materials are being considered for use in a broad range of active and passive optical applications. Some examples of devices where liquid crystals are used include displays, electo-optic beam steering, active spectral filtering and solid-state shutters. The majority of the materials and process development effort internationally has focused on display applications, however, there are other applications for these materials in

which there are distinct materials and processing technical shortfalls. The objective of this topic is to develop materials and/or processing techniques with enhanced performance over existing materials or enable liquid-crystal-based devices to be implemented in nonconventional environments or configurations. Examples of research and development areas appropriate for this topic include the development of materials or cell configurations with enhanced contrast over that currently available; materials which exhibit a broad nematic phase temperature range; guest-host dichroic dye technologies with dichroic ratio > 50; functionalized dye-liquid-crystal molecule development; processing technologies for liquid crystal cells which have curved geometries; high speed (< 1 ms) nematic liquid crystals which are intrinsic or geometry dependent; and, polymer-liquid-crystal composites. Proposals submitted to this topic should clearly address the applications where the device technology can be applied; however, the content of the program should focus on materials and process development - not device demonstrations.

PHASE I: During this phase the offeror will demonstrate the feasibility of the materials or process to satisfactorily demonstrate a proof of principle and identify those materials/process issues which must be addressed during Phase II of the program.

PHASE II: Optimize the materials and/or processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed materials or process which demonstrates an advanced in the state-of-the-art in liquid crystal technology.

POTENTIAL COMMERCIAL MARKET: Liquid crystal materials are employed in a wide range of commercial products such as portable computer displays, solid-state shutters and stereo viewers. Improvements in the materials and processing techniques will have broad applicability in numerous industries such as the display, entertainment and research product markets.

REFERENCES:

1. I. -C. Khoo and S. -T. Wu, Optics and Nonlinear Optics of Liquid Crystals (World Scientific, Singapore, 1993).
2. P. G. de Gennes, The Physics of Liquid Crystals (Clarendon, Oxford, 1974).
3. B. Hahadur, ed., Liquid Crystals: Applications and Uses, Vol. 1 (World Scientific, Singapore, 1990).
4. I. -C. Khoo and F. Simoni, eds., Physics of Liquid Crystalline Materials (Gordon and Breach, Philadelphia, 1991).
5. P. Drzaic, Nematic Dispersions (World Scientific, Singapore, 1995

AF97-170 TITLE: High Temperature Superconducting Thin Films

Category: Exploratory Development

OBJECTIVE: Develop advanced thin film processes to enable fabrication of HTS devices for electronic, microwave and opto-electronic applications.

DESCRIPTION: Significant progress has been made in the fabrication of high-quality high temperature superconducting (HTC) thin films since the discovery of these materials. However, critical materials and processing issues still need to be solved to fully use these films in a variety of device applications. Examples of issues considered appropriate for this program include the following: (1) thin films which have lower loss, better power handling and lower intermodulation products for advanced microwave devices, (2) improved SNS junctions and arrays of junctions with optimized and more uniform properties, (3) tunable HTS microwave filters, (4) textured buffer layers for growth of high-quality, biaxially-textured HTS films on polycrystalline substrates, and (5) HTS heterostructures for devices. This topic addresses the development of materials and processing techniques which will result in solutions to the above issues and increase the potential for successful application of HTS materials. Proposals should identify the potential application and its importance, identify the materials or processing problems which limit performance, and propose an innovative solution to these problems. Devices may be examined only for evaluating and demonstrating the techniques and materials which have been developed for successful fabrication of the devices.

PHASE I: Phase I will address process development and initial testing to demonstrate proof of concept. Delivery of a representative test sample or samples to the government is encouraged.

PHASE II: Phase II will develop and optimize the process or material to demonstrate the potential application and will plan for Phase III commercialization. Delivery of material samples to the government for testing is encouraged.

POTENTIAL COMMERCIAL MARKET: HTS materials technology has great potential for dual use and commercial applications. For example, HTS microwave filters could be used in wireless communication systems to alleviate growing cellular interference problems and improve frequency utilization. HTS SQUID based systems may find applications in the medical field for measuring magnetic signals from the heart, brain, and other organs. SQUID magnetometers may also be used for nondestructive testing of aging aircraft and other structural systems to find deep cracks and hidden corrosion.

REFERENCES:
1. "High-Temperature Superconducting Microwave Devices: Fundamental Issues in Materials, Physics, and Engineering," N. Newman and W. G. Lyons, Journal of Superconductivity 6 119 (1993).
2. "Crystal Interface Engineering in High Tc Oxides," K. Char, MRS Bulletin 19 (9), 51 (1994)

AF97-171 TITLE: Nonlinear Optical Materials

Category: Exploratory Development

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

DESCRIPTION: Nonlinear optical (NLO) materials are required for a variety of Air Force applications including electro-optic countermeasures. LIDAR, laser radar, optical signal processing, and optical interconnects. These applications require new laser sources (optical parametric oscillators and harmonic generators) and electrooptic devices (directional couplers, guided-wave interferometers, and optical phase shifters). However, presently available materials are unsatisfactory for many applications due to small nonlinearities, poor optical clarity, difficulty in processing for devices, and other factors. Proposed efforts shall address inorganic or organic materials in bulk or thin-film forms which exhibit large second-order nonlinear effects. Strongest interest is (1) in bulk crystals for frequency conversion to the 2- to 12-micron wavelength range including quasi-phase matched and periodically poled structures and (2) in thin films for guided-wave devices in the 0.7- to 1.5-micron range. Innovative techniques for preparing new materials or for improving the growth or processing of known materials are encouraged. Nonlinear optical devices may be examined only as a minor part of a materials effort to evaluate and demonstrate the properties of the material(s).

PHASE I: The objective is to demonstrate the proposed growth or processing techniques.

PHASE II: The objective is to develop advanced nonlinear materials and relevant processes to demonstrate potential.

POTENTIAL COMMERCIAL MARKET: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications for NLO bulk crystals are LIDAR for environmental monitoring, medical lasers, and scientific instruments. Examples for NLO thin films are optical switches for cable TV, optical phase shifters for phased array radar, optical interconnects for electronic packages, and switching networks for communications.

REFERENCES:
1. Bordui, Peter F. and Martin M. Fejer, "Inorganic Crystals for Nonlinear Optical Frequency Conversion," Annual Review of Materials Science (Volume 23), ed. Robert A. Laudise et al, Annual Reviews Inc, 1993.
2. Dmitriev, V.G., G.G. Gurzadyan, and D.N. Nikogosyan, Handbook of Nonlinear Optical Crystals. Springer-Verlag, 1991.
3. Baumgartner, R.A. and R. L. Byer, "Optical Parametric Amplification," IEEE Journal of Quantum Electronics QE-15 (1979), pp. 432-444.

4. Fejer, Martin M. et al., "Quasi-Phase-Matched Second Harmonic Generation: Tuning and Tolerances," IEEE Journal of Quantum Electronics QE-28 (1992), pp. 2631-2654.
5. Lackritz, Hilary S. and John M. Torkelson, "Polymer Physics of Poled Polymers for Second-Order Nonlinear Optics," Molecular Nonlinear Optics. Academic Press, 1994.
6. Flyzanis, C. and J. Hutter, "Nonlinear Optics in Quantum Confined Structures," Contemporary Nonlinear Optics ed. Govind P. Agrawal and Robert W. Boyd, Academic Press, 1992

AF97-172 TITLE: Failure Mechanisms in Avionics Equipment Preventable by Dehumidification

Category: Exploratory Development

OBJECTIVE: Determine what electronic components and materials within avionics assemblies change critical characteristics due to moisture.

DESCRIPTION: Significant design, development and testing work is expended to minimize moisture sensitivity of avionics. However many studies suggest significant improvements in the reliability when host aircraft are dehumidified. Most of the data sets collected have been simple summations of maintenance actions for one or more dehumidified, and a like number of very similar, non-dehumidified aircraft. Little or no data has been gathered which identifies the actual causes of degradation and failures dehumidification appears to prevent or reverse. The dehumidification studies have been performed on avionics built using traditional requirements/parts. These suggest dehumidification can apparently effect a 20% reliability improvement (indicating substantial moisture sensitivity), in assemblies using conformally coated hermetic parts. As mentioned, little of no information is available to explain the root causes of moisture sensitivity in older systems or those of more recent design. An additional complication is the trend away from traditional military hermetic parts. These parts are being replaced with technology families often more sensitive to moisture and other environmental stresses. A prime example is integrated circuits (ICs). Military standard ICs were required to be packaged in hermetic metal, glass, or ceramic. Many assemblies now in development include "commercial grade" plastic encapsulated integrated circuits. These have a well documented history of moisture sensitivity. Other examples are plastic encapsulated discrete semiconductors, non-hermetic capacitors, various resistors types, connectors, wiring, and printed wiring boards. When more moisture sensitive technologies are used, even more sensitivity assemblies can be expected. Physics-of-failure data is necessary to optimize dehumidification profiles (temperature, relative humidity, duration, etc.) to stop or reverse each mechanism by device type, or material. These then provide the basis for optimized profiles at system through aircraft levels.

PHASE I: Identification of the most inherently moisture sensitive components and assemblies. Proposals shall include information relevant to understanding the physics-of-failure mechanisms, rates of parametric and material property changes, and contributing factors for the part/material technologies (in rank order from most sensitive) commonly used in fielded assemblies and in common use for new design. While not recognized as sensitive at the piece-part level, these may become sensitive when exposed to manufacturing, use, and logistic support operations and storage conditions. Mechanisms shall be categorized as either reversible or non-reversible by dehumidification. Laboratory and engineering characterization tests shall be performed as necessary.

PHASE II: Develop models which accurately identify assemblies sensitive to moisture related failure mechanisms (both intermittent and `hard' failures) under system operating conditions. The models shall identify moisture sensitive circuit locations based upon components/materials present in the assembly. For each sensitive component or material, a list of contributing factors, such as duration of exposure and onset thresholds, relative humidity, rate of parametric and material properties changes, and acceleration factors shall be provided. In addition, dehumidification process parameters (relative humidity, duration, etc.) necessary to stop or reverse parametric or materials changes shall be established for each sensitive technology family. The cost and mission consequences of moisture sensitive avionics assemblies shall be modeled based upon the presence of moisture sensitive technologies (identified in Phase I) on selected USAF aircraft. These models and analytic tools shall provide the capability to minimize moisture sensitivity of new assembly designs and to aid in locating and identifying root causes of moisture related failures (by circuit location) in aging aircraft avionics systems.

POTENTIAL COMMERCIAL MARKET: Both military and commercial designers benefit from identification of moisture sensitive technologies and the associated contributing and accelerating factors. This will improve first pass success in the design of moisture proof products, reducing development time and increasing customer satisfaction. This SBIR identifies opportunities for innovations in, and development and marketing of, less moisture sensitive parts and materials for use in both military and commercial products. With a knowledge of the sources of moisture sensitivity, an estimate of the maintenance burden attributable to moisture related mechanisms can be performed. This supports cost bendfit analysis required by system owner/operators in making decisions about the use of dehumidification or other alternatives. These capabilities also enable the acquisition community to choose among design alternatives to minimize moisture sensitivity of new assemblies. Operator benefits include identification of opportunities for reduced maintenance burden achievable by "desensitizing" aging equipment.

REFERENCES:
1. Evaluation of Dry Air Dehumidification, United States Naval Air Systems Command Report No. SY50-88-044, September 1988

AF97-173 TITLE: Environmentally Benign Aircraft Deicing/Anti-icing Technology

Category: Exploratory Development

OBJECTIVE: Develop an environmentally benign aircraft deicing/anti-icing agent.

DESCRIPTION: The use of glycols as aircraft deicers has come under scrutiny due to the Clean Water Act. Ethylene glycol is toxic and is no longer purchased by the Air Force for the purpose of deicing, while propylene glycol based deicers have a significant adverse environmental impact in surface and ground water from airfield runoff due to the high biological oxygen demand (BOD) of glycol degradation. Alternative materials are being sought to replace glycol-based aircraft deicers. The USAF is seeking to develop an environmentally benign deicing/anti-icing agent that eliminates or significantly reduces the BOD of airfield runoff, is nontoxic, noncorrosive to aircraft components, and cost-effective. Life Cycle Cost Assessment shall be included in each phase. This assessment will represent the systematic process in the life cycle by identifying environmental consequences and assigning monetary value.

PHASE I: Phase I research should require the development and testing of an alternative deicing material that demonstrates acceptable deicing/anti-icing performance (using SAW AMS 1424 and/or 1428 as a performance guideline), is noncorrosive to common aerospace materials, nontoxic, and environmentally acceptable. Included with this phase will be life cycle analysis for the alternatives. The approach to selection will be a rational design that includes computational prediction of properties i.e. toxicity and partition coefficient, understanding of icing mechanism as well as syntheses and testing of candidate materials.

PHASE II: Phase II should include the identification of a few candidates, further testing and development to support the performance and environmental acceptability of the deicing/anti-icing agent(s), as well as the fabrication and demonstration of a prototype delivery system to apply the material(s) developed for the purpose of deicing an aircraft. Included with this phase will be life cycle analysis of alternate agent(s), processes, system, or facility.

POTENTIAL COMMERCIAL MARKET: The proposed deicing technology would have broad applications in the civil aviation community as well as potential for cross-over into runway and roadway deicing applications.

REFERENCES:
1. Society of Automotive Engineers (SAE) Publications: Aerospace Material Specification (AMS) 1424 - "Aircraft Deicing/Anti-icing Fluid, Newtonian - SAE Type I".
2. AMS 1428 - "Aircraft Deicing/Anti-icing Fluid, Pseudo-Plastic, Non-Newtonian - SAE Type II".
3. Aerospace Recommended Practice (ARP) 4737 - "Aircraft Deicing Methods for Large Transport Aircraft

AF97-174 TITLE: Aero Propulsion and Power Technology

Category: Exploratory Development

OBJECTIVE: Develop innovative approaches for turbine engines, advanced high speed propulsion systems, and electrical concepts.

DESCRIPTION: The Aero Propulsion and Power Directorate aggressively pursues major performance advances in all components of gas turbine engines under the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Technologies derived under this initiative have resulted in higher thrust-to-weight ratios and improved efficiencies. The focus of this topic is to consider those aspects in the design of gas turbine engines that impact affordability and robustness without compromising the performance advances required. Dual-mode ramjets and engine concepts using storable hydrocarbon fuels for sustained high speed flight are being developed. The emphasis is on supportable and affordable sustained high speed flight for military and commercial applications. The More Electric Aircraft initiative is focused on reducing the cost of force projection by doubling power system reliability and reducing dependence on aircraft ground support equipment. New analysis techniques, innovative designs and concepts for gas turbine engines, fuel and lubrication systems, high speed propulsion technology, and aircraft electrical power concepts are solicited.

PHASE I: Explore the feasibility of a new concept or concepts, through analysis and/or small scale testing to demonstrate the merits of the concept.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations.

POTENTIAL COMMERCIAL MARKET: The higher performance gas turbine engines and associated technologies will lead to more efficient, durable, and affordable commercial air breathing systems. Concepts developed under this program are suitable for integration into new engines for commercial use.

AF97-175 TITLE: Power Generation and Thermal Management

Category: Exploratory Development

OBJECTIVE: Develop techniques, devices and components for aerospace power generation and thermal management/control.

DESCRIPTION: Electrical machines are needed that operate at high speeds (30-70 krpm), while transmitting power up to 300 kW. A machine running at higher speed can usually attain a higher power density and lower weight. However, a high power density motor or generator poses difficult technical challenges generally associated with the generation of high heat loads from magnetic and electrical losses and windage. Proposals are solicited which offer ways to either reduce these heat loads, or to ameliorate their effects. Examples of areas of interest include, but are not limited to high temperature windings and potting materials (>400 degrees C, 600 degrees C goal) for switched reluctance machines (SRMs), high temperature bearings for lubeless APU applications, fault tolerant winding configurations for permanent magnet (PM) generators, and high temperature PM materials with high performance. Other areas of interest are self-excitation for switched reluctance generators, hybrid bearings, touchdown (backup) bearings, and windage reduction.

Innovative thermal management concepts are also sought in the area of high temperature electronics and actuator cooling. An emerging family of silicon Carbide (SiC), Silicon Nitride (SiN), and Gallium Arsenide (GaAs) power electronics will operate at junction temperatures >200 degrees C in the near term and >600 degrees C far term. Even though the efficiencies of these devices will be much greater than conventional silicon devices, the power densities will be 4 to 8 times higher. Therefore, even greater power dissipation levels and waste heat fluxes must be dealt with. Passive thermal management concepts for high performance aircraft have the potential for being reliable and simplistic in design, and are therefore preferred. However, such concepts must deal with the inherent coupling of

transient heat generation and transient acceleration-induced forces, and their effects on the cooling performance of the device. For example, as a direct result of aircraft orientation, altitude, and speed, efficient cooling of flight actuation components results in addressing a transient heat generation problem which is coupled to transient accelerations and transient external boundary conditions. When active cooling is proposed, existing aircraft fluids such as JP-8,polyalphaolefin, 7808, or 5606 must be used, unless that cooling system is conceived as a line replaceable unit (LRU) or is modular. Reduction of initial cost, maintenance, and logistics should be a key objective for all efforts. The effects of altitude or the impact of the use of compressor bleed air must be addressed when air cooling is proposed. Areas of interest include but are not limited to, microchannel cooling, immersion cooling, heat exchangers with enhanced heat transfer surfaces, and the use of micro electro-mechanical systems (MEMS) to control and enhance interfacial heat transfer.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, and hardware development.

POTENTIAL COMMERCIAL MARKET: These technologies have application for all high speed motors, generators, actuators, and power electronics which may be used in future high power density electric/hybrid transportation vehicles (commercial air, high-speed rail, and electric car), power generation, and manufacturing facilities.

REFERENCES:

1. "Prediction of Windage Power Loss in Altemators," NASA TN D-4849, James E. Vrancik, NASA Lewis Research Center

2. "High Temperature Generator Development," AFAPL-TR-74-69, Robert Fear, etal., Westinghouse Electric Corporation, AD-786 046.

3. "Cooling Down Hot New Electronics," Leland, J.E., Price, D.C., Hill, B.P. and Collicott, H.E., Aerospace America, Vol.33, No.6, pp. 40-44, 1995

AF97-176 TITLE: Advanced Capacitors for Power Electronic Systems

Category: Exploratory Development

OBJECTIVE: Develop innovative wide temperature range (-55 to >300 degrees C), high reliability, dielectric materials and capacitors.

DESCRIPTION: Power electronics systems will be a pervasive technology in the next generation weapon systems. Typical power electronic systems include motor drives, inverter/converter for switched reluctance starter/generator systems, DC to AC inverters, and DC to DC converters. Common to all of these systems are capacitors, which are numerous and are critical in the operation of the system. Today's capacitors are the weakest link in power electronic system reliability and are limited in temperature capability to 125 degrees C. Application temperatures range from -55 to 200 degrees C and some applications may require >300 degree C operation with superior electrical performance. Candidate proposals shall address novel and innovative dielectric and/or high density packaging and/or manufacturing technologies to reduce cost. Specific uses include DC and AC power filtering, energy storage, and small signal applications for controls.

PHASE I: Demonstrate innovative capacitor approaches with substantial improvements in capacity, dielectric constant, voltage breakdown strength, dissipation factor, and temperature capabilities. Also, demonstrate advanced packaging and manufacturing technologies. Prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the technology.

PHASE II: Demonstrate development of a large-scale prototype capacitor components using innovative dielectric material or advanced high density packaging or manufacturing technology or a combination thereof. Actual application testing should be performed and electrical, thermal and life assessments made.

POTENTIAL COMMERCIAL MARKET: Capacitors are used in nearly every commercial and military system that consumes electrical power. Potential applications include all consumer electronics, medical electronics including defibrillators, automotive electronics including electric vehicles, and electric utilities. High temperature applications include aircraft engine ignition systems and electrical actuation, deep oil well instrumentation, and under the hood automotive applications.

REFERENCES:
1. Schnell, H., "Chemistry and Physics of Polycarbonates," Inter Science Publishers, John Wiley and Sons, New York 1964.
2. Bruno, S.A., Swanson, D.K. and Burn, I., "High Performance Multilayer Capacitor Dielectrics from Chemically Prepared Powders," J. Am. Ceram, Soc., 1233-41 (1993).
3. Conway, B.E., "Transition from Super-Capacitor to Battery Behavior in Electrochemical Energy Storage," J. Electrchem, Soc., Vol 138, No.6, June 1991, pages 1539-1548.

AF97-177 TITLE: Advanced Battery Development

Category: Exploratory Development

OBJECTIVE: Develop novel battery technology which demonstrates improvements over state-of-the-art performance.

DESCRIPTION: The Air Force has a need for high energy density, primary and secondary battery technology which can operate safely over a broad range of environmental conditions (temperature, shock, vibration, etc.) in cell sizes from 1 to 100 amp-hours. Battery designs capable of providing lightweight energy storage at voltages as high as 270 volts for aircraft use are of particular interest. The proposed technology shall include parametric studies of high rate discharge, rapid recharge, cycle life, float or overcharge behavior, safety and environmental.

PHASE I: Demonstrate advancement in the performance criteria cited in the description above.

PHASE II: Demonstrate the technology advancements in cells which are of a design that can be transitioned to a manufacturing capability at the contractor's facility or to a Phase III sponsor.

POTENTIAL COMMERCIAL MARKET: The dual use aspects of high energy density batteries finds application in a wide variety of consumer products. Batteries capable of powering items such as electric vehicles, power tools, laptops and cellular phones will benefit from advances in technology developed under this initiative.

REFERENCES:
1. A comprehensive overview of state-of-the-art battery technology can be found in "Handbook of Batteries, Second Edition," David Linden, Editor, 1995

AF97-178 TITLE: Special Purpose Power and Power Components

Category: Advanced Development

OBJECTIVE: Develop efficient, high performance electric power systems, or components for airborne or ground applications.

DESCRIPTION: This solicitation seeks innovative proposals that address two basic power issues: power switching concepts based on wide bandgap semiconductor (WBG) devices, and power generation concepts based on advanced conversion technologies. These two areas address applications for the More Electric Aircraft program, solar-powered

unmanned aerial vehicles (UAVs), power systems for ground support of UAV systems, air combat training and remote sensor sites.

The More Electric Aircraft program demands high-temperature (350 degrees C) and high-power electronics for use in power management and distribution, actuator motor control, on-site "smart" sensors, and data bus electronics. WBG semiconductor materials are projected to be excellent semiconductors for high power, high frequency and high temperature applications due to their high critical breakdown field, high saturation drift velocity, and high thermal conductivity. An objective of this solicitation is to seek proposals that offer solutions to critical issues related to WBG semiconductors, including, but not limited to (1) both deposited and natural dielectric insulators, (2) deposition and characterization of ohmic contacts, (3) cleaning techniques for WBG semiconductors, (4) ion implantation, doping, for WBG materials including diamond, and (5) concepts for WBG device topographies. Just as the evolution of silicon power semiconductor devices led to the development of advanced power concepts such as "smart" power and "optically-triggered" power, the evolution of WBG-based power semiconductor devices is expected to include implementation of these technologies, as well. This solicitation also seeks proposals containing innovative concepts that integrate such advanced technologies with the WBG-based devices.

There has been increased emphasis within DoD regarding commitmentto the use of UAVs. PV-powered UAVs offer a number of unique military operational advantages; they exhibit virtually nonexistent thermal signatures, their use of lightweight (nonmetallic) materials make them virtually radar transparent, their reliance on a noncombustible propulsion system enables operation at extremely high altitudes (60,000-100,000 ft), and their use of unlimited solar power together with energy storage enables very long duration missions. Such UAVs will require lightweight, high-power density PV arrays mounted on the aircraft wings to provide daylight power for electric-propulsion and charging of batteries for nocturnal propulsion. Power- and mass-density of photovoltaic (PV) cells play an important role in enabling electrically-powered UAVs for a variety of military and civilian missions. Proposals are sought containing high performance PV cell concepts that approach or exceed performance parameters of 18% conversion efficiency, 0.04 lbs/ft*2, 1300 watts/kg.

Small, highly efficient power systems support a number of issues important to Air Force operations: the higher efficiency reduces the problem of fuel resupply in the field, improves mobility, reduces logistics costs for remote sites, and addresses environmental issues associated with operation of inefficient power systems in environmentally sensitive regions. Proposals submitted against this need should offer innovative concepts to transition advanced conversion technologies to use in mobile, and/or unattended power systems. Proposals may address an innovative solution to a subsystem (combustor, power conditioning, conversion system, etc) problem or a complete generator system. Desired features include a system efficiency greater than 10%; i.e. 4-5 times present thermoelectric generator systems; output power of 5 to 200 watts; operating temperature environment +100 degrees F to 135 degrees F; multifuel combustor using JP-4, propane, etc.

PHASE I: Demonstrate feasibility of the proposed system or component. Sufficient progress must be accomplished to make a low risk go/no go decision for a phase II contract. Proof-of-principle experiments are desirable.

PHASE II: Result in an operable prototypic component or system that is completely suitable for the intended application. A complete, standalone system is desirable; however, proposals that address only innovative improvements to existing component technologies such as highly efficient combustors, energy conversion devices, smart switching devices, improved high temperature switches are also welcome.

POTENTIAL COMMERCIAL MARKET: The benefits of smart power include improvements in device protection and power dissipation, and knowledge of device status by the controlling microprocessor. For small-scale electric power systems, present commercial and government systems are based on old conversion technology that is 3-5% efficient. Improving overall performance by implementing advanced conversion technologies dramatically reduces overall cost of operations. Some commercial uses of these power systems include air and marine navigation stations, gas metering stations, weather monitoring stations, off-shore platforms, communication relay stations, cathodic protection, and oil exploration. In addition to commercial applications, DoD uses for these types of power systems also include air training range communications, training range data relay stations, seismic observatories, remote monitoring stations, and intelligence gathering stations.

REFERENCES:

1. K.C. Reinhardt, J.D. Scofield, and W. Mitchel, "Directions in Air Force High-Temperature Power Electronics," Proceedings of Workshop on High-Temperature Power Electronics for Vehicles, Fort Monmouth, NJ, April 1994.
2. B.J. Baliga, "Evolution and Status of Smart Power Technology," Proc. IEEE Appl. Power Electronics Conference, 1993, 18 (1993).
3. T.R. Lamp, "Power System Assessment for the Burnt Mountain Seismic Observatory," Report No. WL-TR-94-2026, Wright Laboratory, WPAFB OH, March 1994.
4. S.F. Brown, "The Eternal Airplane," Popular Science Magazine, p.70, April 1994.

AF97-179 TITLE: Advanced Power Technology Concepts

Category: Exploratory Development

OBJECTIVE: Develop advanced power technology concepts in superconductivity, aircraft high voltage, and electromagnetic effects.

DESCRIPTION: Conduct exploratory development of advanced power technology concepts including superconductivity approaches, high voltage aircraft technologies, and electromagnetic effects solutions. Superconductivity approaches are to select and demonstrate superconducting materials and fabrication processes which offer the potential of superconductor operating capability at liquid nitrogen temperature, in magnetic fields greater than three tesla, and at current densities greater than 100,000 amps per square centimeter. High voltage aircraft technologies include innovative approaches for insulation system design, high electric field dielectrics and insulation aging characterization related to dedicated aircraft high voltage and high power systems. Electromagnetic effects solutions include the assessment of the survivability/vulnerability of More Electric Aircraft (MEA) circuits to both manmade and natural electromagnetic threats.

PHASE I: Tests of at least short samples of superconductors demonstrating the capabilities stated above. Characterization of dielectric needs and aging-related requirements for dedicated aircraft high voltage and high power components. Assess and select most applicable available computer codes which address electromagnetic effects on MEA circuits.

PHASE II: Demonstrate long lengths of superconductors for use in coils, generators, and motors and assess the use of cryocoolers for airborne applications. Develop electrical insulation design criteria and aging-mitigation techniques for dedicated aircraft high voltage and high power systems. Produce a computer code which specifically addresses electromagnetic effects on MEA type aircraft.

POTENTIAL COMMERCIAL MARKET: High temperature superconductors will be used in commercial energy storage applications to manage peak power in utility grids, ground power generators, and electric motors. High voltage insulation technologies are used in both commercial aircraft power systems and utility ground power components. Electromagnetic survivability/vulnerability information is directly related to commercial aircraft.

REFERENCES:
1. G. Kozlowski, C.E. Oberly and I. Maartense, "Effect of Y BaCuO Substrate on Electromagnetic Properties of Melt Processed Yba2Cu3Ox Superconductor," Adv. in Cryo. Eng. (Materials) Vol 41.

AF97-180 TITLE: High Mach, Advanced Air-Breathing, Storable-Fueled Engine Technology

Category: Exploratory Development

OBJECTIVE: Develop key technologies for advanced cycle engines operating from Mach 0 to 8.

DESCRIPTION: Engines of interest in the Mach 0 to 8 flight regime include combined cycle systems (such as turboramjets (TurboRJ) and air-turborockets (ATR)), pulse detonation engines (PDE) and other advanced concepts.

The turbomachinery aspects of cycles such as the TurboRJs and ATR, while flexible, efficient and of great importance in the Mach 0 to 4 range, are not of interest under this topic. Technologies pertinent to the simplicity, low weight, low cost, and high specific impulse of the ramjet in the Mach 3 to 6 flight range and the scramjet from Mach 6 to 8 are of great interest. The PDE, another cycle of interest, combines the simplicity and efficiency of detonation wave combustion with the capability of air breathing at flight speeds of Mach 0 to 4 and ramjet or rocket operation above Mach 4. Technologies of interest directly involve the air, fuel, and/or combustion flow path, and use noncryogenic fuel. These include total engine concepts, the air intake systems; exit nozzles; solutions to reduce drag and total pressure losses; innovative fuel ignition, piloting and flameholding methods; solutions to reduce the length, weight, and/or cost of the inlet, combustor and nozzle and components; ramburner structures and materials, endothermic fuel reactor/engine issues; ramburner cooling techniques. Proof-of-concept testing is preferred, but analytical investigations will be considered at the Phase I level.

PHASE I: Identify novel concepts and quantify their payoff when integrated into the selected high Mach propulsion system, and to conduct small-scale experiments to demonstrate concept feasibility. If a strictly analytical approach is proposed, sufficient analysis must be performed to demonstrate a high degree of concept feasibility and a plan for experimental direction in Phase II must be shown.

PHASE II: Large scale development and testing which would include identification of appropriate facilities, and pertinent capabilities.

POTENTIAL COMMERCIAL MARKET: High Mach, advanced airbreathing, storable-fueled engines have potential application to a multitude of vehicles which require efficient acceleration and cruise capabilities. Military application might include long-range, high speed aircraft for reconnaissance and strike missions, stand-off missiles, and drones. Commercial applications might include high-speed civil transport or passenger aircraft. Dual use applications include military/commercial space launch vehicles which require an airbreathing propulsion system for the initial atmospheric boost phase. The PEGASUS launch vehicle and similar systems could benefit from the use of airbreathing boost propulsion.

REFERENCES:

1. Hay, I.W., Peschke, W.T., and Guile, R.N., "Hydrocarbon-Fueled Scramjet Combustor Investigation," AiAA-90-2337.
2. Roble, N.R., Petters, D.P., and Fisherkeller, K.J., "Further Exploration of an Airbreathing Pegasus Engine," AIAA 93-1832.

AF97-181 TITLE: Accelerated Convergence Rate for Numerical Analysis of Predominantly Supersonic Flows

Category: Exploratory Development

OBJECTIVE: Develop improved algorithms to accelerate the convergence rate of a numerical code for predominantly supersonic flows.

DESCRIPTION: The available computational fluid dynamic (CFD) codes require enormous amounts of computer processing unit (CPU) time to solve steady-state flow problems. Most CFD codes are designed to solve the Navier Stokes equations in a time-marching fashion. This is a reliable technique, but it can be quite expensive in terms of CPU time, especially when one is interested only in the steady-state solution. Added complexity arises due to the present reacting flows at high speeds.

Further development of unfactored implicit relaxation techniques hold the promise for accelerating the convergence of time-asymptotic calculations. Also, alternate equation sets such as the Reduced Navier-Stokes procedure could be aggressively researched either as an alternate solution procedure or to provide an improved initial condition for a traditional time-marching procedure. Other novel ideas for faster relaxation schemes are also applicable.

Development of a new solution technique presents challenges such as accuracy, stability, and optimization. The developer must ensure that the new technique adequately represents the flow physics. It is also necessary for the

new technique to be robust, such that it is stable as it approaches the steady-state solution. The techniques must also be optimized to provide the largest possible savings in CPU time.

PHASE I: A scheme to accelerate the convergence for time-asymptotic solutions will be developed and implemented into a CFD code with multi-block or hybrid grid capabilities. The validity of the concept will be demonstrated and the scheme will be tested for model problems involving streamwise reversed flows, strong streamwise uptstream influence, and supersonic and subsonic flow. Results will be compared to a traditional time-marching solution in terms of accuracy and CPU time.

PHASE II: Extend the acceleration scheme for chemically-reacting flows, including hydrocarbon chemistry.

POTENTIAL COMMERCIAL MARKET: The CFD tool developed will have many applications in industry. The tool is expected to have uses in automotive and other industrial applications, in addition to the military and commercial aircraft industry.

REFERENCES:

1. Chakravarthy, S.R., "Relaxation Methods for Unfactored Implicit Upwind Schemes," AIAA Paper 84-0165.
2. Thompson, D.S. and Anderson, D.A., "A Pseudo-Unsteady Approach for Predicting Steady Supersonic Flows," AIAA Paper 87-0541.
3. Edwards, Jack R. and McRae, D. Scott, "An Efficient Nonlinear Relaxation Technique for the Three-Dimensional, Reynolds-Averaged Navier-Stokes Equations," AIAA Paper 93-0540.
4. Rubin, Stanley G. and Tannehill, John C., "Parabolized/Reduced Navier-Stokes Computational Techniques," Annual Review of Fluid Mechanics, 1992, pp 117-144.

AF97-182 TITLE: Advanced Instrumentation for Ramjet/Scramjet Combustors

Category: Exploratory Development

OBJECTIVE: Develop advanced high resolution, high frequency instrumentation for use in subsonic and supersonic combusting flows.

DESCRIPTION: Obtaining accurate measurements of various flow parameters in a combusting flowfield without disturbing the flow is a difficult task. Various optical "flow" diagnostics techniques are currently under development with the eventual goal of being used in the harsh environments of direct connect and free jet facilities. The need still exists for the development of new techniques and/or refinement of the currently available techniques to allow accurate point or field measurements of velocity, temperature, density, fuel concentration, and the constituency of the exhaust effluence in hydrocarbon and hydrogen fueled ramjet and scramjet propulsion systems. Time resolved and time averaged measurements are required to allow validation of analytical/computational codes.

New robust miniature instrumentation is required to assess the performance potential of subsonic and supersonic ramjet combustors and various flow path components in free jet and direct connect facilities. In particular, the development of micro-scale high frequency sensors for measurements of wall pressure, temperature, skin friction and heat flux capable of surviving high enthalpy (up to Mach 8) flight conditions is desirable. Single- and multi-element addressable micro-opto-mechanical sensors are required for engine health monitoring and flow control. These sensors shall require minimal pre- and post-test calibration.

PHASE I: Develop and refine the measurement technique and/or the instrumentation concept to allow proof-of-concept demonstration in representative subsonic and supersonic research flows with and without chemical reaction and heat release.

PHASE II: Develop the instrumentation and the associated measurement technique to a point where it could be employed and used in realistic combustor temperature and pressure environment of direct connect and free jet facilities.

POTENTIAL COMMERCIAL MARKET: Potential for dual use is great. Similar if not identical instrumentation and measurement techniques are required in automotive, ground power generation, and incineration, and the aerospace

industries. Commercial success is however, dependent on sensor/instrument durability, practicality, accuracy, and cost. The intensive technology requirements and the relatively long system development time period forces the small businesses to look to the government agencies and the national laboratories for partnership and investment. There is, however, a great market in the US and abroad for commercialization of micro sensors and optical instruments.

REFERENCES:
1. Parker, T.E., et al., "Optical Diagnostics in Supersonic Combusting System," WL-TR-91-2101 (ADA-25343).
2. Schetz, J.A., Billig, F.S., "Flow Field Analysis of a Scramjet Combustor with Coaxial Fuel Jet," AIAA Journal Vol 20, pp 1268-1274, September 1982.
3. Winter, K.G., "An Outline of the Techniques Available for the Measurement of Skin Friction in Turbulent Boundary Layers," Progress in Aerospace Sciences, Vol 18 pp 1-57, 1977.
4. Haer, J.M., et al., "Experimental Performance of a Heat Flux Micro-sensor," ASME-92-GT256.

AF97-183 TITLE: Novel Sources of Electromagnetic Radiation for Advanced Combustion Diagnostics

Category: Exploratory Development

OBJECTIVE: Develop and demonstrate electromagnetic radiation sources tailored for measuring key combustion parameters.

DESCRIPTION: A principal driving force in the continuing development of advanced gas-turbine combustors is the reduction of environmentally hazardous emissions. Emerging gas-turbine design methodologies increasingly seek to achieve this low-emissions goal through the use of computational fluid dynamics and chemistry (CFDC) codes. The successful performance of these codes is predicated upon experimental validation through measurement of key combustion parameters. Advanced, nonintrusive, laser-based diagnostics represent an ideal approach to achieving this validation. Unfortunately, the characteristics of existing laser sources often limit the application of these powerful diagnostics techniques. This topic seeks the development and demonstration of novel electromagnetic radiation sources with unique performance advantages over existing sources. Advantages might include, but are not limited to, extended spectral coverage, tailored bandwidth, increased power, decreased noise, and enhanced temporal characteristics.

PHASE I: Demonstrate experimentally the potential for a proposed source to provide improved measurement of key combustion parameters compared to existing state-of-the-art sources. Modeling and other computational support of the concept is advantageous but not sufficient for a Phase I effort. Simply proposing a novel source of electromagnetic radiation is also insufficient; the potential advantages the proposed source brings to combustion diagnostics applications must be thoroughly explored.

PHASE II: Provide complete demonstration and documentation of the performance gains associated with the novel source of electromagnetic radiation. Ideally, this demonstration would be achieved in conjunction with a combustion application of interest to the Air Force.

POTENTIAL COMMERCIAL MARKET: The gas-turbine design methodologies validated through the use of advanced, laser-based diagnostics designed around these novel sources will have tremendous impact on the future of both military and commercial aviation, particularly as these techniques contribute to the reduction of emissions. The sources themselves have tremendous dual use commercialization potential as well. The market for this equipment includes many university, government, and industrial researchers who require tailored sources to make measurements under extreme conditions.

REFERENCES:
1. L.P. Goss and G.L. Switzer, "Combustion Diagnostic Development and Application," WRDC-TR-90-2094; DTIC Accession Numbers AD-A231667 (Volume 1) and AD-A231493 (Volume 2), November 1990.
2. R.A. Cheville and D. Grischkowsky, "Far-Infrared TeraHertz Time-Domain Spectroscopy of Flames," Opt. Lett.20, 1646-1648 (1995).

AF97-184 TITLE: Self Contained Dampers for Gas Turbine Engines

Category: Exploratory Development

OBJECTIVE: Develop a self contained damper for use in an expendable gas turbine engine.

DESCRIPTION: Self contained dampers are required to replace conventional liquid squeeze film dampers in future expendable gas turbine engines. In addition to the properties normally associated with a damper, the dampers developed under this effort should demonstrated the following properties: temperature capability to 1500 degrees F, low cost, low volume, and low weight. The Phase I effort shall produce a system design in coordination with a gas turbine engine manufacturer participating in the Joint Expendable Turbine Engine Concept (JETEC) program. As a minimum, the design shall include analytical predictions of stiffness, damping coefficient, critical speed, and unbalance response applied to a JETEC rotor. The Phase II effort shall result in the fabrication and testing of hardware sized for a JETEC demonstrator engine. The hardware shall be tested at conditions projected for a JETEC demonstrator engine.

PHASE I: Design a self-contained damper system for application in future expendable gas turbine engines.

PHASE II: Successfully demonstrate a self-contained damper system at operating conditions projected for future expendable gas turbine engines.

POTENTIAL COMMERCIAL MARKET: This technology has application in any system where rotor damping is desired without the use of liquid squeeze film dampers. Specific applications where this may be desirable include automobile turbochargers, high speed electric motors, and dental drills.

REFERENCES:
1. Rio, R.A., "Turbine Rotordynamic Evaluation," Vol I, AFAPL-ATR-76-81 (1978).

AF97-185 TITLE: Thermally Stable Jet Fuels, Additives, and Test Methods

Category: Exploratory Development

OBJECTIVE: Develop high heat sink thermally stable jet fuels, additives, improved test methods and improved fuel system components.

DESCRIPTION: Jet fuel is used to cool many aircraft and engine subsystems on current and future aircraft. Subjecting the fuel to high temperatures for long periods of time causes the fuel to degrade and form gums, varnishes and coke that can plug engine fuel nozzles, afterburner sprayrings/spraybars, fuel manifolds and fuel controls. Fuel additives can be used to improve many characteristics of the fuel. For example additives can reduce fuel degradation, prohibit the formation of frozen water particles, improve lubricity, reduce static discharge and improve low temperature flow properties. Advanced engines require fuels that will be used at supercritical conditions or that will undergo endothermic reactions to provide cooling to various engine components. The objective of this topic is to solicit technologies that improve fuel characteristics (i.e.increase thermal stability, improve low temperature flow behavior, inhibit free water from freezing etc.), to improve the design of aircraft and engine fuel system components, and reduce fuel system maintenance. Also of interest are new fuel additives, test methods (both laboratory and field), advanced models and computational chemistry techniques to predict fuel properties and the environmental aspects of fuel, fundamental methods to study fuel freezing, water in fuel freezing, fuelthermal degradation (both autoxidation and pyrolysis), fundamental aspects of the supercritical behavior of fuels, and technologies related to the use of endothermic fuels. Technologies submitted under this topic can be for conventional fuels (i.e. J-8, JP-8+100, JP-5, Jet A or Jet A-1), supercritical fuels (JP-900) or endothermic fuels.

PHASE I: Demonstrate the feasibility of the technology and quantify the payoffs for both military and commercial applications.

PHASE II: Demonstrate the application of the technology, demonstrate a prototype of the technology, validate performance, and quantify payoffs for both military and commercial applications.

POTENTIAL COMMERCIAL MARKET: All technologies developed under this topic have both military and commercial jet fuel applications due to the similarities of the jet fuels (i.e. JP-8 is commercial Jet A-1 fuel with a military additive package).

REFERENCES:
1. "JP-8+100: The Development of High Thermal Stability Jet Fuel," S.P. Heneghen, S. Zabarnick, D.R. Ballal, and W.E. Harrison, AIAA Paper 96-0403, 34th Aerospace Sciences Meeting, January 1996.
2. "Deposition for High Temperature Jet Fuels," T. Edwards and J.V. Atria, ACS Division of Petroleum Chemistry Preprints, Vol 40, No. 4, pp. 649-654, August 1995.

AF97-186 TITLE: Advanced Techniques for Ultra Trace Analysis of Aviation Fuel

Category: Exploratory Development

OBJECTIVE: Develop and demonstrate techniques for quantitating ultra-trace-level contaminants in aviation fuel.

DESCRIPTION: Many aircraft performance improvements are accompanied by substantial heat loads that lead to increased thermal stress on the fuel-the primary coolant for on-board heat sources. The result is increasingly complex thermal management, which affects aircraft design and maintenance requirements. Continuing Air Force research has revealed the critical role that trace quantities of contaminants can play in the chemistry that limits fuel thermal stability. Unfortunately, reliable techniques for quantitating the concentration of ultra-trace-level contaminants in aviation fuel are largely unavailable. The plethora of compounds present in typical aviation fuels complicates efforts to make these important measurements. This topic seeks the development and demonstration of new analytical techniques for quantitating key contaminants, such as water, Cu, Fe, Cn, Pb, S, N, and P, in the problematic fuel matrix. Requirements of a successful technique include extreme sensitivity and selectivity. The measurements achieved through proposed methodologies will drive the continued development of chemical kinetics models essential to designing next-generation aviation fuels.

PHASE I: Demonstrate experimentally the potential for a proposed technique to provide improved measurement of ultra-trace-level contaminants compared to exiting state-of-the-art methodologies.

PHASE II: Provide complete demonstration and documentation of the performance gains associated with the proposed technique. Ideally, this demonstration would be achieved in conjunction with a fuel application of interest to the Air Force.

POTENTIAL COMMERCIAL MARKET: Successful commercialization of the proposed techniques will accelerate the development of advanced fuels and yield benefits in terms of increased performance and reduced environmental impact for both military and commercial aviation. The quantitation methodologies have tremendous dual use commercialization potential as well. Ultra-trace-level quantitation is central to research and development underway in many university, government, and industrial facilities. Applications span a vast array of disciplines including materials and biomedical research.

REFERENCES:
1. D.R. Ballal, R.J. Byrd, S.P. Heneghan, C.R. Martel, T.F. Williams, and S. Zabarnick, "Combustion and Heat Transfer Studies Utilizing Advanced Diagnostics: Fuels Research," WL-TR-92-2112, DTIC Accession Number AD-A260249.
2. S.P. Heneghan, S. Zabarnick, D.R. Ballal, and W.E. Harrison, "JP-8+100: The Development of High Thermal Stability Jet Fuel," AIAA Paper No. 96-0403, Presented at the AIAA 34th Aerospace Sciences Meeting and Exhibit, January 1996, Reno NV.

AF97-187 TITLE: Aircraft Turbine Component Technology - Aerodynamics and Cooling

Category: Exploratory Development

OBJECTIVE: Develop concepts for improving aerodynamic performance and reducing cooling flow requirements of turbine components.

DESCRIPTION: Proposals should address the development of aircraft engine turbine component technologies in the area of aerodynamics and heat transfer. A major trend in turbine components for aircraft engines is increased loading, increased turbine inlet temperature and reduced cooling air. New design concepts, analysis techniques, experimental test methods and high temperature instrumentation development are needed to further the technology in these areas. Proposals should focus on an effort that contributes to meeting the goals of the Integrated High Performance Turbine Engine Technology (IHPTET) program.

PHASE I: Explore the feasibility of a new concept or concepts, through analysis or small scale testing, to demonstrate the potential merits of the concept.

PHASE II: Provide detailed analytical derivations, prototype and/or hardware.

POTENTIAL COMMERCIAL MARKET: Higher performance turbine engines and associated technologies will lead to more efficient, quieter and environmentally acceptable propulsion systems. Turbine technology improvements play a major role in military applications and there is great potential to transition to commercial use.

REFERENCES:

1. "Progress Towards Understanding and PRedicting Convection Heat Transfer in the Turbine Gas Path," Robert J. Simoneau and Frederick F. Simon, International Symposium on Heat Transfer in Turbomachinery, Athens, Greece, August 1992.

AF97-188 TITLE: Compression System Design Methodology

Category: Exploratory Development

OBJECTIVE: Develop concepts or software to advance aerodynamic and mechanical technology of compression systems and secondary gas path systems.

DESCRIPTION: A major trend in compression system hardware is the increased utilization of highly loaded, low aspect ratio, complex shape airfoils in multistage configurations. Increased loading produces larger blade wakes resulting in significant unsteady aerodynamic and aeromechanical interactions between stages. In addition, increased loading has produced stall margin and efficiency sensitivity to blade tip clearance levels. Airfoils shapes tailored to meet specific loading, efficiency, and operability goals produce significant mechanical design challenges. Aerodynamic and aeromechanical design capability does not fully account for the unsteady interactions, the effects of complex airfoil shapes, or the sensitivity to tip clearances that exist in compression systems. Developments that improve the understanding of these phenomena, such as advanced measurement methods and new design models, are desired. Innovative concepts that exploit an understanding of these phenomena are also desired. Areas of prime technical importance include endwall and secondary flows, time unsteadiness, forced response and mistuning, and innovative diagnostic instrumentation.

Obtaining precise secondary gas path flow control will play an increasingly larger role in optimizing engine efficiency, as further gains in the major engine components become more difficult to achieve. Understanding primary and secondary gas path interactions can be critical to the performance of both. Reducing parasitic leakage and seal deterioration, while minimizing air needed for cooling, ventilation, and thrust balancing, is a significant challenge as

the secondary gas path environment becomes more extreme. Innovative concepts and models leading towards precise secondary gas path flow control are desired. Areas of particular interest include film riding seals, trenching and shrouds, innovative thrust balancing, counter rotation, and disk pumping.

PHASE I: Demonstrations of concepts or software for the development of advanced compression system or secondary flow system design.

PHASE II: Bench tested technology concepts or software for advanced compression system or secondary flow system design, adequately documented to be acceptable to the technical community.

POTENTIAL COMMERCIAL MARKET: The improvements gained in compression and secondary gas path system performance and efficiency are directly applicable to both military and commercial gas turbine engines.

REFERENCES:

1. Bullock, R., and Johnson, I., Aerodynamic Design of Axial-Flow Compressors, "Chapter III - Compressor Design System," NASA SP-36, 1965.
2. Puterbaugh, S.L., and Brendel, M., "Tip Clearance Flow-Shock Interaction in a Transonic Compressor Rotor," AIAA95-2459.
3. "Unsteady Aerodynamic Phenomena in Turbomachines," AGARD-CP-468, August 1989.
4. "Loss Mechanisms and Unsteady Flows in Turbomachines," AGARD-CP-571, January 1996.
5. Smith, L.H., "Wake Ingestion Propulsion Benefit," Journal of Propulsion and Power, Vol. 9., No. 1, Jan-Feb 1993.
6. Moore, A., "Gas Turbine Engine Internal Air Systems - A Review of the Requirements and the Problems," ASME Paper 75-WA/FT-1, November, 1975.
7. Mayhew, E.R., Bill, R.C., Voorhees, W.J., O'Donnell, J., "Military Engine Seal Development: Potential for Dual Use," AIAA 94-2699.
8. Steinetz, B.M., and Hendricks, R.C., "Engine Seal Technology Requirements to Meet NASA's Advanced Subsonic Technology Program Goals," AIAA 94-2698.

AF97-189 TITLE: Real-Time Ontogenetic Engine Health Monitoring (EHM) of Gas Turbine Engines

Category: Advanced Development

OBJECTIVE: Develop a real time ontogenetic (RTO) EHM system and demonstrate its capabilities using real or simulated engine sensed or derived data.

DESCRIPTION: The ability to trend an engine's performance has been possible ever since James Watt fired up his first steam engine; however, the development of the ability to monitor and predict an engines life, health and performance has not kept in step with technological advances. The introduction of digital engine control management and the use of electrical data buses enables us to obtain considerable sensed data while the engine is running; however, we have never capitalized on this and have only managed historical trending of vibration, temperature and rotational speeds. By using neural networks, NASA has produced a credible real time engine health monitoring system for their reusable rocket engines. With major advances in computer science and production control technologies, we can now realize a true EHM system that will trend the performance, life consumption and health in real time. The introduction of an ontogenetic EHM system will considerably reduce engine life cycle costs and enhance operational capabilities.

PHASE I: Develop an ontogenetic EHM system that can provide real-time monitoring of creep and fatigue life, component condition and life consumption, engine performance and engine health based on actual or simulated engine sensed or derived data. The system will accept performance algorithms and historical information to produce its own expert system; it will then show the capability to monitor, trend, predict and inform the required monitors, while developing its own ontogenetic knowledge/experience.

PHASE II: Develop the EHM system to fly on a USAF aircraft and provide a true intelligent EHM system that will relate engine condition information in a user friendly form related to Technical Orders. The system will demonstrate a system redundancy capability, in that it will use tools such as probabilities techniques, based on data from the active sensors, to compensate for any system fault.

POTENTIAL COMMERCIAL MARKET: The development of a RTO EHM system will bring major cost reductions to the civilian aerospace community. Never intended to replace the technician, RTO EHM will provide fast and accurate diagnostic information to reduce maintenance times, no-fault founds and turn-around times. The improved critical life management aspect will reduce the engines cost of ownership.

REFERENCES:
1. T. Trode and W. Merrill, "A Real Time Net Estimator of Fatigue Life," NASA Report # TM-103117 for The International Joint Conference on Neural Networks, cosponsored by IEEE and INNS, San Diego CA, 17-21 June 1990.

AF97-190 TITLE: Combustor Acoustics Modeling Technology Research

Category: Basic Research

OBJECTIVE: Develop methods to identify the physical causes of acoustic instability in high performance aircraft gas turbine engine combustors.

DESCRIPTION: Future gas turbine engine combustors will be physically shorter, operate at higher through flows and axial flow velocities, burn liquid and gaseous fuel streams and operate with a lower pressure drop. Occasional breakdown of the combustion flow causes extreme pressure and temperature pulsations inducing low and high cycle fatigue in hot section components. Current combustor design systems lack the capability of identifying acoustic coupling of these combustion processes.

PHASE I: Phase I will require an in depth analysis to identify the casual physics of combustion driven acoustic resonances in gas turbine combustor environments.

PHASE II: Focused towards proposed methods to eliminate resonances. These methods shall be consistent with the practical features and environmental limitations of gas turbine combustors. The information gained under phase I will be used to design and fabricate a subscale test article which exhibits the anticipated conditions in a modern gas turbine engine. A test plan shall be prepared identifying the testing and development work required to validate the physics and suppression concepts identified. Testing shall demonstrate both the resonant states of the test article and the effectiveness of the proposed suppression and avoidance systems.

POTENTIAL COMMERCIAL MARKET: All commercial gas turbine engines require combustion systems. Characterization of the impact of unsteady combustion processes on high and low cycle fatigue will provide great benefits in extending hot section life and performance, therefore, directly benefiting commercial gas turbine engines.

REFERENCES:
1. Sterling, James David, "Longitudinal Mode Combustion Instabilities in Air Breathing Engines," California Institute of Technology, Volume 48/06-B. of Dissertation Abstracts International, Page 1746

AF97-191 TITLE: Adaptive Filtering for Improved Turbine Engine Performance and Component Estimation

Category: Exploratory Development

OBJECTIVE: Develop new adaptive filtering methodologies with capability to optimize over a large number of engine parameters.

DESCRIPTION: Modern gas turbine engines are controlled by digital electronic engine controls. They employ conventional linear control system algorithms which are implemented with discrete time realizations. The most advanced engine control systems now employ model based control techniques which provide more accurate control, optimizing dynamic performance over the engines operating envelope. Model based controls employ a tracking filter to adjust the engine model. Future engine control systems will have higher performance, lower cost, employ damage tolerance techniques, and have significantly reduced maintenance cost. They will require active combustion and stall margin control. These goals are only realizable by employing adaptive filtering, or tracking filters around each subsystem; i.e., sensors, components, and active engine performance loops. The complexity and cost of implementing many individual tracking filters prevent general use of this approach. The development of improved tracking filter methodologies which have the capability to optimize a variety of important engine subsystems will result in a substantial improvement in engine control. Investigation of generalized techniques such as linear adaptive control, and nonlinear sliding mode control are appropriate. Implementation of these new techniques will enable the integration and cost effective implementation of engine performance trending, deterioration estimation, fault isolation, and dynamic control.

PHASE I: Develop conceptual designs for an advanced tracking filter which will estimate a significant number of key engine parameters. The design should apply advanced system identification techniques to the turbine engine system with its associated sensor suite.

PHASE II: Demonstrate the effectiveness of a multiple parameter optimization (tracking) filter over state-of-the-art techniques. In this effort, a tracking filter algorithm which implements the most promising technique developed in the Phase I effort will be designed and tested. An appropriate engine model will be employed in the design and test of the advanced tracking filter.

POTENTIAL COMMERCIAL MARKET: Commercial aircraft engines will realize significant benefits in terms of reduced operating cost by improvements in control efficiency and better predictive diagnostics. Fuel and maintenance costs will go down. The technology can also significantly improve the control of industrial robotic manipulators and advanced electric motors. It will especially benefit systems with large uncertain dynamics.

REFERENCES:

1. "Preliminary Flight Evaluation of an Engine Performance Optimization Algorithm," H.H. Lambert, G.B. Gilyard, AIAA Joint Propulsion Conference, June 24-26, 1991, Sacramento CA, Paper #AIAA-91-1998.
2. "Estimating In-Flight Engine Performance Variations Using Kalman Filter Concepts," G.W. Gallops, AIAA Joint Propulsion Conference, July 10-12,1989, Monterey CA, Paper #AIAA-89-2584.
3. "Performance Seeking Control for Cruise Optimization in Fighter Aircraft," Eric J. Tich, Peter D. Shaw, AIAA Joint Propulsion Conference, June 29 - July 2, 1987, San Diego CA, Paper #AIAA-87-1929.

AF97-192 TITLE: Whole Wafer Thermal Measurement

Category: Exploratory Development

OBJECTIVE: Develop an affordable thermal measurement technique for reliably measuring in-situ temperature uniformity across semiconductor wafers.

DESCRIPTION: The production of <0.5 mm VLSI silicon integrated circuits and III-IV semiconductor heterojunction and quantum well devices requires the capability to measure and control the across-wafer temperature to ±1°C at temperatures ranging from 150°C to 1100°C depending on the type of fabrication processes used. Currently either thermocouples or optical pyrometers are used for measuring the wafer temperature. Thermocouples in contact with the wafer provide the actual temperature of the wafer only in the region of the contact point. While fairly reliable, thermocouples suffer from slow response time, and their lifetime is inversely proportional to the process temperature. Optical pyrometers, on the other hand, respond rapidly, but the measured temperature can be unduly influenced by variations in the wafer emissivity which is a function of the number and type of layers on the wafer. In addition, the

reliability of pyrometers is of concern. For the most part, these techniques are also restricted to measuring the temperature at a point or small region of the wafer.

PHASE I: Develop and demonstrate the feasibility of concepts for measuring in real-time the temperature across a semiconductor wafer to an accuracy of ±1°C at temperatures appropriate for the semiconductor device targeted for the in situ environment. Concepts must be compatible for single-wafer and/or batch processing and have a benign effect on the processing environment.

PHASE II: Fabricate a breadboard demonstration of the concepts defined in Phase I and experimentally demonstrate the approach for in situ, real-time measurement capability, Plans shall be developed to bring the concept to a commercially viable product for use as an in situ, real-time technique for measuring and controlling the across-wafer temperature in a semiconductor production process.

POTENTIAL COMMERCIAL MARKET: An accurate and reliable in situ whole-wafer temperature measurement technique will have an immediate commercial market in temperature monitoring and control for a wide variety of thermal processing technologies such as rapid thermal processing, molecular beam epitaxy and metallo-organic chemical vapor deposition.

REFERENCES:

1. W.F. Kosonocky, et al., "Multi-Wavelength Imaging Pyrometer (M-WIP) for Semiconductor Process Monitoring and Control," WL-TR-95-8010, 1995

AF97-193 TITLE: Systems Engineering Using Key Characteristics

Category: Advanced Development

OBJECTIVE: Develop an integratable software tool to manage the systems engineering process using Key Characteristics.

DESCRIPTION: Key Characteristics (KCs) can be defined as product features, manufacturing process parameters, and assembly process issues that significantly affect product performance, function, and form. They are classified into three different types of engineering functions: 1) Product Key Characteristics (PKCs), which are product geometric features and material properties that have a significant impact on the product performance, function and form at each product assembly level, 2) Assembly Process Key Characteristics (AKCs), which are the features during each assembly stage on the product, tool, fixture, or procedures that significantly affect the assembly process, and 3) Manufacturing Process Key Characteristics (MKCs), which are the manufacturing machine process parameters and/or work piece fixturing features for machine tools and equipment that significantly affect the realization of a product. Key Characteristics when used in conjunction with the development of the Work Breakdown Structures (WBS) and the project planning processes could provide a vehicle to 1) significantly reduce the learning curve associated with the start of assembly by identifying the critical issues early in the product development cycle, and 2) assess manufacturing cost trade-offs during product development by considering engineering issues, manufacturing process capability, assembly issues, and customer requirements. By identifying the critical product features upfront, resources can be allocated to address them through multi disciplinary teams.

PHASE I: Phase I of this effort will consist of a detailed analysis of the appropriate processes and tools that need to interact to provide the maximum utility for the systems engineering managers. Phase I will culminate with the development of an initial concept feasibility demonstration on a tool to help create, manage, and communicate Key Characteristics throughout the life cycle of the product development process.

PHASE II: Phase II will focus on the continued development, refinement, demonstration and implementation of the tool. This phase will culminate with the release of at least a beta version software tool.

POTENTIAL COMMERCIAL MARKET: Any company that designs complex mechanical systems. Boeing, Northrop Grumman, Ford, and General Motors are using the notion of Key Characteristics. However, instead of using software tools to manage them, they have a thick book that is hard to track, update, and distribute.

REFERENCES:
1. Lee, D., et al., "Key Characteristics for Agile Product Development and Manufacturing," Agility Forum 4th Annual Conference Proceedings, Bethlehem, PA.
2. Lee, D. and Thornton, A., "Enhanced KC Identification Methodology for Agile Design," Agility Forum 5th Annual Conference Proceedings, Bethlehem, PA.
3. Cunningham, Timothy, et al., "Definition, Analysis, and Planning of a Flexible Assembly Process," 1996 Japan-USA Symposium on Flexible Automation Conference Proceedings, Boston, MA, July 7-10, 1996

AF97-194 TITLE: New Methods for Copper Electro-Plating Advanced Printed Wiring Boards

Category: Engineering Development

OBJECTIVE: Develop novel plating technologies that decrease environmental impact of producing electro-deposited copper foils.

DESCRIPTION: Department of Defense and commercial suppliers of printed wiring boards require new methods of depositing copper foils which are easily controlled, cost-effective, and environmentally benign. The packaging and interconnection of advanced electronics systems is presently achieved through laminate-based printed wiring boards. This technology is founded in the electrical and mechanical performance gained through the use of electro-deposited copper foils. Electro-deposited copper contained in laminated boards provides the necessary surface and through-hole connections for conductivity. Additive-based chemistries currently in use in electro-plating baths are difficult to control and shorten the life of the plating bath. Additionally, manufacturing processes have not progressed sufficiently to support the level of performance required in advanced printed wiring boards. Novel, more environmentally friendly, plating technology is needed which can achieve the control necessary for increased performance and reliability of newer, fine-featured designs.

PHASE I: Phase I will demonstrate the feasibility of an environmentally friendly, plating technology for depositing copper foils as described above.

PHASE II: The goal of Phase II will be to fabricate a complete prototype plating system using the technology demonstrated in Phase I. Advanced design printed wiring boards with fine-features will be plated and their electrical and mechanical properties shall be measured to demonstrate the performance improvements.

POTENTIAL COMMERCIAL MARKET: Copper plating is the basis of printed wiring board manufacturing for both military and commercial suppliers. These plated boards are the foundation of a world-wide market of $18 billion in commercial electronics. New methods for improved plating can be more reliable, more cost-effective, and provide high technology boards at lower environmental impact

AF97-195 TITLE: Manufacturing Information for Electronics System Upgrades

Category: Exploratory Development

OBJECTIVE: Develop methods and techniques to automate the creation of manufacturing information and simulation models for emerging and legacy electronics systems

DESCRIPTION: Current state-of-the-art methodologies and techniques for creating manufacturing information and simulation models needed to drive the reengineering of "bad actor" electronics or to perform electronics systems upgrades are based upon manual and error prone approaches. In many cases, the design data representing the physical implementations is inaccurate and/or incomplete. The purpose of this effort is to explore and exploit emerging VHDL (VHSIC Hardware Description Language) and VHDL-A (AHSIC Hardware Description Language - Analog) modeling practices and approaches. In addition, new principles and practices must be developed for automating the extraction of

information needed to drive simulation model creation from legacy engineering and manufacturing information. Examples of legacy engineering and manufacturing information sources are test program sets, schematics, performance specifications and netlists.

PHASE I: Phase I will develop methodologies and techniques for a highly automated process to extract the salient information necessary to create accurate manufacturing information and simulation models for emerging or legacy electronics systems. In addition, software tools needed to automate the process and ensure its repeatability will be identified for development in Phase II. The feasibility of the developed process will be demonstrated at the end of the Phase I effort.

PHASE II: Phase II would develop the software tools to automate the extraction and information creation methodologies and techniques defined in Phase I and package them into a commercially viable product.

POTENTIAL COMMERCIAL MARKET: Commercial industries utilize past designs for new electronic product endeavors. With time to market and cost issues critical for global competitiveness, the methodologies, techniques and tools developed during this effort will be applicable to design reuse for many commercial applications.

REFERENCES:
1. Joel M. Schoen, Performance and Fault Modeling with VHDL, Prentice Hall, 1992

AF97-196 TITLE: Three-Dimensional Semiconductor Substrate Inspection

Category: Exploratory Development

OBJECTIVE: Develop and demonstrate methods of three-dimensional (3D) inspection of semiconductor wafers.

DESCRIPTION: State-of-the-art wafer processing is only as good as the quality of the starting substrate materials. As technology has greatly reduced the size of active components and allowed the integration of vast amounts of circuitry on a chip, the starting material quality has become a major variable in determining the final yield of a product. Not only is it important to have high wafer surface quality, it is equally important to have substrate crystal uniformity; i.e. defect free beyond the depth of the junctions of the active devices.

PHASE I: Develop 3D wafer inspection concepts for various substrate materials. Downselect the concepts to the one that has the greatest potential for inspecting the variety of substrate materials. Feasibility of the concept must be sufficiently proven.

PHASE II: Develop the selected concept, design and fabricate a prototype system to 3D inspect wafers. Demonstrate the effectiveness of this inspection system by processing a suitable device with wafers from a baseline inspection system and wafers inspected by the 3D system. Compare the yields and report the results. This demonstration task should be performed on at least two different material types such as bulk silicon, silicon on insulator (SOI), and Gallium Arsenide.

POTENTIAL COMMERCIAL MARKET: The product is valuable to the semiconductor industry to improve fabrication yields and reduce overall costs

AF97-198 TITLE: Innovative Manufacturing Technology Concepts

Category: Basic Research

OBJECTIVE: Develop and demonstrate innovative approaches in advanced manufacturing technology concepts which have broad applicability to AF weapons systems.

DESCRIPTION: The Manufacturing Technology Directorate aggressively pursues advances in manufacturing technology which have broad applicability to the affordability and performance of AF systems. The focus of this

general topic is to allow opportunities for major breakthroughs in the following areas: Composites Processing & Fabrication, Electronics Processing & Fabrication, Metals Processing & Fabrication, Advanced Industrial Practices, and Manufacturing & Engineering Systems. New processing techniques, variability reduction tools, affordability improvements, manufacturing simulation & modeling, are a few examples of the types of proposals that are desired. The emphasis is on innovation, the ability to achieve major advances, and defense/commercial applicability.

PHASE I: During Phase I, the offeror shall determine the technological merit and feasibility of the proposed innovative concept.

PHASE II: The Phase II effort is expected to produce a well defined deliverable product or process.

POTENTIAL COMMERCIAL MARKET: Each proposal submitted under this general topic should have an associated commercial/defense related application of the planned technology. The commercial application should be formulated and developed during Phase I. Phase II will require a complete commercialization plan

AF97-199 TITLE: Weapon Flight Mechanics Research

Category: Exploratory Development

OBJECTIVE: Develop innovative concepts for advanced weapon airframes and navigation, guidance and control.

DESCRIPTION: New and innovative concepts for the area of air delivered conventional munitions and armament is sought. The Weapon Flight Mechanics Division conducts research and directs exploratory development of advanced weapon airframe concepts and the guidance, navigation and control (GN&C) of weapon airframes. Weapon airframes under consideration include air-to-air missiles, air-to-surface munitions (general purpose bombs and hard target penetrators), submunitions, and projectiles. Areas under consideration for weapon airframes include aerodynamic shaping, folding fins and wings, carriage and release technologies (especially multiple carriage and release of submunitions), and innovative control techniques (i.e. reaction controls, body bending, etc.). Areas of primary interest in navigation include very small low cost inertial measurement units (IMUs), Global Positioning System (GPS) guidance, jam resistance GPS, and transfer alignment. Areas of interest in guidance technology include optimal guidance law development, target state estimators and advanced adaptive autopilots.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and feasibility of the innovative concept. The merit and feasibility should be clearly demonstrated during this phase.

PHASE II: The Phase II effort is expected to produce a well defined deliverable product or process.

POTENTIAL COMMERCIAL MARKET: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan

AF97-200 TITLE: Advanced Flight Controls for Small Airframes

Category: Exploratory Development

OBJECTIVE: Develop a technique using advanced non-aerodynamic controls, such as reaction controls, to allow incremental translation maneuvers of small, high speed airframes.

DESCRIPTION: Large, conventional aerodynamic control surfaces not only add to the weight of an airframe, but also its cost. When the advantage of extremely accurate aimpoint selection provided by the global positioning system (GPS) is maximized, flight control devices must enable precise maneuverability. The use of reaction controls aids in countering target location error, assists in the terminal guidance phase, eliminates the weight of conventional control surfaces, and reduces package size and cost.

PHASE I: Phase I of this project should determine the feasibility of controlling a 250-400 pound, 5-7 inch diameter, 70-100 inch length vehicle through a prescribed set of flight maneuvers representative of a hard target penetrator weapon.

PHASE II: Phase II would require the development of a six-degree of freedom (6DOF) simulation of such a weapon. Limited ground tests of representative reaction control hardware, as well as wind tunnel tests of the airframe, are required to produce data for the simulation models.

POTENTIAL COMMERCIAL MARKET: Any aircraft can experience in-flight control system failures. If mechanical control surfaces fail on a small aircraft utilizing this type of alternate control philosophy, a blending of aerodynamic and propulsive flight controls may result in the pilot having some control over an otherwise uncontrollable aircraft. Some aspects of propulsive flight control technology may also be applicable to space vehicles.

AF97-201 TITLE: Tactical Kinematic GPS/IMU Algorithms

Category: Exploratory Development

OBJECTIVE: Develop methods to investigate and evaluate use of Kinematic GPS/IMU algorithms in a tactical munition dynamic environment.

DESCRIPTION: A need exists to improve navigation accuracy of Global Positioning System (GPS) guided munitions. Kinematic GPS uses carrier phase information that greatly improves the accuracy capability of GPS systems. However, high dynamic kinematic GPS navigation is limited by the ability to resolve the carrier integer cycle ambiguity in a timely manner. Ongoing efforts to develop more accurate IMU's (0.1 deg/hour) that are smaller and cheaper can be exploited to enable high dynamic kinematic GPS algorithms resulting in sub-meter GPS navigation accuracy.

PHASE I: Phase I of this project should investigate innovative high dynamic kinematic GPS/IMU algorithms tuned for the high dynamic environment of a tactical munition.

PHASE II: Phase II should be the realization via procurement/fabrication of a breadboarded kinematic GPS/IMU system tuned for the high dynamic environment of a tactical munition.

POTENTIAL COMMERCIAL MARKET: The commercial airline industry plans to use GPS as a primary navigation device. Thus, the FAA is very interested in accurate automated landing systems

AF97-202 TITLE: Multiple Sensor Inertial Measurement Unit

Category: Exploratory Development

OBJECTIVE: Develop the filter for an Inertial Measurement Unit (IMU) utilizing multiple lower performance, low cost gyros and accelerometers and produce an inexpensive IMU with higher performance.

DESCRIPTION: There has been a constant demand to make tactical grade Inertial Measurement Units (IMUs) smaller, less expensive, and more accurate (Many of these factors are interdependent). The goal of this topic is to acquire greater accuracy from lower cost, less accurate sensors by using several of them per axis and then filtering their outputs to obtain lower errors than the single sensor method. A trade off will exist between the number of sensors and the accuracy gained per size increase, therefore, an accuracy improvement versus size/cost model must be developed. The end product will be a miniaturized filter and electronics package used to construct a multiple sensor per axis IMU. The size of the gyros and accelerometers is not relevant, however, once the sensor technology has matured, MicroElectroMechanical (MEM) sensors should be excellent contenders.

PHASE I: Phase I will consist of an analysis to determine the optimal number of sensors used to maximize performance and minimize size and cost. A computer simulation must be developed to demonstrate the performance

improvement obtained when using multiple sensors rather than a single one. The simulation must include the development of the filter algorithms used to process the output of the multiple sensors, as well as depict the design for the filter, electronics, and the packaging. To demonstrate filter potential, single and multiple sensor accuracy for one axis must be tested and documented.

PHASE II: Phase II will develop and fabricate an IMU consisting of multiple sensors per axis, sensing electronics, and the sensor filter. The unit will minimize the package for the electronics and sensor filter without regard to sensor size, however, sensor quantity will be optimized. Single and multiple sensor per axis performance must be tested and documented.

POTENTIAL COMMERCIAL MARKET: Applies to almost all applications which use inertial sensors

AF97-203 TITLE: Guidance Research

Category: Exploratory Development

OBJECTIVE: Develop innovative concepts in guidance technologies

DESCRIPTION: The Advanced Guidance Division of the Wright Laboratory Armament Directorate seeks new and innovative ideas/concepts in several areas: Electrooptical, millimeter-wave, and radio-frequency seeker technology and the components and signal processing systems used in these seekers. This includes, but is not limited to, sources, detectors, polarization-sensing elements and systems, modulators (both single element and pixelated), pattern recognition and processing systems, and basic material and device development for accomplishing all of these; Polarization-sensing elements and systems for studies of the utility of such systems for target characterization and discrimination; Developing algorithms for use within autonomous target acquisition (ATA) applications; Innovative signal and image processing algorithms used, for example, in synthetic-aperture radar (SAR), millimeter-wave (MMW), infrared (IR), and laser radar (LADAR) are needed to autonomously detect and recognize target signatures embedded in sensor data; Operations/functions associated with the ATA process involve noise elimination, detection, segmentation, feature extraction, classification, (i.e., truck vs. tank), and identification (i.e., truck A vs. truck B); Algorithms capable of processing multi-sensor data are of particular interest; The utilization of image algebra in the development of non-proprietary ATA algorithms; Key research areas include signal and image processing, pattern recognition/classification, image understanding, artificial neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, and data fusion. Concepts must have a good dual use/commercialization potential.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: The Phase II effort is expected to produce a well defined deliverable product or process.

POTENTIAL COMMERCIAL MARKET: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan

AF97-204 TITLE: Optical Detection and Discrimination Techniques for Laser Radar

Category: Exploratory Development

OBJECTIVE: Develop alternative detection and discrimination techniques useful for 3D range-imaging and/or range-doppler imaging with an emphasis on low-cost and manufacturable technologies.

DESCRIPTION: Laser range-imagers and laser radars are useful tools for a variety of applications such as remote-sensing, machine-vision, parts inspection, and others. Most existing laser radar systems rely on one of two schemes for finding the distance to an object; either a pulsed detection scheme which measures the photon-time-of-flight or a

coherent detection scheme which measures the radio frequency beat noise of two interfering optical signals. Generally, these systems operate with a single element detector (or a linear array of such elements) combined with a scanning laser beam to assemble an image. Each of these systems has several drawbacks which limit their applications, particularly in areas where cost is a concern. Current direct detection systems tend to have limited range resolution (inches) and are often limited by background noise, while current coherent systems tend to be complex and expensive. The use of a scanner limits the data rate of the system and the environment in which it can be used. The area searched by a system is limited by the required resolution and the data rate of the system. Although these two basic design concepts dominate the laser radar field, several variants of these systems and other system concepts are feasible. The goal of this topic is to develop laser radars based on techniques which promise a substantial performance improvement and/or cost reduction. Approaches which can improve the range or angular resolution are of interest. Systems which rely on previously unexploited optical properties (such as wavelength dependent properties) are also of interest. One possible example is to use modern solid state technology to implement low cost coherent systems. An additional example is to use modulation of the transmitted pulse to simplify/improve detection and or increase resolution.

PHASE I: Phase I of this project would demonstrate the applicability of the detection technique to specific problems in a controlled environment.

PHASE II: Phase II would consist of the construction of a fieldable laser radar system which operates on the principles demonstrated in Phase I.

POTENTIAL COMMERCIAL MARKET: This project would add new capabilities in the laser radar field that would benefit both commercial industry and the military, particularly in areas where current systems can not be used or are prohibitively expensive. A low-cost coherent system would be useful for structural fatigue studies on large buildings and structures. A system with improved range resolution would enable automated parts inspection for manufacturing, and have possible medical applications for the measurement of burns and incisions

AF97-205 TITLE: Narrow Bandwidth Near-Infrared Tunable Optical Filter

Category: Exploratory Development

OBJECTIVE: Develop a high-throughput optical filter with a line-width of 1 nm or less and tunable in the near-to-mid infrared.

DESCRIPTION: Optical bandpass filters are used in a variety of devices to reduce optical background noise near particular wavelengths of interest. Reduction of the optical noise increases the system signal-to-noise ratio, thereby increasing the probability of detection and accurate measurement of a given event. While high-performance compact narrowband filters are available at some specific wavelengths in the visible and near-infrared, there are currently no tunable filters available with equivalent size and performance. Recent advances in tunable laser technology make the development of high-performance tunable filters highly desirable. Currently, there are a few techniques which are used to filter tunable radiation; however, few of these have the size or performance required by our applications. For instance, monochrometers can be used to produce a tunable filter with a fairly narrow optical bandwidth; however, they are large, not particularly rugged, and generally do not have a very high throughput. In this project we are interested in producing a device which can be used as a tunable filter. The desired performance parameters are: tuning range from 1.5 microns to 2.5 microns, full width half maximum (FWHM) bandpass of 1 nm or less, greater than 70% in-band throughput, and greater than 40 dB rejection of out of band signals. This overall device size should be small enough to be incorporated into fieldable optical systems, i.e. comparable or smaller than existing components such as detector assemblies, optical isolators, etc. Additionally, the device should be able to operate over a wide temperature range without elaborate temperature control requirements.

PHASE I: Phase I of this project will investigate and demonstrate candidate techniques for developing compact tunable optical filters with the above performance goals.

PHASE II: Phase II would involve the fabrication, characterization, and packaging of the filters based on the techniques demonstrated in Phase I. The filters will be deliverable items.

POTENTIAL COMMERCIAL MARKET: This project would fill a gap in current filter capabilities that would benefit both the military and commercial industry. A tunable optical filter is required for several applications which have been enabled by recent advances in tunable laser technology. The compact size of this technology will allow the transition of techniques currently being explored in the laboratory into fieldable and commercially viable systems. One potential application of this technology is highly-accurate hand-held chemical and pollution sensors.

AF97-206 TITLE: High Performance Pulse Capture Circuitry for Near-Infrared Optical Receivers

Category: Exploratory Development

OBJECTIVE: Develop, design and construct pulse capture circuitry with high sensivity, wide bandwidth, and large dynamic range.

DESCRIPTION: Recent advances in the field of imaging laser radar have resulted in compact and rugged lasers capable of producing high-quality, short pulses of light. One of the principal challenges to the field use of this technology is the lack of corresponding high-quality receivers. The receiver is needed to convert the returned optical energy to an electrical signal usable by digital circuitry and is generally composed of an optical detector, amplification and discrimination electronics, and an analog-to-digital converter. One challenge to the design of these receivers is the very large dynamic range required; the returned signal falls off as one over R-squared (best case), where R is the range to the object being imaged, and this problem is exacerbated because the reflectance from various objects can range from less than 1% to greater than 99%. A second challenge is the desire to time the arrival of the returned optical energy to greater than 1 ns accuracy, although transmitted pulse lengths are often longer than 10 ns. This requires implementation of pulse discrimination techniques in the receiver. While it is possible to obtain receiver systems which have either high sensitivity, wide-bandwidth, low-noise, or large dynamic ranges; suitable combinations of these desirable characteristics in a single receiver are not currently available. This limits overall performance for an application since systems must often be optimized for a particular region of the desired operating space. Detectors, such as avalanche photodiodes (APDs), are now available which can simultaneously fulfill many of these requirements; however, these detectors are useless without the appropriate electronics to capture and convert the optical signals into electrical signals usable with conventional digital circuitry. It is desirable to have electronics which can capture both the temporal and intensity information from an event with high accuracy over the desired dynamic range. Currently, there are no commercially available electronics packages which can support the desired operating range. The goal for this project is to develop receiver electronics which can accurately capture the intensity of an optical pulse with a dynamic range of at least 5 orders of magnitude and convert this pulse to a digital signal with high accuracy. The dynamic range must start from the minimum detectable signal from the detector. For purposes of initial design, a commercially-available InGaAs APD detector can be assumed. The electronics must be able to detect the pulse arrival with a minimum accuracy of 1 ns for optical pulse lengths from 1 ns to 20 ns in length. The electronics must be able to properly control the bias of the detector and must be reasonably resistant to interference from other electronic components typically used in laser radar systems.

PHASE I: Phase I of this project should include designing the electronics circuitry and demonstrating the critical elements of the electronic design.

PHASE II: Phase II would consist of the construction and hardening of prototype receivers based on the technology developed in Phase I. A working receiver system will be delivered at the end of this phase.

POTENTIAL COMMERCIAL MARKET: This project would extend the field of the laser applications by increasing the robustness and useful operating range of fieldable systems. This technology would be useful in applications where both a high responsivity and a fast response time are required. Examples of such applications include spectroscopy, remote sensing, LIDAR, and fiber optics communications.

AF97-207 TITLE: Advanced Processing Techniques for Restoration and Superresolution of Imaging Sensors

Category: Exploratory Development

OBJECTIVE: Develop innovative and computationally affordable signal/image processing algorithms for image restoration and resolution improvement (superresolution) for smart weapon applications.

DESCRIPTION: The detection, acquisition, classification, identification, and aim point selection of tactical ground mobile, and high value targets are critical issues for smart weapons. The sensor resolution is dependent on aperture parameters and operating frequency. While it's true that the larger the aperture, the better the resolution will be, aperture size is constrained by the missile airframe. Spatial resolution varies proportionally with target distance. To be able to acquire a target at a reasonable range in a high clutter environment, or low signal-to-noise within an aperture-limiting hardware platform, advanced signal/image processing techniques are required. Wright Laboratory's Armament Directorate is interested in innovative signal/image processing techniques to perform image restoration and superresolution for smart weapon applications. Proposed efforts should offer the potential to improve the resolution of a variety of imaging sensors, and enhance target acquisition and classification performance in high clutter environments. Image restoration is essentially accomplished within the system's spatial frequency passband. Superresolution is a technique that recreates the frequency components not present in the image. Superresolution of image data requires bandwidth extrapolation in addition to passband restoration and consequently needs nonlinear processing techniques. Active radar, synthetic aperture radar, and interferometry are all inappropriate for this Research and Development effort.

PHASE I: The Phase I effort will consist of a conceptual study of advanced signal/image processing for image restoration and resolution improvement of images taken by various imaging sensors such as Imaging Infrared (IIR), laser radar (LADAR), or passive millimeter wave (PMMW).

PHASE II: Software development based on the conceptual study of Phase I will be demonstrated against measured and/or simulated data provided by the sponsor. The software must be developed on hardware platforms compatible with sponsor platforms. The software product will be installed on the government hardware platforms. The software documentation/user manual and the final report will be delivered to the sponsor at the end of the program.

POTENTIAL COMMERCIAL MARKET: This technology can be used in medical image enhancement and restoration; law enforcement photo enhancement (for identification purposes); space imaging applications; global terrain mapping; and collision avoidance in air and ground transportation.

AF97-208 TITLE: Data Fusion Using the Wavelet Transform, Fractal Theory, and Statistics

Category: Exploratory Development

OBJECTIVE: Develop a method for characterizing ladar intensity signatures using the wavelet transform, fractal theory, and/or statistics.

DESCRIPTION: The intensity data of a laser radar (ladar) pulse may be extracted when the range data is computed. It would be advantageous to use intensity data to augment the range data to improve automatic target identification (ATI) algorithm performance. Ladar intensity data is not currently being used in ATI algorithms because its inherent characteristics are not thoroughly understood (e.g., speckle fluctuations, aspect dependency, variations associated with range to target as well as atmospheric and weather conditions). These characteristics make it difficult to compare intensity data to some physically meaningful quantity. If the basic characteristics of intensity signatures are identified and a steadfast method of characterizing them is achieved, it is anticipated that the intensity data will provide an indispensable way of distinguishing dissimilar textures. This, in turn, will allow target signatures to be distinguished from background terrain and clutter thus improving detection, recognition, classification, and identification capabilities for autonomous algorithm performance. From previous studies of infrared/ladar sensor data, several mathematical methodologies have shown promise as a means for characterizing intensity data. These methodologies include the wavelet transform, fractal measure theory, and statistical theory.

PHASE I: The purpose of this program is to investigate the use of wavelet transforms, fractal measure theory, and statistical theory in formulating a real-time algorithmic fusion technique for ladar range and intensity data. During Phase I, current and past research efforts relevant to the theoretical development of wavelet transforms, fractal measure theory, and statistical theory as well as pertinent signal/image processing applications will be identified. These techniques will then be evaluated to identify those capable of distinguishing target intensity signatures from clutter, countermeasures, and background information. This will involve developing computer models of the various mathematical methodologies, generating databases of the respective intensity signature characteristics, and defining a set of unique characteristics that will augment information provided by the range data.

PHASE II: During Phase II the successful fusion algorithms formulated under Phase I will be used to develop ATI algorithms for seeker systems capable of acquiring ladar range and intensity data. The associated cost benefits of the methodology will be indentified. This will be achieved through algorithm performance analysis (false alarm rates; target detection, classification, and identification probabilities) and real-time implementation analysis (data throughput, processor requirements).

POTENTIAL COMMERCIAL MARKET: These algorithms will have utility in conduction studies of the earth's resources using ladar data from satellites. For example, in an initial study performed for the Forestry Service, WL/MNGA used ladar to identify different varieties of trees. The results of this study indicated that ladar has the potential to be used as a surveying tool for forests

AF97-209 TITLE: Armament Research

Category: Exploratory Development

OBJECTIVE: Develop innovative concepts in areas associated with air deliverable munitions and armament.

DESCRIPTION: We need new and innovative ideas/concepts and analytical methodologies in the area of air delivered non-nuclear munitions, that have a dual use/commercialization potential. Products include bombs; submunitions; warheads; projectiles; fuzes (including safe and arm devices); explosives/energetic materials; time delayed, self degrading explosives; genetic engineering of molecular explosives; polymer binders for shock survivable explosives; structural technologies; fiber optics; solid-state inertial components; exterior ballistics; lethality/vulnerability and performance assessment techniques; test technology; modeling and simulation resources and techniques; and conventional weapon environmental demilitarization and disposal techniques. Some examples of desired research are target detection sensors; warhead initiation; self-forging fragment warheads; shaped charges; long-rod penetrators; reactive fragment warheads; computational mechanics (including interactive grid-generation techniques, and warhead hydrocode-assessment techniques); and hard-target weapon/penetration technology end energetic materials.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and feasibility of the concept.

PHASE II: The Phase II effort shall provide a deliverable product or process.

POTENTIAL COMMERCIAL MARKET: Each proposal submitted under this general topic should have an associated dual-use commercial application. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

AF97-210 TITLE: Expendable, Low Cost, Solid State Millimeter Wave Components

Category: Exploratory Development

OBJECTIVE: Develop small, expendable, low cost, solid state millimeter wave components. Include a complete description of research materials and processes.

DESCRIPTION: Low cost components serve as the prime design driver in all developmental expendable short range sensors regardless of the optimum operational frequency for the application. Ideally, many short range sensor designs would use the 60 - 110 GHz band of operation if low cost, miniature, expendable components were available. Advantages include antenna size, directionality, and reduced man-made noise sources. Output power levels of +10 dBm would be more than adequate for most intended applications if low cost, miniature, components were available.

PHASE I: Phase I efforts would examine materials, processes, and fabrication techniques for producing millimeter wave sensor components listed in the objective.

PHASE II: Phase II of the program would emphasize fabrication and packaging of several devices for performance testing by the Air Force.

POTENTIAL COMMERCIAL MARKET: Possible areas of commercial application include liquid level sensors, intrusion detectors, collision avoidance systems, "intelligent" vehicles, wireless communications, and space communications

AF97-211 TITLE: Infrared Fisheye Optics

Category: Exploratory Development

OBJECTIVE: Develop, design and construct Infrared Fisheye lenses for fuzing sensors and fuzing test equipment video cameras.

DESCRIPTION: Recent advances show that very wide-angle imaging sensor proximity fuzes can significantly enhance warhead lethality. A key component for such sensors is the optical front-end which may consist of one or two fisheye lenses projecting images onto focal-plane detector arrays. At this time there are no known fisheye lenses in infrared bands, and typical visible band designs exhibit undesirable image compression near the edge of the Field-of-View (FOV). The focus of this effort is to explore the possibilities and limitations of customized fisheye lens designs for the infrared spectrum using optical materials suitable for high supersonic flight regimes and of visible-band customized fisheye lens designs intended for target position truth instrumentation.

PHASE I: Phase I of this project should investigate fisheye lens designs for the infrared bands of 3-5.5 microns, 5.5-7.5 microns, 8-12 microns and the visible band. The designs should achieve uniform magnification over the 180° FOV and will otherwise be optimized for minimum size, low ratio of focal length to aperture diameter, minimum internal reflections and number of elements given notional resolution requirements. Infrared-band designs shall consider materials suitable for operation with missile flight aeroheating and will be scaled to fit available focal plane detector array geometries and notional tactical size requirements. Two prototype visible-band fisheye lenses matching government furnished equipment (GFE) instrumentation video cameras shall be produced.

PHASE II: Phase II would involve scaling infrared fisheye designs to fit available non-developmental item forward looking infrared (NDI FLIR) cameras, constructing and evaluating fisheye lenses of the selected designs for all three identified infrared bands.

POTENTIAL COMMERCIAL MARKET: This project concerns efficient capture of very wide angle imagery with uniform magnification. Advances in this field could lead to low-cost wide-angle imaging sensors for many applications ranging from security cameras to robotics control to transportation (aircraft, marine and automotive) collision avoidance and protection systems

AF97-212 TITLE: Penetrator Communication Link

Category: Exploratory Development

OBJECTIVE: Develop a shock hardened communication link capable of relaying penetrating weapon fuze data.

DESCRIPTION: A need exists for a shock hardened communication link capable of relaying penetration weapon fuze data. The communication link must be capable of surviving and transmitting the fuze data during or after the actual penetration event. The fuze data to be transmitted includes, but not necessarily limited to: Command and control signals between fuzing modules located at various positions within a multiple-event warhead/agent defeat weapon system; or deceleration data from an on-board accelerometer, fuze logic states, and a pre-fire pulse for bomb damage assessment (BDA) information. The communication link internal to the warhead must either be capable of surviving the penetration event or the communication link must not depend upon the survivability of a "hardware link."

PHASE I: Phase I will consist of a requirements study to assess the technology baseline for achieving a shock hardened communication link, and the development of a conceptual design(s). This phase will establish the concept(s) for internal weapon system communication between fuzing modules, weapon-to-weapon communication between fuzing systems, and weapon-to- surface communication capable of being received by an airborne relay.

PHASE II: Phase II will develop and fabricate a shock hardened communication link, or components, capable of relaying fuze data from a penetrating weapon. Static tests will be accomplished to demonstrate the ability to transmit the data through typical warhead media (e.g., simulated explosive material, simulated agent defeat chemicals, etc). The communication link components will be tested on a Very High G shock machine. The shock hardened communication link system will be tested in a subscale projectile from a 155mm Howitzer.

POTENTIAL COMMERCIAL MARKET: Wireless transmission of information through porous media requires characterization of the media which has significant potential for in-bulk monitoring of the manufacture and/or storage of porous media. It is feasible to measure the consistency/purity of bulk materials such as feed grains, flower, fertilizer, or explosives for production control

AF97-213 TITLE: Pyrotechnic Initiator

Category: Exploratory Development

OBJECTIVE: Develop, design and construct an igniter for various pyrotechnics capable of passing the safety requirements for use with in-line fuzes.

DESCRIPTION: Recent advances in the area of semiconductors and semiconductor processing have demonstrated the ability to fabricate a silicon sublayer that will vaporize under the action of a heavy current. The resulting plasma can be used to ignite a pyrotechnic material, which makes these devices suitable for use as igniters or detonators in explosive initiation. However these devices do not pass the safety requirements namely, the 500 V no-fire, and 1 amp/1 watt requirements for initiating sensitive pyrotechnics due to their susceptability to stimuli from external sources. This topic is intended to explore methods for fabricating a small semiconductor device with internal electrical components to allow it to stand off voltages below the 500 V limit (required for noninterrupted trains by MIL-STD-1901) and not function. Such a device will enable the item to be safe from accidental functioning without external electrical circuitry. The ability to fabricate the required components on a single silicon substrate will greatly enhance the versatility, lower the cost, and decrease the required volume. The Air Force applications include ordnance fuzing, munitions dispensers, rocket motor igniters, and actuators.

PHASE I: During Phase I, the offeror shall determine the feasibility of the proposed initiator, as well as develop a preliminary design and test plan.

PHASE II: The Phase II effort is expected to produce a well documented, tested, and deliverable initiator.

POTENTIAL COMMERCIAL MARKET: A safe igniter for primary pyrotechnics would be used most extensively by the oil drilling, mining, and construction companies. This igniter would provide increased safety and reliability versus blasting caps and other conventional components. It would also provide increased precision and control for blasting, oil well casing perforation, cutting, and other multiple or sequential events that require remote initiation or activation of pyrotechnics

AF97-214 TITLE: Hard Target Influence Fuzing Technology

Category: Exploratory Development

OBJECTIVE: Investigate applicable technologies required for influence fuzing of hard target penetrators.

DESCRIPTION: Influence fuzing technology (i.e. acoustic, magnetic etc.) exists for detection and classification of heavy vehicles. However, the existing technology is not compatible with the desire to utilize large (up to 2000 lb) guided unitary weapons to inhibit vehicle traffic. The needed influence fuze technology must be capable of being contained within the existing 3 in. x 7 in. standard fuze well; surviving high speed impact into any media including rock and sensing vehicles out to the bomb crater radius from a buried position. The hardened components shall be capable of sensing heavy equipment such as trucks, earth movers and locomotives to prevent clearing of weapons.

PHASE I: Phase I of this project will study applicable magnetic and acoustic sensor mechanisms and necessary hardening techniques for a hard target attack capability. The study and analysis will also assess the sensor's influence due to heavy machinery through a thick steel case such as the BLU-109/B bomb body and determine approaches to increase sensitivity such as deploying sensors or antennas once the warhead is at rest. A trade study shall be made of survivability versus function/capability to determine the most applicable sensors and concepts including a preliminary design of the influence fuze.

PHASE II: Based on the results of the analysis and preliminary design in Phase I, selected sensors shall be hardened and concepts tested/verified for function and survivability during laboratory shock testing, field cannon testing through concrete targets and influence testing against heavy equipment.

POTENTIAL COMMERCIAL MARKET: This program will develop hardened sensors applicable for use in deep and subsurface mining and trenchless pipe and cable laying. This will allow the area to be explored prior to hitting underground metallic objects. In addition the refinement and environmental harding can produce benefits of higher reliability and placement flexibility to the traffic control industry

AF97-215 TITLE: Munition Instrumentation and Performance Assessment Technology

Category: Exploratory Development

OBJECTIVES: Develop new (revolutionary) instrumentation technologies and methodologies for analysis of data.

DESCRIPTION: a) Innovative ideas are sought for instrumentation to serve the very harsh, transient nature of munitions development and test. Specific requirements exist for: flexible, high capacity, rechargeable battery technology for powering subminiature munition telemetry packages; high power, 100 mw, continuous laser technology that can produce long coherence lengths, 2M, to reconstruct pulsed ruby laser produced holograms; high speed multiplexer technology that will enable image data to be read out from high resolution, high speed infra-red focal plane arrays. b) Performing an assessment of a new weapon concept requires inputs of factors such as target location and vulnerability, warhead lethality, guidance package precision, weapon flight profile, aircraft loadout. Current methods are mostly ad hoc and analyst driven. Research is sought for both conventional and innovative analytical methods to optimize existing personal computer based munitions effectiveness tools and develop new or more effective methodologies.

PHASE I: a) Phase I will include analytically evaluating the feasibility of the proposed concept, investigating alternatives, developing the concept through a design, and documenting proof of principle hardware that will be developed during Phase II. A demonstration of the concept using simple breadboard components is very desirable. b) Proposed analysis models will be investigated to arrive at technology choices. Existing models may be adapted or entirely new approaches may be investigated. A recommended methodology suite, including code requirements will be described.

PHASE II: a) Phase II will be used to develop, fabricate, and test an experimental version of the concept. Sponsor may provide access to actual munition experiments for validation purposes. b) Analysis codes recommended in Phase I will be implemented

POTENTIAL COMMERCIAL MARKET: a) By its very nature, instrumentation has high application potential for commercial uses and industrial processes. As examples: low profile, high current density batteries are needed in consumer devices such as camcorders and cell phones; lasers with long coherence lengths are required for 3-D large display holography and non-destructive test interferometry; and high speed multiplexor technology will support high resolution machine vision cameras for production lines. b) User friendly, PC-environment assessment codes would be a highly marketable product for any R&D organization. Commercial users would include mining and drilling, and industrial safety organizations

AF97-216 TITLE: Electronic Imaging Transient Stereo Photogrammetry

Category: Exploratory Development

OBJECTIVE: Develop stereo imaging sensor/illumination technology with "pulsed light" spatial/temporal gating capability.

DESCRIPTION: Ultrahigh speed diagnostics of conventional blast phenomena are presently based on rotating mirror/prism mechanical cameras. For experimental advanced munitions research, random access to events is required. Current high speed cameras require start up and synchronization, and, as a result, the cameras must trigger the experiment rather than capture random events. Current cameras only provide a sequential record, with no provision for indeterminate delays between events. Sample rates from 100,000 to 5 million frames-per-second are needed to cover the range of applications for detonation research. Advanced sensor/image intensifier/pulsed laser technology could lead to a random access electronic imaging solution for asynchronous capture of 8 to 10 high resolution images at up to 5 million frames-per-second. Research is required to enable film quality resolution (megapixel) at nanosecond or less exposure times with current generation fast image intensifier tubes. Potential approaches include multi-pulse lasers/multi-rod lasers with pairs of gated high resolution CCD cameras and electronic stereo displays. Modeling and simulation will be used to determine requirements such as power, pulse width, wavelength, and optical geometry. This project will also include proof of concept fabrication of the most promising technologies and experimental investigation of a proposed architecture.

PHASE I: Modeling, simulation, and the design of the "camera" to incorporate the technology will be included in Phase I. A proof of concept experiment with an explosive event would be highly advantageous to demonstrate the technical approach.

PHASE II: Phase II will include the design and fabrication of the sensors and support electronics necessary to demonstrate sensitivity, resolution and frame rates of the prototype system as compared to current ultra-high speed film cameras.

POTENTIAL COMMERCIAL MARKET: This technology would greatly benefit commercial explosives research, laser physics, spectroscopy, and auto safety research

AF97-217 TITLE: Blast and Ballistic Loading of Structures

Category: Exploratory Development

OBJECTIVE: Develop physics-based models to simulate the response of structural elements subjected to high amplitude, short duration loading(s).

DESCRIPTION: Engineering models which accurately describe the response of ground-fixed structures to extreme loading conditions are needed. The technical challenge is to be able to accurately capture the essential features of the structural and material response using a physics based approach without having to resort to finite element/finite difference techniques. Areas of research interest include source term modeling of blast and shock, explosive casing breakup to include fragment characterization and subsequent transport, and blast and fragment synergism. Analytical models which simulate the interaction of these source terms with internal structural components are also required. Ultimately, the individual models will reside in a flexible, consistent, and modular overall end-to-end methodology.

PHASE I: Phase I proposals should clearly define objectives, approach, and payoffs for the innovative model concept. Although being exploratory in nature, the proposals should also address follow-on implementation concepts for modeling the response of hardened structures to high amplitude, short duration loading.

PHASE II: During Phase II the concepts developed during Phase I will be implemented in a modular assessment, PC or work station based format, user friendly environment. Unique features of the physics model based analysis methodology will be documented.

POTENTIAL COMMERCIAL MARKET: Proposals submitted must have an associated commercial application potential, such as prediction techniques for building demolition and safety-related assessments

AF97-218 TITLE: Non-Intrusive, Remote Identification of Chemical Contaminants

Category: Exploratory Development

OBJECTIVE: Develop technologies to remotely detect and identify environmentally damaging residue from munitions development and testing.

DESCRIPTION: Conventional munitions contain a variety of materials which could be hazardous to the environment. These materials include explosives, electronic components, plating materials, heavy metal alloys, as well as hazardous chemicals associated with the aforementioned. When munitions are tested at military land test ranges, some of the chemical and explosive residues remain in or on the soil, some may be deposited on the surface of vegetation, and some is dispersed into the atmosphere. Conventional identification and mapping of the exact contaminated areas is a costly and time-consuming process. The inability to quickly and efficiently map contaminants potentially limits use of test ranges due to closing large test areas as a safety measure when contamination occurs during testing. As an example of a remote, non-intrusive detection capability, a radar using extremely short pulses has been used to penetrate soil and detect the interface between soil layers. If such a non-intrusive technique could be developed to detect chemical contaminants in the soil using specific properties of the contaminants, identification of contaminated areas could be rapidly accomplished. This is not an effort to detect underground buried objects nor is it intended to develop one technology to identify all environmental contaminants. We are looking for innovative methods and technologies that will address specific remote sensing capabilities for contaminants related to conventional munitions research and testing.

PHASE I: Phase I is intended to explore and evaluate existing remote detection and identification technologies for their potential use in detecting environmental contaminants. This phase will also include the evaluation of chemical, heavy metal, and other environmental contaminants to determine specific properties that would lend themselves to detection using innovative applications of existing sensor technologies. Using these evaluations, candidate technologies for remote sensing applications will be recommended, and a program plan for exploiting these technologies in Phase II will be developed.

PHASE II: This phase will include developing and demonstrating new technologies, applications, or further refinements of existing technologies to solve the stated problem. Experiments will be performed that will demonstrate the ability to remotely detect and identify chemical and/or heavy metal contaminants in soils. The cost effectiveness of the sensor technology will be analyzed.

POTENTIAL COMMERCIAL MARKET: The commercial world would be interested in a technology that could sense and detect the presence of chemicals or heavy metals without taking core samples. The benefit would be safer, faster, and less costly assessment of contaminated areas

AF97-219 TITLE: Slipper Wear/Gouging Phenomena

Category: Exploratory Development

OBJECTIVE: Develop analytical techniques to characterize wear and gouging phenomena of slippers at speeds up to hypersonic and demonstrate means to eliminate or reduce slippler wear/gouging.

DESCRIPTION: The High Speed Test Track, Holloman AFB, New Mexico, is a ground based aerospace test facility used for testing various types of military hardware such as missile guidance systems, aircraft seat ejection systems, and weapon systems. Testing is conducted using rocket propelled sled vehicles guided by steel slippers which ride on continuous steel rails. The rails are standard 171 lb/yrd crane rails, butt welded in 39 foot sections for a length of 10 miles. Extreme straightness of the rail is required to reduce the dynamic loading induced into the sled vehicle traveling along the track, particularly at high speeds approaching Mach 10. Straightness of the rails is maintained through precision survey and rail alignment. In spite of this, small irregularities of the rail do exist. These irregularities cause a _dynamic bounce_ of the sled traveling down the rail at high speeds. At hypersonic speeds, the impact of the sled on the rail can cause a tear-drop shape of material (gouge) to be eroded away from the surface of the rail, sometimes resulting in a mirrored effect, occurring simultaneously (lasting micro seconds) on the inside of the slipper. Slipper wear is affected by a combination of conditions, including slipper materials, slipper bearing pressure, and ram-air pressure (between the slippers and the rail) that produces forces affecting rail contact and causes aerodynamic heating. These effects change as a function of velocity. This study would discourage _active air bearing_ systems as they have not proven to be operationally viable, but innovative ideas might be considered.

PHASE I: Develop analytical techniques that can be used to predict slipper wear patterns and gouging phenomena throughout the sled velocity regime to Mach 10. This will require characterizing bearing and aerodynamic pressure distributions, aerodynamic and friction heating, and material wear resistance.

PHASE II: Validate and provide analytical techniques developed to predict slipper wear/gouging via laboratory and/or sled testing. Develop and test candidate state-of-the-art slipper design, materials, coating lubricants, possibly transpiration cooling (total system weight limitation not to exceed 10 lbs) for hypervelocity sleds to eliminate or reduce slipper wear and gouging effects.

POTENTIAL COMMERCIAL MARKET: Wear prediction methods can be applied to high speed and high temperature bearings and brakes. Materials, lubricants, and designs developed could also be applicable. Analytical techniques and use of state-of-the-art designs, lubricants, and materials developed can reduce and eliminate gouging effects in electromagnetic rail guns and hypervelocity artillery.

REFERENCE:
1. Hypersonic Rocket Sled Development, AD-TR-82-41; Krupovage, Daniel J., Rasmussen, Hans J., Sept 1982.
2. Surface Gouging by Hypervelocity Sliding Contract Between Metallic Materials; Sandia Corp, Sand 87-1328, Baker L.M. and Trucano T. G., Sept 1987.
3. Rail Friction & Slipper Wear on the Holloman High Speed Test Track; Krupovage, Daniel J., Oct 1987. _38th Meeting of the Aeroballistic Range Assoc._
4. Rail Gouging on the Holloman High Speed Test Track; Krupovage, Daniel J., Sept 1984. _35th Meeting of the Aeroballistic Range Assoc._

AF97-220 TITLE: Rail Tension/Compression Phenomena

Category: Exploratory Development

OBJECTIVE: Develop techniques to predict and measure tension/ non-tension conditions in the tract rail due to temperature variations (0° to 120°F)

DESCRIPTION: The High Speed Test Track, Holloman AFB, New Mexico, is a ground based aerospace test facility used for testing various types of military hardware such as missile guidance systems, aircraft seat ejection systems, and weapon systems. Testing is conducted using rocket propelled sled vehicles guided by steel slippers which ride on continuous steel rails. The rails are standard 171 lb/yrd crane rails, butt welded in 39-foot sections for a length of 10 miles. Extreme straightness of the rail is required to reduce the dynamic loading induced into the sled vehicle traveling along the track, particularly at high speeds approaching Mach 10. Even though straightness of the rails is maintained through periodic precision survey and rail alignment, there remains small irregularities in the rail which can be reduced by maintaining rail tension. The crane rail, when initially installed, was pretensioned to ensure the rail would remain in tension over the temperature range of 120° to 0° F. Over the years, various rail breaks have occurred and the design pretension has not been systematically maintained.

PHASE I: Explore design ideas in non destructive measurement techniques for determining local rail tension/non-tension. Develop and provide analytical techniques that can be used to accurately predict temperature effects on rail tension and straightness.

PHASE II: Demonstrate and provide non-destructive methods of rail tensioning measurements, and validate analytical prediction techniques and tension measurements at various track locations. Develop and validate rail break repair techniques to maintain original design rail tension. Survey rail to identify areas that do not meet design pretension, supervise rail retensioning by Test Track personnel.

POTENTIAL COMMERCIAL MARKET: Analysis and measurement techniques (and hardware) developed by this effort will be directly applicable to the Department of Transportation and railroads in designing rail based ground transportation, and monitoring rail conditions. In addition, this effort might be applied in metal production mills to determine stress conditions during various processes including extrusion, drawing, and rolling.

REFERENCES:

1. Hypersonic Rocket Sled Development, AD-TR-82-41; Krupovge, Daniel J.,Rasmussen, Hans J., Sept 82.
2. Original Stress Analysis of Holloman Supersonic Track, Black, J., 7 Jan 56.
3. Rail Cuts, Standard Missile (SM-2), Gragg, C. D., Sept 95.
4. Study of the Longitudinal Force in the Holloman Test Track Rail, Turnbull, D., Aug 1990.
5. Structural Report, Holloman AFB High Speed Test Track, Thermally Induced Displacement, Kaman Science Corp., Sept 1995.

AF97-221 TITLE: Low Cost Laser Range Finder

Category: Engineering Development

OBJECTIVE: Develop a low cost means of accurately measuring slant range to target.

DESCRIPTION: For Airborne Forward Air Control, Close Air Support, and Air Interdiction platforms, current weapon delivery algorithm solutions are subject to errors based on uncertainty in slant range and/or elevation of the target. Addition of a capability to slew a laser rangefinder to a target, designate the target, track the target and provide accurate slant range vector measurement, would enhance weapon delivery computation and accuracy. Acquisition and integration of an attack radar on the aircraft to provide this capability is undesirable due to cost, space, and pilot-vehicle interface concerns. Also, the inherent jam resistance and controllable emissions of a laser system are preferable. The system, when integrated with aircraft radar altitude, barometric altitude, GPS, and inertial navigation information, should be capable of providing single, or continuous, slant range to target measurements to an accuracy of 3 meters or 1 percent of altitude (whichever is greater) up to an altitude of 5,000 feet above ground level (AGL), with a goal of 10,000 feet AGL or higher.

PHASE I: Research and analysis of alternatives for integrating laser range finding technology into aircraft target acquisition an weapon delivery functions.

PHASE II: Development of a prototype, pylon-mounted unit for potential concept exploration flight testing.

POTENTIAL COMMERCIAL MARKETS: Aerial Survey, Mapping

AF97-222 TITLE: Storing Energy and Delivering Power Using Capacitors

Category: Engineering Development

OBJECTIVE: Develop a Capacitive Energy Storage System to use in concert with or in place of battery backup systems.

DESCRIPTION: Alternative energy sources are needed to supplement and replace battery back up Uninterruptible Power Supplies (UPS). Capacitor energy storage systems are one method of providing short term ride through for critical loads. A capability to carry through short term power sags and outages as well as a capability to hold a load until a generator can come on line is needed. A Capacitor based energy storage has no stray field limitation and appears to be more inexpensive than some other technologies. Efficiencies and cost effectiveness will be determined.

PHASE I: Develop and demonstrate (using conventional power electronics) a capacitor array which will provide the same ride through as a similar battery based UPS. Verify energy hold times, leakage currents, maximum voltage, and dissipation of the array.

PHASE II: Develop a power electronic converter specifically designed for the capacitor storage unit. Enclose power electronics and capacitors in an appropriately cooled container. Verify and compare energy hold times, leakage currents, maximum voltage, and dissipation. Compare overall system footprints.

POTENTIAL COMMERCIAL MARKET: Capacitive Energy Storage Systems open up a new range of power quality applications. Computer manufacturing facilities, DoD installations, and any other facility that contains sensitive electronic equipment type loads will benefit from alternative energy sources. Specifically, any facility where magnetic fields or noise levels are problems would be interested in this type of alternative energy solutions.

AF97-223 TITLE: Modeling the Effects of Gamma Irradiation on Electro-Optic Components

Category: Exploratory Development

OBJECTIVE: Develop detailed models of specific electro-optic devices to accurately demonstrate effects of gamma, neutron and/or proton irradiation ranging from zero to the high end of FOTP-64 dose rates and total dose levels.

DESCRIPTION: High quality detailed models of specific electro-optic devices are not readily available from standard industry sources. This is particularly true in the area of modeling performance in hostile environments as caused by nuclear effects and space. The benefits of using modeling and simulation to predict system performance have become widely understood in the industry and the DoD. System behavior can be evaluated early in the design cycle, well before expenditures and resources are more deeply committed to a design with an unforeseen flaw. Also, "what if" scenarios may be readily accomplished, speeding up decisions regarding approach, and hence mitigating design risk. The more detailed the model, the more accurately system behavior will be predicted. Detailed electro-optic device models are very complex mathematical structures which combine concepts ranging from applied physics to advanced numerical analysis. Hence, development of these models is no small task, and the development of a partnership between the Air Force and Industry would greatly benefit both through the sharing of technology and knowledge. To this end, these models should be developed using Analogy, Inc's MAST R modeling language for execution on their SaberTM Simulator. The purpose of this project is to develop detailed models of the following devices:

1. LED:p/n IRS-1306-640, from Laser Diode,Incorporated.
2. Fiber-Optic Cable:FlightguideTM 100/140 mm Fiber Optic Cable, from Spectran.
3. PIN Diode: p/n LCP-3080, from Laser Diode, Incorporated.

Models should demonstrate the effects of Irradiation using FOTP-64 dose rates and total dose levels.

These devices have been selected because their performance specifications make them strong candidates for use in DoD communications systems and weapons systems, particularly the F-22 ATF, RAH-66 Commanche Helicopter, and B-52 (FOIS) aircraft. For example, the Spectran fiber-optic cable is a customized product developed in a cooperative effort involving Lockheed, Sikorsky, Boeing, Spectran and the Electro-Optics Technology Group (EOTG) at McClellan AFB, to target use in military avionics systems such as the F-22 ATF aircraft.

PHASE I: Determine feasibility, as well as level of detail and accuracy required in order for these models to be used effectively in the simulation of electro-optic device performance in space and aircraft applications. Provide cost analysis to achieve these goals using Analogy's MAST R modeling language and SaberTM Simulator .

PHASE II: Design and develop the above specified models using the MAST R modeling language. Demonstrate and evaluate model performance in the EOTG at McClellan AFB, CA.

POTENTIAL COMMERCIAL MARKET: Electro-optic models will have widespread applications in the commercial sector, not only in modeling communications links, but also in electro-optic sensor applications. Optical models of this caliber are needed for applications in the space and aerospace industry. These models will reduce costs associated with redesigning optical components for use in radiation hardened (Rad-Hard) environments.

AF97-224 TITLE: Sustainment Science and Technologies

Category: Basic Research

OBJECTIVE: Develop software to support the information, processes, objects, and rules necessary for successful maintenance and repair of large weapon systems.

DESCRIPTION: Sustainment is all the activity necessary for the maintenance and repair of an end item with a minimum amount of disassembly. Sustainment is only working on what needs attention (on-condition-maintenance) as opposed to most remanufacturing (total teardown and rebuild). A great deal of technology exists to aid the production and manufacturing domain. However, little has been developed for the sustainment domain. Normally, the assumption has been that _what works for manufacturing_ will also work for remanufacturing and sustainment. This is verifiable by the current DOD _acquisition_ process which appends operations and support to the end of the development and production and recommends the same systems engineering process and tools for maintenance and repair of weapon systems. In reality, and especially for large complex systems, the nature of maintenance and repair is such that a portion of the work is unpredictable (not identified until programmed work has been initiated), and therefore not planned for through the methods and tools used to manage the work. In cases where the end item is completely disassembled and routed for repair (remanufactured), information systems developed for standard production prove quite useful. However, when the objective includes minimizing the amount of invasive disassembly needed for overhaul, then the information and decisions necessary for efficient management and control of the repair changes dramatically. Production management and scheduling systems (such as Critical Path Method, or _CPM,_ and Project Evaluation and Review Technique, or _PERT,_ which assume knowledge of and independence of activities) often produce impossible _work to lists_ due to the heavily shared resource pools, and activity dependencies found in sustainment. The information concerning the maintenance and repair is continually being acquired during the repair cycle. Especially for large systems, e.g. aircraft and ships, there exists a substantial amount of work which is identified only after the depot has taken possession of the end item and repair work has been initiated. Moreover, the lag between the time when these _unpredictable_ discrepancies are identified when the replacement parts have been ordered and

acquired can be extremely long, and therefore costly. The nature of this type of (minimized disassembly) remanufacturing necessitates that the rules, processes, and objects needed to minimize the effect of maintenance and repair on large system availability at a minimum cost of resources must be examined so that the appropriate science and technology can be applied. These characteristics of the maintenance and repair domain will be documented using the enterprise engineering Integration Definition language (IDEF) family of methods. Minimally the research should investigate the nature of:

1. Unknown work effect on labor and bills of repair and materials
2. Flexibility of sequence on repair, especially on large weapon systems
3. Access and repair constraints
4. Shop floor knowledge base (point of discovery)
5. Managing the iterations and progression of unknown work changes throughout the life cycle of the weapon system.

PHASE I: Produce a sustainment principles document containing at a minimum the information, processes, and relationships which must be maintained for sustainment at minimum life cycle cost and maximum availability of weapon system. Develop a system requirements document and a system software architecture for information technology necessary to support the nature of sustainment from the time the work specification is identified to the time the end item is released for redeployment. Included in this document should be a set of verifiable principles which govern the nature of large end item (minimized disassembly) sustainment environments.

PHASE II: Complete the Phase I design and develop a full scale prototype. Test, document and revise as necessary the documents from Phase I.

POTENTIAL COMMERCIAL MARKET: This technology has immediate application in any remanufacturing industry. Commercial airlines, power plants, railcar maintenance, and ship maintenance are a few of the many application industries.

RELATED REFERENCES:

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2. Mayer, R. J., et al. (1992, in press). IDEF4 Object-oriented
Design Method Report. Wright-Patterson AFB, OH: AL/HRGA.
3. Mayer, R. J., et al. (1994, in press). IDEF5 Ontology Capture Method Report. Wright-Patterson AFB, OH: AL/HRGA.

AF97-227 TITLE: Miniaturized/Universal Flight Termination System (FTS)

Category: Engineering Development

OBJECTIVE: Develop a Miniaturized FTS capable of application on a wide range of weapon systems.

DESCRIPTION: Flight termination systems (FTS) are installed in a large variety of weapon systems and drones to abort the vehicle's flight if a failure occurs and continued flight becomes dangerous. The current approach to design and testing of an FTS is to develop a unique FTS for each individual weapon or system. Physical space limitations available for the FTS have resulted in the FTS design being incorporated into the system design process resulting in long term design cycles. One to two years of design and environmental qualification testing are required for each unique FTS using today's methods. This approach has resulted in a separate FTS for the JDAM, JSOW, AGM-130, MMTD, and QF-4 systems, with no interchangeability or interoperability. Yet all the FTSs in these systems accomplish the same end - initiate an explosive or actuator. This effort should provide the engineering, research, and development necessary to standardize and miniaturize an FTS suited for wide ranging applications in future weapon systems. The baseline design may offer several options to meet the widest possible range of vehicles, considering retrofit of existing FTS designs as a possibility. The effort will perform verification testing to measured or calculated extreme environmental conditions rather than the minimum necessary for a specific program. Innovative design and packaging is essential.

Guidelines for system requirements should be taken from RCC-STD-319-92, Flight Termination Systems Commonality Standard. System specifications, component specifications, drawings and test procedures will be part of this effort.

PHASE I: Define hardware and software system requirements, research appropriate technologies for the best short-term design baseline, and identify new areas of emerging technologies capable of offering further miniaturization. Develop system specifications and verification test plans.

PHASE II: Design, develop and produce a limited number of flight worthy prototype FTSs. Validate the system through verification testing and document results.

POTENTIAL COMMERCIAL MARKET: Industries such as oil and mining, commercial aviation and transportation have potential uses for this miniaturized, hardened, highly reliable communications package capable of performing many functions remotely.

RELATED REFERENCES:
1. RCC-319-92, Flight Termination System Commonality Standard.

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AF97-228 TITLE: Miniature Munitions Aerodynamic Global Positioning System (GPS) Receiver/Transmitter (MMAGRET)

Category: Engineering Development

OBJECTIVE: Develop a miniaturized, aerodynamic GPS receiver, capable of mounting on a high speed munition and providing real-time telemetry of position data to a ground station.

DESCRIPTION: The technology shortfall exists in determining highly accurate Time Space Position Information (TSPI) for high-speed ballistic or guided munitions. This information is critical to the development of missile warning receivers, missile signature models, and missile flight tracking capabilities. Current methods and capabilities are very limited for modeling and radar tracking of small, high-speed munitions at significant ranges and altitudes. Development of a munitions mounted GPS receiver with the capability to telemeter real-time position data to mission control appears to offer a substantial technology leap in test and evaluation capability. The technical challenge is to produce a very low drag, rugged, miniature, aerodynamic GPS receiver and telemetry kit which would not break lock during munitions maneuvers.

PHASE I: Determine hardware and software requirements of the MMAGRET system, research appropriate technologies and accomplish design trade-offs, and prepare validation test plans.

PHASE II: Design, develop and produce a flight worthy prototype MMAGRET instrumentation system. Validate the system through verification testing and document results.

POTENTIAL COMMERCIAL MARKET: Commercial aircraft, surveying, oil and mining, intelligent automotive, and emergency medical/ search & rescue industries.

REFERENCES:
1. Abstract: "Carrier Phase Time Space Position Information Demonstration (CAPTIDE)."
2. Abstract: "Navigation and GPS Lessons Learned from the EGDE Program."

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AF97-229 TITLE: Multi-Spectral Airborne Common Calibration Source (MACCS)

Category: Engineering Development

OBJECTIVE: Develop a multi-spectral airborne calibration source, with wavelength generation capability ranging from 0.2 to 15 micrometers.

DESCRIPTION: The technology shortfall exists in providing quality multi-spectral airborne target signature data to airborne sensors under test. This effort will address the problem of absolute calibration of airborne measurement instrumentation in the Ultraviolet/Visible/Infrared wavelengths. All current measurement instrumentation is calibrated in the ground lab environment. The instrumentation is then subject to changes in pressure, vibration and temperature when brought to altitude where data are collected. The current practice is to compensate for instrument changes with out-of-focus onboard sources; success has been limited. The need is for a pod based calibration source traceable to the standards of the National Institute of Standards and Technologies (NIST) that is capable of being flown on target aircraft. This calibrated source must be measurable on both the ground and in the air; instrumentation changes that occur between ground to air and from day to day must be monitored and tracked. This capability would aid in the evaluation of sensors such as radiometers, spectrometers and imagers measuring in the same wavelength region by providing a common calibration source in flight and offering continuity from instrument to instrument. Additionally, this common calibration source would benefit in the test and evaluation of several weapon system sensors such as Lantirn, ASSRAM and AIM-9X by creating a standard for their performance evaluation.

PHASE I: Determine hardware and software requirements of the MACCS system, research appropriate technologies and accomplish design trade-offs, and prepare validation test plans.

PHASE II: Design, develop and produce a flight worthy prototype MACCS system. Validate the system through verification testing and document the results.

POTENTIAL COMMERCIAL MARKET: Commercial uses include all industries using sensors requiring calibration, such as intelligent transportation, environmental monitoring, and medical equipment.

REFERENCES:
1. Joint Tactical Missile Signatures (JTAMS) Common Source Techniques "Improved Data Quality."

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AF97-230 TITLE: Inertial Measurement Simulation for Global Positioning System (GPS) Guidance Receivers

Category: Engineering Development

OBJECTIVE: Develop a simulation of an inertial measurement unit, capable of electronic signal injection into a GPS guidance receiver.

DESCRIPTION: Current munition GPS receivers use an inertial measurement unit for updating position data during periods of highly dynamic flight. A need exists to simulate the function of the inertial measurement unit and to electronically inject the output into a GPS guidance receiver. This process would be used during installed systems ground testing in an anechoic chamber facility located at Eglin AFB, Florida. Current GPS receiver testing is accomplished without simulation of the aircraft or munition inertial motion. The purpose of this simulation is to predict alignment accuracy between the aircraft and the carried munition. Flight motion tables that move the aircraft or munition during simulated flight in an installed systems environment are not a viable solution. The simulated forces

and torques that represent platform forces and torques in the three axes would be generated by an existing six degree of freedom (6DOF) flight simulator. The 6DOF simulator also provides synchronized state vector data to the real-time GPS Satellite Constellation RF Simulator. A method must be devised to inject these simulated forces and torques into the GPS receiver to simulate the measured forces and torques of the receiver's inertial measurement unit. The design must provide the least intrusive method of signal injection and be applicable to a wide range of GPS guidance receivers.

PHASE I: Determine hardware and software requirements of a system capable of electronic signal injection of inertial forces and torques into GPS guidance receivers. Research appropriate technologies, accomplish design trade-offs, and prepare validation test plans.

PHASE II: Design, develop and produce the necessary hardware and software to accomplish system requirements. Validate the system through verification testing and document the results.

POTENTIAL COMMERCIAL MARKET: Inertial measurement simulation input capability would be useful to many commercial applications, such as aviation, trucking, shipping, and surveying.

REFERENCES:

1. "Closed-Loop Performance of GPS (Global Positioning System) Aided INS (Inertial Navigation System)," December 1989. Author: Gregory B. Johnson. Report Number: AFIT/GE/ENG/89D-19. DTIC Accession Number: AD-B139 003.

2. "Estimation of the Local Vertical State for a Guided Munition Shell with an Embedded GPS/Micro-Mechanical Inertial Navigation System," May 1995. Author: David J. Lucia. Report Number: AFIT-95-015. DTIC Accession Number: AD-A294 641.

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AF97-231 TITLE: Time-Space-Position-Information (TSPI) and Terrain Three Dimensional (3-D) Visualization (TT3DV)

Category: Advanced Development

OBJECTIVE: Develop the capability to visualize TSPI and terrain data on a three dimensional (3D) display system in real-time.

DESCRIPTION: TSPI visualization systems used today at the Air Force Development Test Center (AFDTC) and the Air Force Flight Test Center (AFFTC) utilize two dimensional (2D) display systems for both real-time and post-mission data analysis. Examples are monitors and large screen projection systems. Some TSPI visualization systems generate 3D data as outputs, but the 3D data are translated so that it's compatible with 2D display systems. Currently, 3D volumetric display systems are being utilized by the Federal Aviation Administration (FAA) for monitoring air traffic in 3D without the 3D goggles; the aircraft's position information is derived from radars. The AFDTC needs a similar system for IST using simulated TSPI as a data source. AFFTC needs a similar system for OAR testing utilizing the Global Positioning System (GPS) as the source of position information. The system should be capable of displaying realistic terrain, structures, vehicle models and physical test configurations along with data overlays. The ability to display TSPI in real-time on a 3D display system makes it possible for test engineers to observe resource utilization continuously as the mission develops. Quicker turn-around time in the decision process will lead to more efficient use of limited test resources and will increase the information content of the data being collected. Success in this endeavor, if its results in the development of affordable products, will eventually produce cost savings for AFDTC and AFFTC customers. Proposed solutions might consider improvements in 3D volumetric display systems.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Construct a prototype system and demonstrate it at the AFDTC.

POTENTIAL COMMERCIAL MARKET: This capability is applicable to the testing of both military and commercial aircraft. 3D volumetric systems can be used for a wide variety of applications for scientific, commercial and military purposes.

REFERENCES:
1. P. Soltan, J. Trias, W. Dahlke, M. Lasher and M. McDonald (1994) Laser based 3D volumetric display system (2nd generation), SID `94 digest, pp. 1-4,2) D.L. MacFarlanee (1994) A Volumetric three dimensional display, Applied Optics, 38 pp.7463-7457.

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AF97-232 TITLE: Operation of Diesel Engines on Low Lubricity/Low Viscosity Fuels

Category: Exploratory Development

OBJECTIVE: Develop fuel injection system modifications needed to minimize the problems associated with the use of low lubricity/low viscosity fuels.

DESCRIPTION: The problem of operating vehicles on low lubricity and/or low viscosity fuels is currently shared by both commercial and military vehicle users. As new Environmental Protection Agency (EPA) regulations require the commercial market to use low-sulfur diesel fuel, and as the Department of Defense (DoD) is adopting the use of JP-8 fuel (referred to as DF-8 when used as a ground fuel) as a "Single Battlefield Fuel," it is apparent that all of our vehicles will be subjected to the problems associated with using low lubricity/low viscosity fuels. Both low-sulfur diesel fuel and DF-8 fuel present various problems for current engines in use, as shown in military field operations. This task will require the contractor to evaluate the associated low lubricity and low viscosity characteristics of the new low-sulfur diesel and DF 8 and their resulting effects on engine performance and component life. Because engine components are lubricated and cooled by the fuel, the fuel injector pump operation and failure rates, which result from the use of such fuels is a primary concern. The ultimate goal of this effort is to develop a modification, replacement, or relocation of the fuel injection system that will operate using DF-8 or low-sulfur diesel fuel without significantly reducing engine performance or component life as a result of the fuel used. San Antonio Air Logistics Center (ALC) is the center primarily responsible for fuels and engines, while the Warner Robins ALC Vehicle Management Directorate (WR-ALC/LV) is the prime for the support and operation of Air Force vehicles. LV is the Air Force lead on solving this problem.

PHASE I: This phase of the effort should identify exactly how such low lubricity/low viscosity affect the components of vehicle fuel injector systems. In addition, the effort should delineate the resulting degradation of component mean-time-between-failure (MTBF) and system operation. The relative impact of low lubricity versus low viscosity should be identified for each fuel injection system component affected. Finally, conclusions should be drawn which identify the feasibility of proposed solution(s) to this problem, given the results of the Phase I effort.

PHASE II: This phase of the effort will require the contractor fully research and develop the proposed solution(s) to this problem. If the proposed solution is a replacement issue, a prototype should be developed, tested, evaluated and be subjected to a form, fit, and function verification. If the proposed solution is a modification or relocation issue, such a solution should be researched, implemented, and tested.

POTENTIAL COMMERCIAL MARKET: Both low-sulfur diesel fuels, used in commercial vehicles, and DF-8, used in military vehicles, share the problems associated with the use of such low lubricity/low viscosity fuels. Both commercial and military vehicles would benefit from a solution to this problem.

REFERENCES:
1. Lacey, P. I. (January 1992). The Relationship between Fuel Lubricity and Diesel Injection System Wear, Interim Report: 1Sep90-1Nov91. (Available from DTIC: AD-A247927).
2. Lacey, P. I., & Lestz, S. J. (February 1991). Fuel Lubricity Requirements for Diesel Injection Systems, Interim Report: Sep90-Feb91. (Available from DTIC: AD-A235972).
3. Lacey, P. I., & Lestz, S. J. (January 1991). Failure Analysis of Fuel Injection Pumps from Generator Sets Fueled with Jet A-1, Interim Report: Nov90-Jan91. (Available from DTIC: AD-A234930).

AF97-234 TITLE: On-Aircraft Radio Test Set

Category: Exploratory Development

OBJECTIVE: Develop a compact, lightweight, carry-on, and self-contained test set for on-aircraft, noninflight evaluation of common radio communications equipment.

DESCRIPTION: Past U.S. Air Force maintenance philosophy allowed for "Three-Level Maintenance," in which very simple equipment tests were conducted on the aircraft, in-depth equipment tests and minor repairs were handled at an _intermediate_ maintenance shop, and major repairs were handled at maintenance depots (not collocated with the operation site). The U.S. Air Force maintenance philosophy is now looking more toward "Two-Level Maintenance," which eliminates the intermediate maintenance shop, thus precluding in-depth minimum performance and functionality testing of aircraft electronic equipment, such as radio communications equipment. As a result, the aircraft maintenance technician must now, with no method of evaluating on-board equipment other than intuition and _talk tests,_ decide if the on-board equipment should be removed, repaired, and replaced with a functioning unit. When the unit is removed, it is then sent to the central depot maintenance facility for testing and repair, if necessary. Too often, the equipment is not defective and returned to the field, resulting in unnecessary expense for transportation, depot evaluation, and replacement. A radio test set should be developed that is lightweight, rugged, self-contained, and simple to use on common aircraft radio communications equipment not inflight (i.e. AN/ARC-164 UHF receiver-transmitter) to test only essential functional characteristics and determine if the equipment should be replaced.

PHASE I: This effort should identify essential tests and system interference considerations, determine the feasibility of technical methods of producing and analyzing signals, determine the feasibility of the proposed technological solution(s), explore innovative packaging concepts.

PHASE II: This effort should be focused on the development, test, and evaluation of a prototype test set.

POTENTIAL COMMERCIAL MARKET: Not only will the development of such a test set benefit the U.S. Air Force, as outlined above, but such development will also enable commercial providers of radio communications equipment to provide their customers with quick, inexpensive tests to determine if their equipment is functional. The tester also has potential applications for testing cellular telephones, cordless telephones, citizen's band radios, pagers, and commercial walkie-talkies, in which simple tests of salient characteristics will determine if indepth repair is required.

AF97-235 TITLE: Remote Positioning Capability for Accurate Placement of Test Assets

Category: Advanced Development

OBJECTIVE: Develop a system to accurately locate, in six dimensions, test assets in a large Anechoic Chamber.

DESCRIPTION: Testing of installed, integrated Avionics requires stimulation of multiple sensors, having one or more apertures on a System Under Test (SUT). Performing this testing in a large Anechoic Chamber requires the placement of testing assets in various locations around the SUT. These test objects will include, but not be limited to individual

antennas and antenna arrays for RF stimulation, and light and heat sources for IR Stimulation. The SUT itself and its adjuncts are testing assets. The placement of the SUT can be anywhere inside large Anechoic chambers (264 feet x 250 feet x70 feet), including suspended on a sling from one of two hoists.

This requirement is for a device and its necessary adjuncts that accurately record the positions and orientations of testing assets within six dimensions (X, Y, Z, Roll, Pitch, and Yaw) in a repeatable configuration. The recording should be an archiveable digital data file. Test repetitions must be able to use the same device, together with the archived recording, to determine correct test assets placement. It should be able to show individual asset repositioning errors using graphical visualization.

PHASE I: Should result in a feasibility analysis and a proposed system design and cost analysis. Trade-off of various methods and placement and installation of these devices is desired.

PHASE II: Develop a system capable of measuring, recording, and logging hundreds of objects which may be located in the anechoic chamber. Each object's position and orientation error will be presented numerically and graphically.

POTENTIAL COMMERCIAL MARKET: This technique is directly applicable to testing of military and commercial aircraft as well as ground vehicles to accurately determine orientation of stimulators on RF and IR signatures. This system could be used to position object in stage setup and other operations which require objects to be removed and replaced in a given orientation. Configuration control of general test setup would be maintained with this system.

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AF97-237 TITLE: Automatic Telemetry Stream Data Format Generation

Category: Engineering Development

OBJECTIVE: Develop an algorithm or a process based automatic telemetry stream data format generation system.

DESCRIPTION: Designing a telemetry data format is a manual, expertise-intensive, time-consuming task. Frequent revisions are discouraged. Even though different tests have different data requirements, designing different telemetry formats to accommodate those requirements efficiently are typically not done. Instead, flexible, inefficient formats are designed and modified slightly to avoid gross inefficiencies. Currently, Flight Test Instrumentation Engineers manually create the telemetry frame format. The format must accommodate the test's required sampling rates for specific measurements on-board the aircraft. It must also accommodate the sampling capabilities of the instrumentation system. For example, the aircraft longitude, latitude, and altitude may only need to be sampled once per second, while more safety-critical parameters like pitch, roll, and airspeed may be required at 10 or 20 samples per second. The instrumentation system may require data settling time or recovery time before another sample from a transducer's data channel can be processed. Instrumentation Engineers use their knowledge of test requirements, transmission bandwidth restrictions, and instrumentation system capabilities to design the data format. The design process involves trade-offs and compromises, requiring the application of logic and reasoning. If an algorithmic or a process-oriented solution for designing telemetry formats could be devised, it could revolutionize the Flight Test Instrumentation business. If a unique format could be produced satisfying the constraints of the instrumentation system, requirements of the testers, and limitations of transmission bandwidth significant cost reduction would result. Not only would requirements and constraints balancing be automated, saving staff-hours, but the significant amount of communication and coordination between airborne and ground systems about telemetry format details could be eliminated. This reduction in coordination and communication would make both ground and airborne systems less complex and easier to operate and maintain. Finding an algorithm or process to automate telemetry data format design will require the creative and innovative application of technology and a deep understanding of the telemetry process.

PHASE I: Assess current instrumentation system data requirements and constraints; bandwidth considerations and restrictions. Develop metrics to evaluate different algorithms and processes.

PHASE II: Develop the automatic telemetry stream data format generation system.

POTENTIAL COMMERCIAL MARKET: The problem of designing telemetry data formats is universal among telemetry users, especially where bandwidth is at a premium and large quantity of telemetering is required. This research has broad applicability across several industries including airframe manufacturing, automobile manufacturing, medical telemetry equipment manufacturing, space and satellite communication system manufacturers and operators, and other telemetry users. The products of this research have broad dual-use potential.

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AF97-238 TITLE: Optical Slip-Ring Connector (OSRC)

Category: Advanced Development

OBJECTIVE: Develop advancements in optical rotary connector technology by developing and demonstrating an affordable replacement alternative to copper slip-ring and wave-guide rotary connectors.

DESCRIPTION: Current ground-based electro-optic tracking systems at DoD test and training ranges use copper slip-rings; cable wrap, and wave-guide rotary-joints for the conduction of electrical power; ground; and signals between the electro-optic imaging sensors located on the rotating platform and other system elements at fixed locations relative to the sensors. Existing connection methods impose severe limitations on the operational capabilities of these systems. In the case of copper slip-rings, noise severely impacts the quality of data at higher rates. Cable wrap techniques limit the ability of the tracking system to track continuously without dropping track and "unwrapping" the cables. Rotary wave-guide joints are only used for the transmission of radio-frequency signals through the axes of the mount. Most ground-based tracking systems at the AFFTC use mounts with two orthogonal axes, an elevation axis that is constrained to approximately 180 degrees of motion, and an azimuth axis. Some systems use cable wrap connections that limit rotation in azimuth to about 360 degrees, while others use rotary joints and slip-rings that allows them to rotate freely. New technological changes use electro-optical sensors are smaller, lighter, and provide higher performance than their predecessors. There is a tendency to add more sensors to existing mounts resulting in an increased number of data streams at higher rates. High definition color video and infrared sensors are among the new packages being installed on tracking systems that generate high-rate data streams. A reliable method of transmitting the higher data rates is required without impacting the data quality or limiting the tracking capabilities of the system. An optical approach would provide a high bandwidth, low noise transmission path without limiting the rotational capability of range instrumentation systems. Optical rotary connectors must be capable of duplex transmission of multiple high-rate electro-optic sensor data streams and control signals between the rotating and stationary parts of the system. A robust, affordable, solution to the current limitations in slip-ring/wave-guide rotary connectors could have wide applicability across all DoD test and training ranges.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Construct a prototype system and demonstrate at the Air Force Flight Test Center (AFFTC).

POTENTIAL COMMERCIAL MARKET: This technology is directly applicable to numerous commercial applications involving the transmission of large amounts of data to and from moving platforms. Potential applications include robotics (as used in the fabrication of automobiles and aircraft); surveillance systems (as used in monitoring aircraft and automobile traffic); instrumentation and observation systems located on rotating platforms (such as turbines and jet engines); and multi-spectral vision systems located on automobiles and aircraft.

REFERENCES:

1. Optical Fiber Data Transmission System, McMillan, 1988, NASA-CR-181704, 124p.

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AF97-239 TITLE: Standard Automatic Test System (ATS) Interface

Category: Engineering Development

OBJECTIVE: Develop the capability to rehost Test Program Sets (TPSs) more cost effectively.

DESCRIPTION: The DoD spends billions of dollars each year rehosting older TPSs to newer, more modernized ATS due to hardware obsolescence and supportability problems. One of the primary driving cost factors in rehosting TPSs is the ATS Interface Test Adapter (ITA). In the past, weapon system managers have acquired proprietary test systems with unique interfaces to support their TPS requirements, greatly adding to the long term costs of maintaining the TPSs, when rehosting is required. Review of commercial ITA products indicates that standardization is possible, representing a tremendous opportunity to cut these long term supportability costs. The DoD currently uses commercial product standards to meet ITA requirements, which has helped in some degree to reduce TPS rehost cost. The DoD's ITA requirements can be expressed in a commercial standard, eliminating dependence on single sources, increasing competition, and stimulating market growth by allowing multiple vendors to participate in manufacturing products for market. Consensus exists within the DoD and industry to formulate an ITA standard which would drastically cut TPS rehost costs. Initial contacts with industry concerning the development of such a standard has been very positive. The goal of this project would be to migrate existing products standards (i.e. vendor specific products) to a single commercial standard (i.e. an open specification). The proposed standard would ultimately be sponsored under the Institute of Electrical Engineers (IEEE) forum.

PHASE I: Development of the ITA standard/specification and preparation for submittal to the IEEE as a standard. The submittal would encompass the formation in a industry technical forum (existing DoD commercial ITA vendors) to resolve any technical design and manufacturing issues. The successful completion of Phase I would be successful submission of the standard for balloting within the IEEE community for trial use.

PHASE II: Ballot resolution and publication of the standard, with parallel development of a full-up product as specified by the IEEE standard. The primary goal of this phase would be to manufacture at least two ITA assemblies based on the IEEE standard and demonstrate the rehost potential on selected DoD ATS. Successful completion of phase II would conclude with a compatibility demonstration of the ITA assemblies across different selected DoD ATS.

POTENTIAL COMMERCIAL MARKET: This project has the potential to revolutionize the commercial ATS market as we currently know it. The standardization of ITA assemblies will be quickly embraced by the DoD and the commercial airline industry. Successful demonstration of the IEEE standard would serve as a springboard to other standards forums including the International Electrotechnical Commission (IEC - European Countries) and the International Standards Organization (ISO - Worldwide). International ITA standardization would also strengthen NATO functions where weapon systems could be tested on other allied systems.

REFERENCES:
1. IEEE 1226 - A Broad Based Environment For Test (ABBET) Longuemare Memo, dated 29 April 94, "DoD Policy for Automatic Test Systems"
SECDEF Memorandum, dated 29 June 94, "Specifications and Standards -
A New Way of Doing Business"
USD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons
Systems Electronics Using Open Systems Specifications and Standards"

AF97-241 TITLE: Robotic Test Probe

Category: Engineering Development

OBJECTIVE: Develop a x-y robot probe with camera to embed in a VXI test system, to automate probing during test.

DESCRIPTION: In many automatic test programs it is necessary to manually probe the circuit card to measure signals and voltages inaccessible from the card connector. If the test fixture contained an x-y robotic probe, this probing could be automated as part of the test program procedure. A visual image of the probe points could be captured and mapped, so that the test programmer calls up the image during test generation and indicates the probe point. The robot probe point is then directed during test to that point to pick off the signal of interest. With the proper support software and controller, this can make test points normally inaccessible without manual probing available, greatly enriching the capability of the test program developer.

PHASE I: Contractor will identify available off-the-shelf hardware and software that can be applied to prototyping this capability on a VXI test station. The prototype will be demonstrated to show that automatic control is possible during test execution.

PHASE II:

1. Produce a working model test fixture:
   a. The appropriate interfaces and routines are developed to embed the test development capability in a commercial mainstream test development environment (like LabView or HP VEE).
   b. Users can interactively call up the visual image of the circuit card and specify the location to probe. The robotic probe accurately probes the required test points and measures the signal.
   c. The robot controller is constructed and integrated into the VXI test system.
2. Extensively test the robotic test fixture and test development/execution capability.
   a. The test fixture is demonstrated to be usable with a variety of interface test adapters.
   b. The fixture is demonstrated to provide consistent and acceptable measurement of the desired signal. Variations due to different probe pressure applied or poorly placed contact are not acceptable.
   c. The software must be well integrated into the test development/execution environment.
   d. The robot controller electronics must be successfully integrated into the VXI system, matching the VXI physical and electrical interfaces.

POTENTIAL COMMERCIAL MARKET: This test tool has the potential of greatly increasing the flexibility of the test program developer, by fully automating the test program and by making all signal points accessible to the test system.

AF97-242 TITLE: Noninstrusive System for Replication of Interlayer Printed Electronic Circuit Patterns

Category: Engineering Development

OBJECTIVE: Develop a nonintrusive method and system for replication of interlayer printed electronic circuit patterns from multilayer printed circuit boards.

DESCRIPTION: Sophisticated electronic and computer circuitry used in military weapon systems is being compacted into high density printed circuits interlayered together into mulitlayered printed circuit boards. Miniaturized electronic components are mounted on these boards. These fully assembled printed circuit boards are central to the function, performance and reliability of their associated weapon systems. With an aging arsenal, the Department of Defense (DOD) is in constant need of maintaining systems where past suppliers are not willing to continue their supply role or parts have become obsolete. Both situations lead to the need to modify system electronics. Presently, boards must be delaminated to determine the circuit patterns in the absence of technical data. Development of a nonintrusive method and system for replication of interlayer printed electronic circuit patterns from multilayer printed circuit boards would be of significant benefit to the DoD. This SBIR effort will develop a nonintrusive method and system including software for replication of interlayer printed electronic circuit patterns from multilayer printed circuit boards. The method and system will be evaluated using multilayers up to 30 layers and circuit spacings down to 5 mil.

Additionally, this effort will develop a prototype commercializable system that will allow for the nonintrusive replication of printed circuit cards. The prototype tool will be designed such that it can be integrated with any required commercial analyzing or imaging tools.

PHASE I: Provide a detailed description and design of the proposed method for achieving nonintrusive printed electronic circuit replication of multiple layer printed circuit boards as described above including materials, components, interface requirements, limitations, and expected performance criteria. Details shall include particular subsystems to be enhanced, programs to be utilized, proposed hardware and software development platforms, software development methodologies, as well as any necessary interaction with existing systems. Details shall also be provided as to the proposed method for integrating the developed system and findings into existing systems. A clear path to a Phase II should be established.

PHASE II: Develop a working prototype of the system and implement a proof of concept demonstration. The prototype should be able to fully demonstrate the benefits of the proposed technology. Perform system analysis to determine the performance benefits of the technology. Cost, time, and manpower savings shall be quantified.

POTENTIAL COMMERCIAL MARKET: Development of a nonintrusive method and system for replication of interlayer printed electronic circuit patterns from multilayer printed circuit boards would be of significant benefit to the DoD and its contractors in the private sector. With an aging arsenal, the DoD is in constant need of maintaining systems where past suppliers are not willing to continue their supply role or parts have become obsolete. Both situations lead to the need to modify system electronics. Presently, boards must be delaminated to determine the circuit patterns in the absence of technical data. Nearly every department of the military faces this need regularly.

REFERENCES:

1. Mamaros, T. C., Fullwood, R. R., "Ultra-Sonic Imaging of Multi-Layer Printed Circuit Boards," AFWAL Final Report No. AFWAL-TR-84-1147, Oct 1984, 172p.

AF97-243 TITLE: Carboxyl-Terminated Pllybutadiene (CTPB) Process for ANB-3066 Solid Rocket Propellent

Category: Engineering Development

OBJECTIVE: Develop a new process for the Air Force to make Carboxyl Terminated Polybutadiene (CTPB) that can be qualified for a use as a binder in ANB-3066 solid rocket propellant.

DESCRIPTION: ANB-3066 and other solid rocket propellants use CTPB as the polymeric binder during propellant manufacture. This polymer is one of the key ingredients that affects the overall processing ballistic and mechanical properties of the propellant. Therefore, it is very critical to the propellant manufacturing process that the chemical and physical properties of the CTPB material meet the standards of Aerojet specification ASPC-34242. The chemical and physical properties that are controlled with this specification and molecular weight, water content, acid content, viscosity, volatiles, refractive index, antioxidant, ash, unsaturation type, viscosity ratio, and carbon tetrachloride insolubles. An effort in the past tried to qualify an existing CTPB product to the Aerojet specification, but was unable to meet the requirements. It is the intent of this effort to develop a new manufacturing process for CTPB, on a laboratory scale, and qualify the material to the Aerojet specification. Once the standard is met, the process will be scaled-up to produce enough CTPB to be mixed with subscale propellant batches and cured. The cured propellant will then be tested to the Aerojet propellant specification SPC-36392AF. It is envisioned that, for this effort, all propellant processing and testing will be subcontracted out to one of the major solid propellant manufacturers who are qualified to process ANB-3066 propellant.

Currently there is only one manufacturer that is qualified to produce the CTPB polymer for use in ANB-3066 propellant, and their process is proprietary. Due to known and projected cost increases and potential programmatic risks of having only one source, it is in the best interest of the Air Force to develop an alternate process and qualify a second source to produce this product.

PHASE I: This effort will develop a new process to manufacture CTPB and qualify it to the Aerojet specification ASPC-34242. This will be done at a laboratory scale initially, manufacturing only enough CTPB to support the specification testing.

PHASE II: This phase will involve the effort to qualify the new CTPB material in ANB-3066 propellant. The contractor will be required to scale up the manufacturing process to produce enough CTPB to support small subscale propellant qualification batches. It is envisioned that the small business contractor would then subcontract the effort to process and test propellant, using the new CTPB material, with one of the current producers of solid rocket propellant. As part of this effort, the small business contractor would work with the propellant manufacturer during the propellant evaluation. Working together, contractors will modify processes as needed to qualify the new CTPB material.

POTENTIAL COMMERCIAL MARKET: CTPB is primarily used in the defense industry in several different solid rocket motors and across several different weapon systems. In addition to the defense usage, some commercial rocket motors for satellite launches also use this material.

REFERENCES:

1. Aerojet Specification ASPC-34242, Notice 1, 17 Jan 72, _Polybutadiene, Carboxyl-Terminated._
2. Aerojet Specification SPC-36392AF, 2 Feb 90, _Propellant, Polybutadiene, ANB-3055, Process for._
3. Aerojet Final Report MRP-180, Sep 94, _CTPB Second Source Evaluation._

NOTE: All references are unclassified, but have some limited distribution requirements.

AF97-244 TITLE: Advanced Test Software Technologies

Category: Basic Research

OBJECTIVE: Develop a more reliable test method to detect electronic failures using innovative software techniques; and using existing and/or planned future Air Force computer testing hardware.

DESCRIPTION: Newly developed and future generations of avionics and electronic equipment planned for use in Air Force applications will be significantly more complex than present systems, and rely exclusively on existing test software methods for repair. Also, the use of imbedded and distributed systems within aircraft pose additional testing challenges. Current test software methods that rely exclusively on the algorithmic analysis of digital patterns and analog signals will require too much processing time and computational power to determine the operational status of these equipment in a timely manner. New approaches for testing utilizing alternative software technologies must be created and/or applied to meet the testing requirements of these new equipment and systems throughout the complete development lifecycle.

PHASE I: The goal of Phase I is to identify and assess candidate technologies and approaches for improving test performance, accuracy, and reliability. Recommendations will be provided as to the potential usefulness of these technologies in specific application areas.

PHASE II: During Phase II further investigation into the most promising technologies and approaches will be made, including the design and prototype development of experimental applications to evaluate their effectiveness.

POTENTIAL COMMERCIAL MARKET: Successful results of this topic can be applied to improving failure detection in the entire commercial electronics/photonics community. Current avionics technology in the commercial aviation industry would directly benefit by allowing more repair and less replacement of complex and costly circuitry. Functional analysis and quality assurance/control in the commercial computer manufacturing industry could be greatly improved by providing the ability to detect faults in circuitry too complex for current fault detection . Techniques

developed as a result of this topic could even be used in analyzing failure modes in communication networks, medical systems, and other areas of commerce.

REFERENCES:
1. Kirkland, L.V., "ATE Enabling Technologies," AUTOTESTCON 94' Anaheim, California, 21-24 September, 1994.
2. Smith, Erik S., "An Application of Fuzzy Logic Control to a Classical Military Tracking Problem," May 1994, DTIC # - AD A284 905

AF97-245 TITLE: Adhesive-Sealable Barrier Material

Category: Basic Research

OBJECTIVE: Develop an easily sealed recyclable barrier material that approaches or meets the requirements of MIL-B-131 and MIL-B-117.

DESCRIPTION: A highly WVP barrier material, which can be made into large or small bags with high strength seams, and sealed without special pre-treatment, equipment, or electricity (in the field) is needed for packaging sensitive items at packaging lines in both warehouses and in the field. The best barrier material currently available is MIL-B-131 which consists of aluminum foil between two thermoplastic layers. The plastic layers add puncture resistance and allow the material to be heat-sealed. Bags made from this material, in accordance with MIL-B-117, are watervaporproof (WVP) with strong WVP seals, have high strength seams and are used to package items which are easily damaged by low levels of humidity. Because it's highly WVP, items can often be packaged without further preservation (coatings or desiccant). However, this material is not recyclable, and requires special equipment and electricity to seal, making its use difficult in field conditions where dirt and no electricity prevent sealing. An ideal material would meet the requirements of MIL-B-131 and MIL-B-117; minimum requirements would still include high watervapor resistance of the sealed bags and puncture resistance. The ideal material would also be easily recyclable.

The AFPTEF has found that using aluminum foil sealed with double-sided tape is promising. Many double-sided tapes with strong adhesion to metals exist and uncoated aluminum foil would be easily recyclable. However, aluminum foil requires cleaning before tape adhesion is maximized and an easy, effective cleaning method is unknown. Also, dirt may prevent an adequate seal with tape. Another barrier material, or a different sealing method for uncoated aluminum foil would be acceptable as long as the resulting barrier bags approach or meet the above specification requirements.

PHASE I: End products shall include proposed watervaporproof (or resistant) barrier material(s), proposed sealing method(s), test methods (if those in referenced specifications are not suitable to proposed materials and methods) for both materials and sealed bags, and preliminary test results or manufacturer data for material(s) and sealed bags. Materials and methods shall be chosen based on the ability to meet both technical requirements and ease of use.

PHASE II: End products shall include test results for sealed barrier bags using proposed material(s) and sealing method(s), and results of field testing of material(s), method(s) and sealed bags at selected DoD warehouses and field activities. Field testing shall include ease of use and how readily material(s) and method(s) may be formed into sealed barrier bags which meet requirements.

POTENTIAL COMMERCIAL MARKET: In general, any commercial process needing to package items in a watervaporproof bag, in areas where dirt or access to electricity make heatsealing difficult may be interested in a new barrier bag technology. Agricultural, food and drug companies who need to package seed, plants or chemicals in barrier bags to prevent moisture loss or absorption, manufacturers of gaskets or bare metal parts with high tolerance surfaces may be potential prime users of these bags.

REFERENCES:
1. MIL-B-131, MIL-B-117

AF97-246 TITLE: Environmentally Safe, In Situ Surface-Protection of Carbon Steel Structures

Category: Exploratory Development

OBJECTIVE: Develop the "Laser Induced Surface Improvements" (LISI) surface alloying concept into an economically viable, for specific applications, and environmentally safe capability.

DESCRIPTION: Trends in turbine engine performance capabilities, made possible through improvements in component efficiency, have increased sensitivity of turbine engines to flow quality. In particular, increases in turbine inlet temperatures and the advent of fine blade cooling passages have increased the emphasis on providing flow, free from contamination, in ground test facilities. Corrosion of aging carbon steel ductwork can introduce undesired particulates, typically iron oxide, that can melt and adhere to engine hot-section components or clog cooling passages. The potential for turbine engine performance degradation, unrepresentative of flight, or even component damage has elevated this aspect of flow quality to one of Arnold Engineering Development Center's (AEDC's) top test-facility issues.

AEDC has initiated a program to implement methods that ensure the Engine Test Facility (ETF) meets current and future flow purity needs. The University of Tennessee Space Institute (UTSI) recently introduced a "Laser Induced Surface Improvements" (LISI) surface alloying concept, patent pending (Patent Application Serial Number 08/587,553), as a technique to extend the longevity of the existing plant air supply ducts while meeting future air purity needs. The technique uses heat generated by the absorption of a high-powered laser beam to coalesce metallic compounds that are introduced at the surface of a base metal. The method forms an alternate alloy with desirable characteristics in a thin surface layer. In the AEDC application, the addition of chromium produces a corrosion resistant surface alloy.

AEDC and UTSI recently engaged in an experimental feasibility investigation focused on determining the applicability of the method in the ETF environment. Although, the investigation addressed proof of concept, AEDC requires the development of an efficient and cost effective LISI system, optimized to the ETF plant environment, prior to large-scale application. The ETF plant environment contains approximately two miles of air supply durcting with diameters ranging from 24 inches to 108 inches, as well as valves, elbows, and expansion joints. The interior surfaces contain irregularities produced by welded seams or existing corrosion. A limited number of strategically placed 18 inch diameter ports provide access to the interior of the ductwork. ETF test requirements limit the time available for system installation and utilization. The developed LISI system must be portable, able to be rapidly put in place, and capable of modifying large and irregular surface areas. Typical access times to areas requiring repairs will be less than three days.

A system for implementing the LISI technique at AEDC must include the following: (1) a remotely-operated robot capable of traversing the ductwork, (2) a laser beam delivery unit on the robot capable of precisely focusing the laser beam and scanning the beam over predetermined patterns, and (3) an alloying element delivery unit that operates in conjunction with the beam delivery unit. It is desirable to position the laser external to the duct; a method for delivering the laser beam to a remote site inside the duct from an externally positioned laser (e.g., a fiberoptic cable) is needed.

The development must provide an increase in the demonstrated application rate of 10 sq ft/hr by at least a factor of two. Higher application rates are desirable. The economic viability issue will center on the application rate. A robotic unit that can be rapidly deployed and removed must be developed to permit quick response to the AEDC operational schedule.

PHASE I: A demonstration and evaluation of the proposed technique or process will be performed.

PHASE II: Phase II should result in a fully functional prototype capability for use by the Air Force.

POTENTIAL COMMERCIAL MARKET: The commercial market for this capability is extensive. Chemical refineries, power plants, ocean shipping facilities, bridges, and any steel structures exposed to the environment will benefit from this technology. The useful design life of these critical structures will be greatly increased. The replacement of aged and corrosion damaged structures can be avoided or postponed. The cost of fabricating new corrosion resistant structures will be reduced dramatically.

REFERENCES:
1. Donald J Wulpi, "Understanding How Components Fail," 1988, ASM, Metals Park, OHIO
2. Narendra B. Dahotre, C. Xio, W. Boss, M.H. McCay, and T.D. McCay, "Laser Induced Reaction Coatings of Ceramics." Surface Modifications Technologies VIII, T.S. Sudarshan, M. Jeandin, Editors, The Institure of Materials, London, UK, 1995
3. Narendra B. Dahotre, K. Mukherjee, "Laser Surface Melting and Alloying of Steel With Chromium," Laser Materials Procesing III, J. Mazumder, K. Mukherjee, Editors, The Minerals, Metals & Materials Society, 1989

Notice: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small business

AF97-247 TITLE: Tunable IR Laser for Spectroscopic Use

Category: Exploratory Development

OBJECTIVE: Develop a compact uncooled tunable mid-infrared laser source for use in engine emission, gas diagnostics, laboratory spectroscopic, and environmental applications.

DESCRIPTION: Accurate techniques are required for gas diagnostics and emission measurements in high temperature flow environments. A narrow line width source is required to separate the various spectral features required for accurate quantification of exhaust gases. A nonintrusive optical technique such as laser spectroscopy offers the possibility of highly accurate low-concentration specie determination. Current laser technology does not readily allow obtaining in situ spectral data on several compounds simultaneously due to limited tuning range, limited output power, and/or physical constraints such as high operating powers or cryogenic cooling requirements.

A laser source with an output power of 1 to 2 milliwatts in a single mode with a spectral width of approximately 10-3 cm-1 is required to isolate specie specific spectral features. The tunable range of the laser should be no less than 5 cm-1 with a tuning rate of at least 10kHz over the 5 cm-1 spectral region. The high tuning rate will allow for the use of frequency modulated spectroscopy. The laser source should not require cryogenic cooling and should be packaged in a unit of no more than 2' x 2' x 2'.

PHASE I: Analytically and experimentally investigate the feasibility of a tunable mid-infrared laser system.

PHASE II: Produce a marketable tunable laser-source for in situ and analytical laboratory applications.

POTENTIAL COMMERCIAL MARKET: The commercial market for such a device is extensive. This device would have use as a key component in gaseous phase monitors for air quality measurements and chemical process monitoring. Uses will include automobile emission measuring and monitoring devices, smoke-stack emission monitors, and commercial building air-quality monitors.

REFERENCES:
1. "The Atmospheric Effects of Stratospheric Aircraft: Report of the 1992 Models and Measurements Workshop," NASA Reference Publication 1292, Vol. II., 1993.
2. W.J. Phillips, R.L. Moyers, D. G. Brown, L. T. Lay, "Improved FTIR Open Path Remote Sensing Data Reduction Technique," "Optical Sensing for Environmental and Process Monitoring," Air & Waste Management Association, Nov. 1994.
3. D.G. Brown and W.J. Phillips, "High Temperature Infrared Reference Spectra," "Optical Sensing for Environmental and Process Monitoring," Air & Waste Management Association, Sep. 1995.
4. Lowry, H.S. and C.J. Fisher, "Line Parameter Measurements and Calculations of CO Broadened by H2O and CO2 at Elevated Temperatures," Journal of Quantitative Spectroscopy and Radiative Transfer, Vol. 31, No. 6, p575, 1984.

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AF97-248 TITLE: Nonintrusive Smoke Measurement

Category: Exploratory Development

OBJECTIVE: Develop an optical instrument for evaluating turbojet engine smoke.

DESCRIPTION: Current turbojet smoke measurements require drawing a sample of the exhaust gases through a filter. These techniques, besides being very time consuming, are subject to question due to the agglomeration and loss of particulates in the sampling system. A diagnostic instrument that will utilize a nonintrusive technique, such as laser induced incandescence, to map the soot mass flow across the engine exhaust plane is needed.

The instrument must be capable of measuring the total mass fraction of soot in the exhaust plume and it is desirable to determine the particle size distribution. The jet engine plume conditions would typically fall within the following range: temperature from 1000 to 1800 F, Static pressure of 2 to 14 psia, and equivalence ratios of 0.5 to 0.8. The instrument should be capable of measuring soot mass loading of 100 micrograms per cubic meter of combustion products, to within a desired accuracy of +- 10 %. For the Phase I effort, there are no restrictions on the instrument size or weight.

PHASE I: A demonstration and evaluation of the proposed techniques will be performed.

PHASE II: A prototype system, configured to an AEDC test cell that will be selected during Phase I, will be built, tested, and installed at AEDC.

POTENTIAL COMMERCIAL MARKET: Operators of all types of oil fired engines, both stationary and mobile, are in need of diagnostic instruments to quickly and accurately measure the soot levels in the exhaust gases. Currently, various standards exist requiring invasive techniques and are not readily applicable nor directly interpretable in terms of mass release rates. Potential customers also include those organizations responsible for environmental monitoring and compliance.

REFERENCES:

1. "Spatially Resolved Measurements of Soot Volume Fraction Using Laser-Induced Incandescence," B. Quay, T.W. Lee, T. Ni, and R.J. Santoro, Department of Mechanical Engineering, The Pennsylvania State University, University Park Pa., "Combustion and Flame," 97:384-392 (1994)

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AF97-249 TITLE: Combined Total Integrated Scatter (TIS) and Retro-Reflectance Instrument for Hyperspectral and Laser Line Sources

Category: Exploratory Development

OBJECTIVE: Develop a portable instrument with the capability to measure both total integrated scatter (TIS) and retro-reflectance (or opposition effect) data for laser or hyperspectral sources.

DESCRIPTION: An instrument is needed that will provide the capability to measure total integrated scattered (TIS) radiation and the simultaneous measurement of the retro-reflected scatter component. Since both laser and noncoherent sources are of interest, capabilities for both types of source measurement must be included in the design. The

instrument must also have the capability to obtain angular data (from normal incidence to 75 degrees off-normal) and data for both the parallel and perpendicular polarization components for both the TIS and Retro Reflection measurement modes.

This instrument will be used to augment thermal radiative-property data required for the measurement of hardbody signatures. Target surfaces are associated with surveillance, interceptors, camouflage, targets, and decoys. The retro-reflectance capability of the instrument also will be used for detecting backscattered radiation from hot particles in gaseous flows. The proof-of-concept laboratory version of the instrument will be upgraded to a portable prototype during Phase II.

PHASE I: A demonstration and evaluation of the proposed techniques will be performed.

PHASE II: A marketable portable-prototype system for general application to instrumentation requirements for both field and laboratory applications will be produced, tested, and delivered to AEDC.

POTENTIAL COMMERCIAL MARKET: The commercialization potential for such a device appears to be high. As electro-optical instrumentation manufacturers seek to refine their products and expand capabilities, the ability to calibrate their devices to known standards becomes more critical. This device will aid in the calibration phase of product testing. Remote sensing and noncontact measurement devices made for use in high-speed manufacturing processes will also benefit from this technology.

REFERENCES:

1. Nicodemus, F.E., Richmond, J.C., and Hsia, J.J., "Geometrical Considerations and Nomenclature for Reflectance," Institute for Basic Standards, National Bureau of Standards, Washington, D.C. 20234, October 1977

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AF97-250 TITLE: Long Taper Hone

Category: Exploratory Development

OBJECTIVE: Develop a device that can hone bores with a taper over lengths up to 100 feet.

DESCRIPTION: A honing device is needed that can efficiently hone long tube bores with a taper. The subject tubes range in bore size between 2.5 inches and 8.0 inches in diameter and lengths up to 100 feet. The tubes are threaded together at regular intervals. The use of corrosive electrolytic fluids that may seep into the threaded joints during honing is not permissible. It is desirable to taper their bore with a taper ranging from 0.0 - 0.100 inch over their lengths. Small discrete steps are permissible but not desirable. The device should be one system with interchangeable heads and either completely replace the existing honing system or mate with the existing system. It should have as a minimum an "in situ" bore measurement device, a linear distance measurement device, and a load feed mechanism that provides feedback to a control system for full automation of the hone control process. It is desirable to have the control system adaptable to other hone systems. The device should occupy approximately the same space as the current 100-foot hone system and provide similar capability for moving into and out of position for honing so that it does not interfere with normal testing operations. The dimensions of the current device are 30 inches wide by 30 inches high by 115 feet long. It should provide substantial savings in time over the current method in use; e.g., 40 hours for a honing taper of 0.045 inch over 68 feet in a 2.5-inch- diameter bore tube. The device should be rugged, reliable, and usable in an industrial application. It should also be usable for daily maintenance honing operations to maintain the taper as the bore diameter grows over time.

PHASE I: Phase I should develop the concept for the hone and demonstrate the concept on a 10-foot length of steel tubing with a bore of at least 2.5 inches.

PHASE II: Phase II should result in a fully functional prototype device for use at AEDC.

POTENTIAL COMMERCIAL MARKET: This honing device will have commercial application in the precision machining of short and long tubular products.

REFERENCES:
1. Yeomans, Bernard, "COMPUTER GETS THE MEASURE OF HONED BORES" Metal working Production, v131 n8, Aug. 1987, P 53,55.
2. Astrop, A.W., "DEVELOPMENTS IN IN-LINE TRANSFER HONING MACHINES" Machinery and Production Engineering, v126 n 3240; Jan 8,1975;P 18-22.

Notice: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small business

AF97-252 TITLE: Airborne Monitoring of Ground Vehicle Motion

Category: Engineering Development

OBJECTIVE: Develop methods of detecting and maintaining track of ground vehicles during their periods of travel and rest.

DESCRIPTION: Airborne radars are capable of detecting both stationary and moving ground targets. Stationary targets can be detected with high resolution Synthetic Aperture Radars (SARs), while moving targets can be detected and tracked with Moving Target Indicator (MTI) radars. However, joint SAR/MTI operations are needed to detect and maintain continuous track of subject vehicles which intermittently travel and rest. Our ability to meet this goal is currently frustrated by the limited ability of SARs to distinguish stationary targets of interest from background clutter; and by the limited ability of MTI radars to distinguish moving targets of interest from other background traffic, particularly in regions of high-traffic density.

PHASE I: Identify concepts by which airborne radars can locate and maintain continuous track of vehicles of interest, in motion and at rest, over long periods of time. Show the feasibility of implementing the concept with current and/or advanced technologies.

PHASE II: Design a system to implement the concept derived in Phase I. Develop the key technologies needed to implement the design.

POTENTIAL COMMERCIAL MARKET: This research could yield important results for the military and commercial sector. The detection, identification, and tracking of critical mobile targets (such as mobile missile launchers, artillery, etc.) is of major importance to the military. Similarly, the detection, identification, and tracking of civilian vehicles is needed in support of border patrol, counter-drug enforcement, and counter-proliferation. For these activities we need to be able to monitor subject vehicles over long periods of time. The ability to observe the origins, destinations, and travel routes of suspect vehicles would be immensely valuable for identifying illegal activities and for rapid apprehension of the offending parties. The commercial sector would produce the radars, the airborne platforms (aircraft or lighter-than-air craft) to carry the radars, and the computer hardware/software to implement the desired detection and tracking system.

REFERENCES:
1. E. Schwartz, et al. "A Radar for Unmanned Air Vehicles," The Lincoln Laboratory Journal, Spring 1990, Vol. 3, No.1.
2. "Mastering the Fourth Dimension," International Defense Review, 1 Feb 96
3. Hewish, M. & Wilson, J.R., "Closing the Loop -- New Technology to Counter Mobile Targets," International Defense Review, 1 Mar 95.
4. Hewish, M., "Airborne Ground Surveillance/New Technologies Meet Urgent Demands," International Defense Review, 1 Jan 95.

5. Boatman, J., "Systems under Study to Fill Korean Gap," Janes's Defense Weekly, International Edition, 12 Nov 94

AF97-253 TITLE: Assessing Environmental Impacts on the Life Cycle of a System

Category: Advanced Development

OBJECTIVE: Develop a methodology and process to consider and analyze the environmental impacts throughout the life cycle of a weapon system.

DESCRIPTION: Both military and civilian system developers face the problem of design, manufacturing, maintaining, and disposing of systems while adhering to environmental laws, budgetary constraints and minimizing risks. Currently there are no accepted techniques, tools or valid metrics to treat the impacts or trade offs of hazardous materials (Haz Mat) on the life cycle of a system. A real vacuum exists in attempting to treat the Haz Mat problems during the early stages of a system concept. For example, Public Law 103-337, Section 815 requires analyzing as early in the process as feasible the life cycle environmental costs for major defense acquisition programs. A methodology, especially a quantitative one, that treats environmental impacts from system inception to system disposition is needed for both DoD and the commercial private sector.

PHASE I: Develop a prototype process for treating environmental effects on a weapon system (or commercial system), considering concept design, manufacturing, life cycle cost, and risk. Develop a prototype methodology and perform a feasibility demonstration.

PHASE II: Extend prototype into a working model, detailed process or toolset. Demonstrate the technique on an agreed-to-system concept to illustrate potential trade-offs while showing possible impacts on selected metrics including cost, schedule, performance and impacts on the environment.

POTENTIAL COMMERCIAL MARKET: Process, technique, computer model or tool kit will have direct application to the commercial sector or DoD.

REFERENCES:

1. DoD Instruction 5000.2, Defense Acquisition Management Policies and Procedures, Feb 93.
2. Environmental Consequence Analysis of Major Defense Acquisition Programs, P.L. 103-337, Section 815.
3. Rasumssen, K., "Natural Events and Accidents with Hazardous Materials," Journal of Hazardous Materials, vol 40/1, 1995.
4. Englehardt, J.D., "Identifying Promising Pollution Prevention Technology," Journal of Environmental Engineering, vol 120(3), 1994.
5. Schwab, J., "Industrial Performance Standards for a New Century," Report - American Planning Association, Planning Advisory Service, vol 444, 1993.
6. Padgett, D.A., "Assessing the Safety of Transportation Routes for Hazardous Materials, "Geo Info Systems," vol(2), 1992.

AF97-254 TITLE: Application of Genetic Algorithm to Optimization Problems

Category: Exploratory Development

OBJECTIVE: Develop methods to demonstrate the utility of the genetic algorithm or other suitable machines that learn techniques to solve commercial and DoD problems.

DESCRIPTION: The ever increasing processing speed of modern digital computers make the application of genetic algorithm practical alternatives toward solving problems that require optimization of an objective function. The utility of these algorithms have been demonstrated to solve transportation and queuing problems. One possible use of the genetic algorithm is to apply it to evolve better tactics for air-to-air combat. Solutions to the problem have been solved

only for simple cases such as one participant versus another (lvsl). Few solutions have been demonstrated at the many-on-many level (M vs N). One objective of this effort is to optimize one opponents' exchange ration (red kills/blue losses) while the other opponent is performing to the best of its ability. Real-time operation is not required.

PHASE I: Perform a proof of principle application of the genetic algorithm and demonstrate its utility by a demonstration.

PHASE II: Develop a detailed process, apply the genetic algorithm to a large scale M vs N air-to-air combat and write the necessary software to interface with selected Air Force air-to-air combat models.

POTENTIAL COMMERCIAL MARKET: Many commercial applications in the area of transportation, checkout lines and others, have been demonstrated. This could extend the realm of application to fields where the two sides react to each other including bio-medical fields.

REFERENCES:

1. Johnson, R. Colin, "Genetic Algorithm Trains Fuzzy System", Electronic Engineering Times, 1995.
2. Celko, J., "Decision, Decisions," DBMS, 1995.
3. Johnson, R. Colin, "Robot "evolves" without programming. (field programmable gate arrays under the control of a genetic algorithm are described at the European Conference on Artificial Life," Electronic Engineering Times, 1995.
4. Johnson, R. Colin, "Fuzzy Logic Genetic Algorithms Gain," Electronic Engineering Times, 1995

AF97-255 TITLE: C4I Systems/Subsystems

Category: Exploratory Development

OBJECTIVE: Develop innovative concepts for improving or increasing the capability of Air Force command, control, communication, computer, and information systems or subsystems.

DESCRIPTION: Proposals may address any aspect of C4I systems not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative approaches to accomplishing the following: Employing commercial off-the-shelf communications technology; definition and development of qualitative and quantitative metrics and exit criteria associated with developing and producing C4I-related products and technologies; C4I concepts for fixed and mobile command centers, tactical operations, and special forces operations; tools for modernization of base-level business processes. In addition, the following areas are of particular interest:

1. ATMOSPHERIC PROFILE ALGORITHMS: Computer algorithms which will be able to ingest and apply meteorological information provided by various weather sensor suites to DOD atmospheric prediction models, to allow determination of how horizontal profiles can be used to enhance forecast models.
2. BUSINESS PROCESS RE-ENGINEERING TOOLS AND METHODS: Innovative tools and methodologies which support Business Process Re-engineering, including the use/reuse of IDEF-0 and IDEF-1x models for: process simulation, performing workflow analysis, creating IDEF-3 (Process Description Capture Method) models, linking to domain analysis/Object Oriented methodology, leveraging Groupware concepts in developing IDEF models and repositories for IDEF models data manipulation.
3. IMPROVED PHASED ARRAYS FOR MOBILE PLATFORMS OPERATING OVER COMMERCIAL Ku-BAND SATELLITES. Improved cross-polarization discrimination within the terminal antenna to minimize interference and simplify the polarization tracking process. Low-loss electronic means to perform dual-linear polarization alignment, with update rate determined based upon platform dynamic motion characteristics.
4. IMPROVED UHF MOBILE ANTENNAS: UHF SATCOM antenna which provides greater low-angle gain without sacrificing high-angle gain, is lightweight, and minimizes modifications to the platform.
5.TECHNOLOGY TO TAKE ADVANTAGE OF THE ASYMMETRIC DIGITAL SUBSCRIBER LINE STANDARD (ANSI T1.413 category 1) Allow multi-megabit per second download with kilobit per second uplink on plain old telephone service (POTS) lines, to accommodate the asymmetrical bandwidth requirements between echelons.

6. AIR-GROUND-AIR INTERNET PROTOCOL CONNECTIVITY: Method to distribute the common view of the battlespace (e.g., Air Tasking Order, Threat Assessments) from command and control centers to platforms such as the Airborne Warning And Control System and Airborne Battlefield Command and Control Center.
7.INTERACTIVE WIDE SCREEN DISPLAYS: Large format display to support planning teams and allow situation monitoring by groups as needed. Display must interface with known open system computer environments, and include a means for the team to interact with supporting software through or at the screen and adjustment of display parameters.
8. CORRELATION OF MOVING TARGET INDICATOR (MTI) DATA: Robust technique for associating and correlating MTI radar-derived data to establish a unified ground picture of moving vehicles and to predict future locations and traffic densities. Must accommodate different update rates and differing accuracies and resolutions of vehicle location; must operate in near real-time relative to the radar scan rates, and be tolerant to lost reports caused by line-of-sight blockages to the vehicle.

PROPOSAL TITLES MUST REFLECT THE SPECIFIC C4I PROBLEM BEING ADDRESSED.

PHASE I: Provide a report which describes the proposed concept in detail and shows its viability and feasibility. PHASE II: Fabricate and demonstrate a prototype device or subsystem or software program.

POTENTIAL COMMERCIAL MARKET: All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

AF97-256 TITLE: Advanced Distributed C4I Simulation Capabilities

Category: Exploratory Development

OBJECTIVE: Develop M&S technology for use in analysis, training, and acquisition based modeling

DESCRIPTION: Historically, Modeling and Simulation (M&S) programs have been developed to serve particular purposes, with little or no attention to later integration or interoperability. The Air Force has recognized these deficiencies and is now emphasizing the definition of standard architectures, frameworks, etc. The goals are to reduce the number of models and simulations employed, and to maximize re-use, interoperability, and utility. The research proposed under this topic may address different domains of simulation, such as training, analysis, test and evaluation, etc., and varying degrees of resolution. Or, the research may span interoperability questions across varying domains or levels of resolution. Unique and innovative applications of existing commercial tools will be considered. Following are specific areas of interest.

ADVANCED VIRTUAL BATTLESPACE SYNTHETIC ENVIRONMENT: The use of advanced visual and distributed computing techniques to provide synthetic battlespace feeds to real C4I, such as those which enhance the operation of the ESC Command and Control Unified Battlespace Environment (CUBE).

INTER-DOMAIN SIMULATION INTEROPERABILITY: The integration of various M&S capabilities, initially intended for a specific purpose (e.g., training, analysis, etc.) and now interoperating in a high level architecture, into common frameworks for the future.

MULTI-LEVEL SIMULATION INTEROPERABILITY: Correlation of models which currently represent various levels (e.g., system, engagement, mission, theater) of war within a given domain of modeling and simulation.

ADVANCED EXERCISE SCENARIO GENERATION: Advanced visual toolsets which enhance the capability to provide scenario generation capability, e.g., system laydown, geographical representation, weather effects, etc.

ADVANCED EXERCISE AFTER ACTION REVIEW AND ANALYSIS (AARA): Tools which can be used for AARA, such as statistical analysis, plotting, etc.

PHASE I: In Phase I the contractor is expected to survey and analyze the modeling and simulation state, specifically relative to C4I issues, and provide a report containing the results of the survey and analysis, and recommendations. PHASE II: In Phase II, the contractor will develop a prototype of the recommended tool.

POTENTIAL COMMERCIAL MARKET: The modeling and simulation area is significantly ripe for both commercialization and dual use applications. Modeling and simulation is currently used extensively in the private sector, for both business and pleasure (games, amusement parks, etc.). The tools, prototypes, and research developed under this topic will be broadly applicable to the commercial sector with application to games, business use, the medical community, etc.

AF97-257 TITLE: Improved Satellite Data Communications

Category: Exploratory Development

OBJECTIVE: Develop new protocols and techniques to improve capability and performance of communication over satellite links

DESCRIPTION: The military's expanded use of computers is resulting in expansion of the data networks supporting communications between the computers and the interconnection of local area networks (LANs) to form wide area networks (WANs) using satellite systems. This is resulting in problems and inefficiencies. Innovative approaches are desired to provide the following added capabilities. Proposals may be submitted addressing any one of these subtopics. The proposal title should identify the particular subtopic.

a. ON-THE-FLY, LOSSLESS DATA COMPRESSION The data rates on the WAN links are generally far less than required to support the timely transfer of perishable data. The data subsystem does not have sufficient time to format and file the perishable data for compression processing. This limitation leaves only one alternative for increasing transfer rates other than increased use of satellite resources: On-the-fly data compression within the data network. The challenge for the innovator is to develop an inexpensive, lossless compression system that will not adversely affect either the current (TCP/IP) networking protocols or future (ATM) protocols.

b. DATA LINK CONTROL PROTOCOL. Local area networks are being interconnected to form wide area networks using satellite systems. The standard networking protocols in use by the commercial-off-the-shelf computers and networking equipment do not tolerate the bit error rates and delays that are typical of satellite links. This results in the inefficient use of satellite resources. The challenge for the innovator is to develop a data link control protocol that will work with the current (TCP/IP) networking protocols or future (ATM) protocols and allow these protocols to operate efficiently over satellite links.

c. SELECTIVE RETRANSMISSION APPLICATION LAYER PROTOCOL. The defense community's standard transport protocol, transmission control protocol (TCP) does not perform well over satellite links with large delay bandwidth products. Standard commercial protocol stacks generally support both TCP and the user datagram protocol (UDP). An application layer protocol using UDP would require users to install an additional application on their existing computers. This application would use UDP to establish one-way connections between computers transferring information. The application layer protocol would use the UDP connections to transfer the information efficiently regardless of delay or link bit error rate since only corrupted data packets would be retransmitted unlike TCP where all the packets in the sliding window are retransmitted. PHASE I: In Phase I, the contractor should produce a conceptual design of the relevant system or protocol and identify the system's effects on or interaction with standard networking protocols. The contractor would also identify interface requirements between satellite systems and cryptographic equipment (subtopic a), or perform analyses comparing satellite resource use when the proposed protocol is in use and when only standard networking protocols are in use. A report will be provided containing a description of the design and the results of the analysis.

PHASE II: In phase II, the contractor would develop and demonstrate a working prototype of the system or protocol software.

POTENTIAL COMMERCIAL MARKET: Commercial satellite communications providers are entering the nomadic computing market and also wrestling with the problem of efficient use of satellite resources for network connectivity. A lossless data compression system would be useful in circuit switched networks where bandwidth limitations also exist. The development of a new efficient data link control protocol would benefit both commercial satellite and

networking service providers The development of a new application layer protocol providing selective retransmission of corrupted packets would allow the continued use of the installed network infrastructure.

AF97-258 TITLE: Lightweight, Portable Tactical Weather Terminal

Category: Exploratory Development

OBJECTIVE: Develop a lightweight, portable weather tactical terminal that provides an interactive meteorological satellite data analysis capability without reliance on surface communications.

DESCRIPTION: The criticality of supplying complete, on-line weather data to the Department of Defense (DoD) and commercial organizations alike continually increases. A primary source of the data is the Defense Meteorological Satellite Program (DMSP). The mission of DMSP is to collect and disseminate global visible and infrared cloud data and other specialized meteorological, oceanographic and solar-geophysical data. This capability is required to support worldwide DoD operations and other high-priority programs. The Meteorological Satellite Basic Small Tactical Terminal (B-STT) is a major element of the DMSP user segment. Currently this system consists of a 480 pound (including power supply) portable weather terminal that provides an interactive meteorological satellite data analysis capability without reliance on surface communications. The B-STT ingests, processes, stores and displays: a) Real-time Data Smooth (RDS) data transmission (at 2207-2268 MHz) from the DMSP satellites; b) Automatic Picture Transmission (APT) data transmitted (at 137-138 MHz) from the National Oceanic and Atmospheric Administration (NOAA) satellites; the Television Infrared Observations Satellites (TIROS); the Chinese FENG YUN satellites and the Russian METEOR satellites and c) Weather Facsimile (WEFAX) data transmitted (at 1690-1695 MHz) from the Geostationary Meteorological Satellite (GMS), METEOSAT, the Geostationary Operational Environmental Satellite (GOES) and GOES-NEXT geostationary satellites. B-STT major system functions include: 1) Receiver/Antenna equipment including antennas, pedestals, controllers, down converters, low noise amplifiers and receivers; 2) Classified DMSP decryption devise (size of a CD ROM Drive and weighs less than four pounds) 3) Processing equipment including central processing unit, memory, data storage, data display, keyboard, mouse, input/output devices and hard copy devise; 4) Auxiliary equipment, including power distribution, power generation equipment (portable generator, 120 volt/60 Hz, 240 volt/50 Hz, 24 volt DC) and 5) System software including Unix based operating system, system control, satellite tracking and receiving, data reduction and processing, display generation and application software. The need is to innovatively package items 1,2,3,4 and 5 above into a maximum 100 pound (targeted 20 pound) portable, lap top computer type, back pack unit capable of single person unhindered transport and operation. Items 2 and 5 will be controlled/supplied by the Air Force.

PHASE I: Develop complete familiarity with current B-STT. Produce an operational prototype that defines required miniaturization. Provide proof of concept, including preliminary chip designs, selected non developmental items, etc. that clearly demonstrate the feasibility of building a light weight, B-STT.

PHASE II: Build five light weight, ruggedized B-STT prototypes and test under actual conditions in conjunction with the Air Force.

POTENTIAL COMMERCIAL MARKET: Development of a miniaturized, portable weather terminal, capable of providing the spectrum of on-line weather information, as is required to be provided through the B-STT Air Force terminal, would be in high demand by organizations involved in agriculture, commercial fishing, terrestrial/marine transportation, commercial/general aviation, sports, etc.

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AF97-259 TITLE: Electro Magnetic Suspension Two Axis Gimbal Satellite Antenna System

Category: Exploratory Development

OBJECTIVE: Develop a non-contacting, friction free, no lubrication, fault tolerant, electromagnetic suspension, two axis satellite antenna gimbal system.

DESCRIPTION: Electro-Mechanical satellite antenna gimbal systems currently in use display mechanical wear and vibration, require lubricants, and have limited life. As payload functions continuously expand in complexity and mission life is dramatically extended the need for precise vibration free antenna gimbal mounting functionality and reliability similarly increases. The recent advances in electromagnetic suspension technology portend potential application for improvement in the area of satellite antenna gimbal mounting. One potential solution (among others) to improved antenna gimbal mounts is the development of a small, non-contacting, friction free, no lubrication, fault tolerant, electromagnetic suspension, two axis satellite antenna gimbal system. Generalized system requirements to handle a typical antenna payload of 300 pound (feet)2 (mass properties) includes azimuth and elevation excursions of minus 10 degrees to plus 10 degrees, at a slew rate of 0.40 degrees per second. Positioning error must be less than 0.008 degrees. Operational life is at least ten years. Total gimbal assembly weight is less than 22 pounds and volume is less than 1.9 cubic feet. Power requirements are in the range of 6 watts per axis (normal) and 12 watts (maximum). Required output torque per axis is greater than 22 foot pounds. Operational temperature span is minus forty to plus one hundred seventy degrees Fahrenheit. Materials from which the gimbal assembly is fabricated must not display outgassing characteristics greater than 1 percent total weight loss and 0.1 percent volatile condensable materials in a vacuum of 1X10-5 torr or less. The resulting two axis gimbal system must be include a lock down launch mechanism capable of withstanding 15 g's launch vibration for a period of 3 minutes. A two axis gimbal mount design capable of meeting the above criteria should be capable of being up sized or down sized to meet additional application requirements.

PHASE I: 1) Through cooperation with Air Force, develop complete familiarity with current satellite gimbal designs and requirements, 2) develop preliminary two axis gimbal design, complete with documentation that will provide proof of functionality, 3) produce/demonstrate "small breadboard operational prototype" to ensure proof of basic design concept. PHASE II: 1) Complete/finalize two axis gimbal design, 2) build/demonstrate full scale operational prototype of final design to mutually agreed upon Air Force specifications.

POTENTIAL COMMERCIAL MARKET: Development of a long life, vibration/maintenance free, operationally reliable antenna gimbal mount will have high DoD/NASA/Commercial demand for use in satellite, air and ground based radar, and communication antenna applications and security surveillance equipment. Technology developed through this topic will lay the basis for light weight, machine platforms capable of 10-100 fold increase in freedom from vibration, movement accuracy, and range of velocity/motion, required for the next generation of terrestrial and high vacuum (space based) precision manufacturing technologies. Immediate application in: single point diamond turning of mirrors, lenses, precision metallic components; high density storage laser scanning systems; force feed back mechanisms for micro assembly processes and two and three axes gyros, are apparent.

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AF97-260 TITLE: Environmentally Conscious Solder Process for Manual/Bench Applications

Category: Exploratory Development

OBJECTIVE: Develop an environmentally conscious replacement lead based solder process for manual bench operations.

DESCRIPTION: Lead is one of the Environmental Protection Agency's (EPA) 17 materials targeted for industrial reduction. Although elimination of lead in solder is a target, the amount of lead involved in the soldering process is small. Equally important environmental hazards in the solder process are contained in the pre-cleaning and post-cleaning operations. The chemicals used in these operations are major contributors to environmental pollution and hazards to worker's health. DoD specific electronic assemblies, and countless commercial products, currently rely on lead based connection processes ranging from automated surface mount technology to manual bench operations. Nonhazardous automated, high volume soldering processes are under development in many areas. A high priority need exists, however, for innovative development of environmentally acceptable manual/bench top soldering processes, as a replacement for current hazardous solvent/flux/lead based solder processes. The need is for a conductive material soldering process which will allow environmentally conscious, rapid, simple, low temperature, wide latitude processing. The successful process/materials must be oxide tolerant, insure complete flux removal (if flux is required) and require no environmentally objectionable solvent cleaning. In addition the conductive material solder alternatives must be cost effective, tractable, capable of manual application, have similar joint strength as current lead solder techniques and not have any negative impacts to performance of hardware.

PHASE I: Will include analysis of the State-of-the-Art materials compatible with the requirements of environmentally conscious manual soldering processes, development of candidate formulations, down select tests to identify the most promising materials, and laboratory simulated manual production application demonstration of selected candidates.

PHASE II: This phase will optimize selected formulations, conduct applicable production/process/application/performance tests to prove feasibility, and provide prototype demonstrations of applicability to manual processing/performance requirements.

POTENTIAL COMMERCIAL MARKET: Current electronic fabrication methods require the use of solvent/flux/lead based soldering processes in applications from surface mount technology to manual operations. Although lead is an objectionable component in these processes, other environmental hazards in the solder process are contained in the pre-cleaning and post-cleaning operations. DoD and commercial industry alike require an environmentally acceptable substitute for current manual/bench top soldering processes; a successful substitute will have enormous application in all areas of the DoD/commercial electronics industry, DoD/commercial electronic/electric repair and remanufacturing operations, as circuit board implants, and small quantity electronics production.

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