AIR FORCE
SMALL BUSINESS INNOVATION RESEARCH
PROPOSAL PREPARATION INSTRUCTIONS

The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the Air Force SBIR Program. The Air Force SBIR Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. Do not submit SBIR proposals to the AF SBIR Program Manager under any circumstances. All questions concerning proposal submissions, Fast Track applications and requirements, and award/contracting issues should be directed to the appropriate agency SBIR Program Manager listed beginning page AF-5. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-5 through AF-7.

Technical questions may be submitted directly to the topic author prior to December 1, 2001, or after that using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this and other technical information assistance systems from DTIC, please refer to section 7.1 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the contractual period of performance for Phase I shall be nine (9) months, and the price should not exceed $100,000. Only one cost proposal for the entire nine-month contractual period of performance will be accepted.

The Phase I award winners must accomplish their primary research during the first six months of the contract. This primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. We anticipate no more than 80% of the total cost should be expended within the first six months. After the first six months, additional related research should further the Phase I effort and put the small business in a better position to start Phase II, if awarded.

The last three months of the nine-month Phase I contract will provide project continuity for all Air Force Phase II award winners so that no modification to the Phase I contract should be necessary. The Air Force will accept proposals for modifications to maintain project continuity under special circumstances such as Fast Track.

Air Force Phase I and Phase II Evaluation

Our evaluation of the primary research effort and the proposal will be based on the factors listed in Section 4 of the solicitation; a) the soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution; b) the qualifications of the proposed principal/key investigators, supporting staff, and consultants (qualifications include not only the ability to perform the research and development but also the ability to commercialize the results) and c) the potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization. The actual assigned weightings will not be disclosed outside of the DoD. Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

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 businesses.

You must receive a written invitation before submitting a Phase II proposal. All Fast Track applicants may submit a Phase II proposal prior to receiving a formal invitation letter. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including Fast Track applicants.

Air Force Phase I Proposals

Phase I proposals shall reflect a nine month effort that should not exceed $100,000. Remember, the first six months constitutes the primary research effort and will be used to evaluate whether a Phase II proposal will be requested.
Proposals are limited to 25 pages, excluding Company Commercialization Report.

Air Force Phase II Proposals

Phase II proposals are typically 24 months in duration not exceeding $750,000. The Air Force anticipates that pricing will be based on adequate price competition. Phase II Instructions from the sponsoring Air Force organization will specify the number of proposal pages (typically 75). However, if the Air Force selects your company to receive an award, be prepared to submit further documentation to substantiate costs. This further information is necessary to facilitate the contracting process.

Air Force Phase II and Fast Track

Detailed instructions on the Air Force Phase II program and notification of the opportunity to submit a fast track application will be forwarded to all Phase I awardees by the awarding Air Force organization at the time of the Phase I contract award. The Air Force encourages businesses to consider a Fast Track application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract. For Fast Track applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offerer will not be considered for any Phase II award.

Air Force Phase II Enhancement Program

On active phase II awards, the Air Force will invite a limited number of Phase II awardees to apply and compete for a Phase II Enhancement to address new unforeseen technology barriers that were discovered during the Phase II work. The selected enhancements will extend the existing Phase II contract award for up to one year and the Air Force will match dollar for dollar up to $250,000 of non-SBIR DoD matching funds.

Air Force Commercial Potential Evidence

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (http://www.dodsbir.net/submission) 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Air Force SBIR Program Management Improvements

The Air Force reserves the right to modify the submission requirements. Should the requirements change, all Phase I awardees who are invited to submit Phase II proposals will be notified. The Air Force also reserves the right to change any administrative procedures at any time that will improve management of the Air Force SBIR Program.

Air Force Submission of Final Reports

All final reports will be submitted to the sponsoring Air Force agency. **Companies should not** submit final reports directly to DTIC.

Proposal Submission Instructions

Your proposal will be ACCEPTED if you meet all of the following criteria. Failure to meet any one of the criteria will result in your proposal being REJECTED.

1. The Air Force Phase I proposal shall be a nine month effort and the cost shall not exceed $100,000.

> **The Air Force will not accept any proposals that have not electronically submitted the Proposal Cover Sheet (http://www.dodsbir.net/submission). The electronic forms submitted must match the paper copies submitted via mail, express, or hand delivery.**

3. A copy of the Company Commercialization Report with summary page prepared on the Submission site must be submitted with all proposals. (See Section 3.4n. of the solicitation.) Even if you have no Phase I or Phase II information to report, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company has never had any SBIR Phase I's or II's in the past.

4. Both the electronic submission of the Proposal Cover Sheet and the paper copies of your proposal must be received on or before the deadline. The Air Force will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself time to contact the Air Force activity and get an answer to your question. Submit the Electronic Proposal Cover Sheet and Company Commercialization Report early, as server traffic increases, server response slows down. Do not wait until the last minute. The Air Force will not be responsible for late proposals caused by servers being "down" or inaccessible.

Electronic Submission:

Prepare your SBIR proposal to the Air Force using the DoD Electronic Submission Web Site at **http://www.dodsbir.net/submission**. This site allows your company to come in at any time (prior to the closing of the solicitation) to add, edit or print out your Proposal Cover Sheet and Company Commercialization Report. The Air Force will not accept any Proposal Cover Sheet or Company Commercialization Report except those from the Electronic Submission Web Site as valid proposal submission forms.

*** Note: The Air Force period of performance for Phase I is nine months.**

Once you have prepared, printed, and signed the Proposal Cover Sheet and Company Commercialization Report, mail it along with one original and four copies of your entire proposal (the copies should include four copies of the signed Proposal Cover Sheet) to the appropriate Air Force offices at the addresses listed below.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your Phase I Proposal Cover Sheet submitted electronically on the Submission site.

____2. Your Company Commercialization Report submitted electronically on the Submission site.

____3. Your Cost Proposal does not exceed $100,000 and the period of performance is 9 months.

___4. Your entire proposal is 25 pages or less, excluding the Company Commercialization Report.

____5. A signed copy of the Proposal Cover Sheet and Company Commercialization Report are attached to the technical and cost proposal.

____6. One original and four copies of your entire proposal are mailed to the appropriate Air Force office and received by January 16, 2002.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, both the electronic submission of Appendix A and B and the paper copies (original and 4 copies) of your proposal must be sent 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)
AF02-001 thru AF02-003 AF02-005 thru AF02-013 AF02-015 AF02-017 thru AF02-023	Directed Energy Directorate AFRL/DE 3600 Hamilton Avenue SE Bldg 382 Kirtland AFB NM 87117-5776	Dave Tuttle (505) 846-8133
AF02-004 AF02-025, AF02-031 AF02-033 thru AF02-046 AF02-050 thru AF02-052 AF02-054, AF02-055 AF02-057, AF02-059, AF02-060 AF02-062, AF02-063	Space Vehicles Directorate AFRL/VS 3600 Hamilton Avenue SE Bldg 382 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Francisco Tapia (505) 846-5021
AF02-032, AF02-048 AF02-058, AF02-064	Space Vehicles Directorate AFRL/VSOT 29 Randolph Road Hanscom AFB MA 01731-3010 (Noreen Dimond, (781) 377-3608)	John Flaherty (781) 377-2529
AF02-067 thru AF02-073 AF02-078 AF02-080 thru AF02-085	Human Effectiveness Directorate AFRL/HEOP 2610 Seventh Street, Bldg 441, Rm 216 Wright-Patterson AFB OH 45433-7901 (Sabrina Davis, (937) 255-2423 x226)	Mary Jones (937) 255-2527
AF02-089 thru AF02-094 AF02-096 AF02-099 thru AF02-104 AF02-106 thru AF02-110	Information Directorate AFRL/IFB 26 Electronic Parkway Rome NY 13441-4514 (Jan Norelli, (315) 330-3311)	Joetta Bernhard (315) 330-2308
AF02-111 thru AF02-126 AF02-128 thru AF02-134	Materials & Manufacturing Directorate AFRL/MLOP 2977 P Street, Bldg 653, Suite 13 Wright-Patterson AFB OH 45433-7746	Terry Rogers (937) 656-9001

	(Marvin Gale, (937) 255-4839)	
AF02-138 AF02-141 thru AF02-147 AF02-149 thru AF02-153 AF02-157 AF02-155, AF02-159, AF02-160 AF02-163 AF02-166 thru AF02-171	Munitions Directorate AFRL/MNOB 101 W Eglin Blvd, Suite 140 Eglin AFB FL 32542-6810 (Richard Bixby, (850) 882-8591 x1281)	Selesta Abbott (850) 882-4294 x3414 Linda Weisz (850) 882-2872
AF02-175 thru AF02-179 AF02-181 thru AF02-188 AF02-190	Propulsion Directorate AFRL/PROP 1950 Fifth Street, Bldg 18 X067 Wright-Patterson AFB OH 45433-7251 (Dottie Zobrist, (937) 255-6024)	Susan L. Day (937) 255-5499
AF02-191 thru AF02-194	Propulsion Directorate AFRL/PROP 5 Pollux Drive Edwards AFB CA 93524-7033 (Debbie Spotts, (661) 275-5617)	Donna Thomason (661) 277-8596
AF02-196 thru AF02-202 AF02-204 thru AF02-206 AF02-208, AF02-209 AF02-211 thru AF02-215 AF02-218, AF02-219 AF02-221 thru AF02-224 AF02-227 thru AF02-229 AF02-232 thru AF02-237	Sensors Directorate AFRL/SNOX 2241 Avionics Circle, Bldg 620 Wright-Paterson AFB OH 45433-7320 (Marleen Fannin, (937) 255-5285 x4117)	John Stovall (937) 255-5380 x097
AF02-242 thru AF02-248 AF02-250, AF02-251 AF02-253 thru AF02-257 AF02-259	Air Vehicles Directorate AFRL/VAOP 2130 Eighth Street, Bldg 45, Rm 149 Wright-Patterson AFB OH 45433-7542 (Madie Tillman, (937) 255-5066)	Capt. Bill Surrey (937) 255-5901
AF02-263 thru AF02-264	Oklahoma City ALC OC-ALC/TIET 3001 Staff Drive, Suite 2AG70A Tinker AFB OK 73145-3040 (Bill Tilley, (405) 736-3990)	David Cricklin (405) 739-4468
AF02-265 thru AF02-270 AF02-272	Ogden ALC OO-ALC/TIEH 5851 F Avenue, Bldg 849, Rm A-15 Hill AFB UT 84056-5713 (Bill Wassink/Joe Burns, (801) 777-2977)	Martha Scott (801) 777-0199
AF02-276 thru AF02-282	Warner Robins ALC	Ken Burke

	WR-ALC/TIECT 420 Richard Ray Blvd, Suite 100 Robins AFB GA 31098-1640 (Jamie McClain, (478) 926-6617)	(912) 926-3695
AF02-283 thru AF02-284 AF02-286 thru AF02-288 AF02-291	Air Armament Center 46 TW/XPP 101 W. D Avenue, Suite 222 Eglin AFB FL 32542-5492 (Cosmo Calobrisi, (850) 882-6434)	Lorna Tedder (850) 882-4141 x4557
AF02-292 thru AF02-298	Arnold Engineering Development Center AEDC/DOT 1099 Avenue C Arnold AFB TN 37389-9011 (Ron Bishel, (931) 454-7734)	Kathy Swanson (931) 454-4409
AF02-301 thru AF02-307	Air Force Flight Test Center AFFTC/XPST 307 East Popson Avenue Bldg. 1700, Rm 107A Edwards AFB CA 93524-6843 (Abe Atachbarian, (661) 277-5946)	Donna Thomason (661) 277-5946

Air Force 02.1 SBIR Topics

DIRECTED ENERGY DIRECTARATE, KIRTLAND AFB

AF02-001 Ultra-Wideband (UWB) Target Identification
AF02-002 Optical Systems Fault Management
AF02-003 Drilling 170 Micron Diameter Holes
AF02-005 Frequency-Agile Monolithic Micro-Laser with Ultra-Narrow Linewidth
AF02-006 Solid State Low Energy Lasers for Space Based Lasers
AF02-007 High Energy Laser Diagnostics for Space Based Applications
AF02-008 Active In-Situ Contamination Control
AF02-009 High Temporal and Spatial Resolution Laser Beam Diagnostic Sensor
AF02-010 High Temperature Target Failure Sensor
AF02-011 New Thermal Sensors for Use with Inverse Heat Conduction Problems
AF02-012 Active Target Tracking through Deep Atmospheric Turbulence
AF02-013 Develop Coatings that Repel Contamination
AF02-015 All-Optical High-Energy-Laser Beam Control
AF02-017 Coatings for Large, Lightweight, Compliant, and Scalable Deployable Space Optics
AF02-018 Application of Quantum Cascade Lasers to High Explosive Detection
AF02-019 Real Time Adaptive Signal Processors for On-line Performance Optimization of Adaptive Optical Systems
AF02-020 Tracking Through Laser-Induced Clutter for Air to Ground Directed Energy Systems
AF02-021 Periodically Poled Stoichiometric Lithium Tantalate for Nonlinear Optical Frequency Conversion
AF02-022 Artificial Dielectrics for High Power Microwave Applications
AF02-023 Grating Surface Emitting Semiconductor Laser Incoherent Array with High Average Power

SPACE VEHICLES DIRECTORATE, KIRTLAND AFB

AF02-004 Beam Train Flexible Structure Control for Airborne/Space-Based Systems
AF02-025 Novel Low-Noise Extra High Frequency Amplifiers

AF02-026 Dynamic DC Source and Load System with Energy Recycle Capability
AF02-027 Multifunction Phase Array Antennas
AF02-028 Next-Generation 35-40% Efficient Multijunction Solar Cell
AF02-029 Phased Array Antenna Power Amplifier Modules
AF02-030 Miniature Traveling Wave Tubes for Space Application
AF02-031 Lightweight Primary Mirror Technology
AF02-033 Power Efficient Space Computer
AF02-034 High Temperature Polymer Substrate for Thin Film Solar Cells
AF02-035 Reconfigurable Logic for Space
AF02-036 Multi-functional Polymer Optical Interconnect Technologies for Wireless Satellite Data Communications
AF02-037 Novel High Current Switch for Spacecraft Power Bus Control
AF02-038 Integrated Thin Film Solar Array and Phased Array Antenna
AF02-039 High Efficiency Non-Vacuum Processed Thin-Film Photovoltaics
AF02-040 Parallel-Connected Converters with Innovative Control
AF02-041 Advanced 10 Kelvin Cryogenic Cooling Technology
AF02-042 Advanced Component Technology for Next Generation Cryocoolers
AF02-043 Advanced Multi-stage Cryogenic Cooling Technology
AF02-044 Advanced Thermal Integration Technology for Space Cryocoolers
AF02-045 Large Focal Plane Array Cryogenic Integration Technology
AF02-046 High-Performance HgCdTe VLWIR Photovoltaic Detectors
AF02-050 Small Launch Vehicle Technology
AF02-051 Small Shuttle-Compatible Propulsion Module
AF02-052 Payload Adapter for Satellite Missions Launched using ICBM-derived Launch Vehicles
AF02-054 Insulated Stainless Steel or Molybdenum Substrate for Thin Film Photovoltaics
AF02-055 Star Trackers Based Upon Advanced Sensor Technologies
AF02-057 Polarization Phenomenology Modeling and Simulation
AF02-059 Smart Membrane Structures
AF02-060 Long-Stroke Isolation System for Large Flexible Space Structures
AF02-062 Autonomous Satellite Cluster Data Fusion
AF02-063 Remote Satellite Diagnostics

SPACE VEHICLE DIRECTORATE, HANSCOM AFB

AF02-032 Electrodynamics of the High-Latitude Ionosphere
AF02-048 Advanced Algorithms for Exploitation of Space-Based Imagery
AF02-058 Geophysical Interpretation of Digital Ionosonde Signatures
AF02-064 Ground-based Daytime Optical Imaging of the Ionosphere

HUMAN EFFECTIVENESS DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-067 Deployable Ceramic Oxygen System
AF02-068 DMT Training Requirements and Capability Analysis
AF02-069 Aircrew Bladder Relief Capability
AF02-070 Time Critical Targeting Cell (TCTC) for Team Training and Evaluation
AF02-071 Distributed Interactive Training for the C2 Aerospace Operations Center (AOC)
AF02-072 Integrated Satellite Operations Training and Rehearsal for Multiple Satellite System Ground Control
AF02-073 Advanced Runway Lighting Technology for Portable Applications
AF02-078 Messaging Interaction Simulation
AF02-080 Imagery Manipulation for Simulator Databases
AF02-081 Advanced 50 dB Hearing Protective/Voice Communication System for 150 dB Noise
AF02-082 Viewer for Vision Research in Developing Agile Laser Eye Protection
AF02-083 Fatigue Assessment through Voice Analysis
AF02-084 Robotic cRNA Processing System for Gene Microarray Analysis
AF02-085 Adaptive Training for Real-Time Intelligence Monitoring & Evaluation

INFORMATION DIRECTORATE, ROME NY

AF02-089 Enhanced Interoperability Through Common Translation Architecture
AF02-090 Data Link Common Software for Multiple Link-16 Applications
AF02-091 Innovative Method for Performance & Mission Worth Analysis of Integrated Command and Control Systems
AF02-092 Portable Universal Ground Processing Unit

AF02-093	Lightweight, Highly Deployable, Jam-resistant Satellite Communications Modem
AF02-094	Signal Diversity Combining for Improved Satellite Communications
AF02-096	JAVA-Based, Performance Oriented Visualization System
AF02-099	Data Mining of GMTI Databases
AF02-100	Coordinating Multiple Airborne Platforms to Improve Targeting Accuracy
AF02-101	Feature Aided Tracking (FAT) to Augment Track Continuity
AF02-102	Spectral Filtering
AF02-103	Innovative Information Technologies
AF02-104	Innovative Approaches for Information Fusion
AF02-106	Quantum Information Science
AF02-107	HPC for C2 Decision Support
AF02-108	Configurable Enterprise Test Harness for Publish and Subscribe Architectures
AF02-109	Multisensory Assimilation of Complex C2 Information
AF02-110	Secure Peer-to-Peer Object Repository

MATERIALS & MANUFACTURING DIRECTORATE, WRITE-PATTERSON AFB

AF02-111	Casting Hard Alpha Inclusion Detection
AF02-112	Lightweight Titanium Heat Exchangers
AF02-113	Component Surface Treatments for Engine Fatigue Enhancement
AF02-114	Corrosion Preventative Coatings
AF02-115	Superlattice Materials for Very-Long Wavelength Infrared Detectors (VLWIR)
AF02-116	Conductive Resin Systems for Aircraft Composite Structures
AF02-117	Tamper Resistant Coating Development
AF02-118	Secure Circuit Board Materials and Processes
AF02-119	Tailored Adhesives for Damage Tolerant Joints
AF02-120	Qualifying Light, High-Performance Materials for Airborne Expeditionary Forces (AEF)
AF02-121	Use of Alternate Materials for Infrared (IR) Missile Domes
AF02-122	Individual Plastic Component Water Sealing
AF02-123	Innovative Approaches in Secure Hardware
AF02-124	Demonstration of Compound Semiconductor Films on a Compliant Substrate
AF02-125	Crack Growth Behavior of Hard Alpha Inclusions in Titanium Castings
AF02-126	Verification of Composite Bonded Joint Integrity
AF02-128	Logistic Fuel Sulfur Removal for Fuel Cell Use in Air Expeditionary Force (AEF) Operations
AF02-129	Advanced Materials for Lightweight Space-Based Mirrors
AF02-130	Dynamic Filtering of MidWave InfraRed (MWIR) Radiation
AF02-131	Novel Materials for Spacecraft Thermal Control Coatings Technologies
AF02-132	Polymer Claddings for Space Photonics
AF02-133	Multifunctional Thermally and Electrically Conductive Carbon Nanotube-Polymer Hybrid Material
AF02-134	Virtual Nondestructive Evaluation (NDE): Computational Methods for Virtual Prototyping

MUNTIONS DIRECTORATE, EGLIN AFB

AF02-138	Distributive Processing Techniques For Interconnected Embedded Systems
AF02-141	Micro Air Vehicles for Munition Bomb Damage Indication
AF02-142	Bomb Impact Analysis and Damage Assessment via Remote Sensor
AF02-143	Effects of Internal Weapons Bays on Advanced Munitions
AF02-144	Reconfigurable Computing Applications for Aircraft, Munitions and Dispensers
AF02-145	Liquid Payload Expulsion and Aerosolization
AF02-146	The use of synthetic aperture radar (SAR) imagery for targeting of Laser Radar terminal seekers
AF02-147	Improvement of Penetrator Performance by Increasing/Engineering Case Mechanical Properties
AF02-149	Agent Defeat Short Time Neutralization Data Collection and Modeling
AF02-150	Low Cost Universal Flight Termination System
AF02-151	Use of Kalman Filter Residuals for Independent Fuze Safeing
AF02-152	Intraweapon Wireless Communication
AF02-153	Innovative Sensor Precision Guided Munition Accuracy
AF02-155	Automatic 3-Dimensional Wire-Frame Model Generation Algorithm
AF02-157	Zero-Zero Target Sensor
AF02-159	Munition Thermal Management
AF02-160	Low Cost Manufacturing of Range Extension Wing Kits
AF02-163	Development of Structural Explosives for Low Collateral Damage (LCD) Warheads
AF02-166	Munitions Research
AF02-167	Miniature Initiation System Technology (MIST)

AF02-168 Enhanced Laser RADAR Through Augmenting Signal Information Content
AF02-169 Navigation Solutions by Terrain Imaging
AF02-170 Positron Energy Conversion Based Weapons
AF02-171 Biomimetic Concepts for Situational Awareness

PROPULSION DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-175 Aero Propulsion and Power Technology
AF02-176 Improved Composite Duct Design for Increased Safety Margin or Weight Reduction
AF02-177 Innovative Onboard Power and Cooling Solutions
AF02-178 Fuel Additives For Reduced Engine Emissions
AF02-179 Fuel Tank Compatible Oxygen Sensor
AF02-181 Fuel Tank Ullage Oxygen Sensor for Live-Fire Ballistic Testing
AF02-182 Advanced Vibration Monitoring Diagnostics and Prognostics Techniques
AF02-183 Small, Low Cost, High Performance Engines for Miniature Munitions
AF02-184 Global Reach High-Speed air Vehicles and Weapons
AF02-185 Technologies for Air Breathing Propulsion
AF02-186 High Heat Flux Laser Diode and/or Solid State Laser Cooling for Airborne and/or Spaceborne Directed Energy Applications
AF02-187 Ultra-wide bandwidth high-power solid state photoconductive power switch technology
AF02-188 Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components
AF02-190 Improved Composite Front Frame for Weight and Cost Reduction

PROPULSION DIRECTORATE, EDWARDS AFB

AF02-191 Advanced Rocket Propulsion Technologies
AF02-192 Air-slew Package for Air-launched Missiles
AF02-193 Significant Improvements in High Temperature Resins for Solid Rocket Motor (SRM) Boost and Orbit Transfer Composite Cases
AF02-194 Determination of Composite Motor Case Damage

SENSORS DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-196 Multi-Sensor Data Exploitation Capability
AF02-197 Digital Beamforming Transmit Subarray With Waveform Agility
AF02-198 Improved Inertial Reference Transfer Unit (IRTU) - Gyros, Mounts, Models
AF02-199 Improved UHF Antenna
AF02-200 Continuous Track and ID Fusion (CTIF)
AF02-201 High-Efficiency Amplifiers with Discretely Variable Output Power
AF02-202 Low Mass, Low Power, Digital Beamforming (DBF) Subarray for Satellite Applications
AF02-204 Simulator Technologies for Rapid Prototyping of Advanced Receiver/Processor
AF02-205 Efficient Luneberg Lens for Multi-frequency SATCOM Antenna
AF02-206 High Performance Atomic Clocks for Space
AF02-208 Global Positioning System/Inertial Measurement Unit Ultra-Tightly Coupled Integrity Monitoring
AF02-209 Innovative Sensors and Algorithms for Detection and Identification of time critical targets
AF02-211 3-D Reconstruction for Missile Recognition
AF02-212 Dual-Use Visualization Tools For Aircraft System/Subsystem Performance Assessments
AF02-213 Material and Component Development for Millimeter(MM)-Wave Imaging Systems
AF02-214 140 GHz Imaging Technology
AF02-215 Real Time Sensor Image Fusion
AF02-218 Network Multiple frame Data Association
AF02-219 Environmentally Driven Signal Processing Technology for Overland Height Finding
AF02-221 Improved Pose Estimation for Tracking and Identification Systems
AF02-222 Fusion-Aided Continuous ID for Targeting (FACIT)
AF02-223 Coupled Tracker and Identification Algorithms
AF02-224 Multiple Database Evidence Accrual Techniques
AF02-227 Ultra-Wide Band Perimeter Surveillance Sensor
AF02-228 Move-Stop-Move Signature-Aided Tracking
AF02-229 Analog to Digital Coverters
AF02-232 Accurate Computational Electromagnetics (CEM) Techniques for High Frequency Applications
AF02-233 Integrated Electro-Optical and Radio-Frequency Aperture
AF02-234 Truth Quest: Enabling Operational/Exercise Data
AF02-235 Opportunistic Sensor Resource Management for Extended Operating Conditions
AF02-236 Novel Concepts for Multi-Mission Radar
AF02-237 Innovative Phenomenology Characterization and Advanced Algorithms

AIR VEHICLES DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-242 Variable Speed Aerial Refueling Drogue
AF02-243 Logistics and Maintenance System Model Development and Integration into Real-Time Mission Level Simulation Environment
AF02-244 Rapid Fatigue Life Projection for Thermal and Acoustic Loads
AF02-245 Crack-Growth Methodologies for Cold-Worked Fastener Holes in Aluminum and Titanium Alloys
AF02-246 Lightning Protection of Revolving Aircraft Turrets
AF02-247 Supportable Sandwich Control Surfaces
AF02-248 Structurally Efficient Composite Concepts with Non-Traditional Load-Paths
AF02-250 Aerial Targets Modernization and Integration
AF02-251 Integration of Hypersonic Vehicle Inlets, Isolators and Exhaust Nozzles for Multiple Engine Flowpaths
AF02-253 Metal Deposition for Locally Tailored Properties
AF02-254 High-fidelity Tools for Three-dimensional Multi-physics Computation
AF02-255 Reactive Flow Control for Virtual Aerodynamic Shaping
AF02-256 Distributed, Embedded Sensing for Quasi-Static Shape Control of Wings
AF02-257 Biologically Inspired Autonomous Control Technologies
AF02-259 Affordability Development and Integration into Simulation-Based Research and Development (R&D)

OKLAHOMA CITY ALC, TINKER AFB

AF02-263 e-Learning and Aptitude Evaluation Through A Web-based Training Framework
AF02-264 Simulation of Repair and Rebuild Processes

Ogden ALC, Hill AFB

AF02-265 Aircraft Wiring Characterization, Tracking, and Testing System (AWCTTS)
AF02-266 Active Bus Analysis and Failure Forecasting
AF02-267 Sound Technology For Test And Diagnosis
AF02-268 Advanced Composite Materials Replacement on Metal Structures/Shelters
AF02-269 Performance Based Support Model
AF02-270 Advanced Molecular Coating Process
AF02-272 Semi-automatic or automatic development of Test Program Sets (TPS) without a board model using hardware reconstruct

WARNER ROBINS ALC, ROBINS AFB

AF02-276 Compact Hydrogen Storage using Metal Hydride
AF02-277 Micro JP8 Fuel Reformer
AF02-278 Advanced Electric Vehicle Research
AF02-279 72kw Hydrogen Fuel Genset
AF02-280 Aircraft Wiring Inspection System
AF02-281 Inspection of Subsurface Flaws Around Fasteners on Aircraft
AF02-282 Inspect Composite Components of the Aircraft

AIR ARMAMENT CENTER, EGLIN AFB

AF02-283 Sled Vehicle Aerodynamic Load Prediction Capability
AF02-284 Cellular Telemetry of Flight Test Data
AF02-286 Electromagnetic Modeling and Simulation (EMMS) Capability
AF02-287 Hybrid Computational Fluid Dynamics (CFD) Analysis System for Rapid Assessment of Store Separation
AF02-288 Global Positioning System (GPS) Simulator Phase Calibration
AF02-291 High Performance Real-Time Synchronization Clock

ARNOLD ENGINEERING DEVELOPMENT CENTER, ARNOLD AFB

AF02-292 Ultra High Speed Framing Pulsed X-ray System
AF02-293 Exhaust Gas Trace Species Detection System for Turbine Engines
AF02-294 Determination of Airframe and Weapons Bay Acoustic Signature in High Subsonic Speed Wind Tunnel Tests
AF02-295 Integrated Visible/IR Calibration Source
AF02-296 Non-Intrusive Flow Visualization Diagnostic System for Aircraft Flow Fields
AF02-297 Vortex Flow Detector for Turbine Engine Test Facilities
AF02-298 Microsensors for Gaseous Emissions Analysis

AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB

AF02-301 Subminiature GPS Instrumentation (SGI)
AF02-302 Wireless Solutions for Time Space Position Information (TSPI) Data Links
AF02-303 Improved Aeronautical Global Positioning System (GPS) Antenna Systems
AF02-304 High Power, Miniature Infrared (IR) Sources
AF02-305 Clutter Model Based on Real-Time Terrain
AF02-306 Real-Time Infrared (IR) Source Calibration
AF02-307 Advanced Airspace Modeling, Characterization, and Planning

AF02-001 TITLE: Ultra-Wideband (UWB) Target Identification

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Based on advances in ultra-wideband technology, develop a capability to detect, identify, and locate ground targets.

DESCRIPTION: The wide bandwidth and short pulse length of ultra wideband (UWB) time domain impulse signals make it attractive for application to the detection, identification, and location of targets. UWB time domain signals are characterized by an impulse waveform with a rise time on the order of 100 to 300 picoseconds (ps) and a pulse width of 4 to 8 nanoseconds (ns). The concept of a time domain impulse application for target identification is not new, but new and innovative approaches are needed for time domain conformal receiver antenna concepts for small airborne platforms to make a system implementation feasible. The antenna requirements include the ability to provide a broad area of coverage for initial detection and focus on a specific potential target of interest. The antenna system should be capable of receiving analog time domain data signals with sufficient dynamic range to allow the target features to be extracted for target identification. The receiver components must also be capable of withstanding the high peak electromagnetic field levels that may be coupled to them during transmission of the main illuminating pulse. Both mono-static and bi-static configurations are of interest.

PHASE I: Develop a conceptual or preliminary design which would lead to the successful demonstration of the proposed innovative conformal receiver antenna system. Demonstrate basic antenna system concepts in a laboratory environment.

PHASE II: Develop and fabricate a prototype article, conduct laboratory, simulation and field tests which will demonstrate the capability that meets the requirements developed in Phase I. Create an application tree linking this proven technology to commercial and government uses.. Create an investment decision matrix of all the applicable uses as a function of need, utility, cost and schedule. The application tree and the investment decision matrix should only apply to uses that the prototype has successfully demonstrated during this phase. A more definitive requirements and validation specification shall be developed for the technology so that pre-production units in phase III can be built and tested in less time. Prepare a report containing the application tree and the investment decision matrix with the proposed selections for phase III. Develop commercial partnership interests for a Phase III production program.

PHASE III DUAL USE APPLICATIONS: The primary potential military application for this technology is the location and identification of obscured objects. Civilian applications include future time domain communications systems as well as airborne mapping of buried cables, pipelines, and mine shafts.

REFERENCES:
1. C.E. Baum, ed., Detection and Identification of Visually Obscured Targets, Taylor & Francis, Bristol, PA, 1998.
2. C.E. Baum, E.J. Rothwell, K.M. Chen and D.P. Nyquist, "The Singularity Expansion Method and Its Application to Target Identification," Proceedings of the IEEE, October 1991.
3. C.E. Baum, "Signature-Based Target Identification and Pattern Recognition," IEEE Antennas and Propagation Magazine, Vol. 36, No. 3, June 1994.
4. C.E. Baum, et al., "Polarimetric SAR Imaging of Buried Landmines," IEEE Trans on Geoscience and Remote Sensing, Vol. 37, No. 1, January 1999.
5. R. Kapoor, N. Nandhakumar, "Features for Detecting Obscure Objects in Ultra-Wideband (UWB) SAR Imagery Using a Phenomenological Approach", Pattern Recognition, Vol: 29, Issue: 11, pp1761-1774, November, 1996, Elsevier Science.

KEYWORDS: Targets, Ground, identification, Ultra-Wideband, Electromagnetic, Sensors, Airborne

AF02-002 TITLE: Optical Systems Fault Management

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop an optical systems fault management system for air- and space-borne optical applications.

DESCRIPTION: A dynamic optical diagnostics system is needed (including development of a data analysis tool) to create the capability for the Airborne Laser (ABL) to effectively detect and isolate faults and to provide diagnostics data on demand to maintenance personnel for rapid correction of optical component failures. BACKGROUND: A frequent objective of optical systems diagnostics design is to provide feedback for initialization and monitoring of a system's performance and operational health. However, this approach does not correlate and store all pertinent diagnostic data in a nonvolatile memory that maintenance personnel can access on demand, nor does it expedite the unambiguous isolation of any system or weapon malfunction to the defective part or item. The information most important to the maintainer must be derived from the performance data. As more and more optical systems are developed and deployed, the need for maintenance-enhancing, integrated optical diagnostics systems grows. Such systems are needed to reduce operations and support costs and for developing refinements to existing systems. They may also play a significant role in developing specifications for the procurement of future systems.

PHASE I: Define the proposed system concept and specific system requirements. System requirements may include the ability to define decisions in need of diagnostic information, functions which need to be diagnosed, constraints on diagnostics and the ability to predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component/system and laboratory demonstration which meets mutually agreed upon performance parameters and which demonstrates the capability to support both ground and airborne experiments in government laboratories or aircraft. The prime interests at this stage are deliverable system hardware and a clear demonstration of an integrated high-performance system capable of a 20-year lifetime.

PHASE III DUAL USE APPLICATIONS: Tremendous growth in the use of adaptive optics -- especially in the field of astronomy -- along with the requirements of Airborne Laser (ABL), Space Based Laser (SBL) and Ground Based Laser (GBL), has created a market composed of commercial and Department of Defense (DOD) customers seeking effective optical fault management systems. Successful development of the described system could lead to further interest and opportunities for related applications in both the defense and commercial sectors. The transition from defense to commercial applications may be expected to follow a pattern comparable to the introduction of adaptive optics.

REFERENCES:
1. Baird and Hanes, in Kinglake, Applied Optics and Optical Engineering, vol 4, New York, Academic, 1967.
2. Habell and Cox, Engineering Optics, London, Hilger 1948. Hopkins, in Shannon and Wyant, Applied Optics and Optical Engineering, vol 8, New York, Academic, 1980.
3. Strong, Procedures in Applied Optics, New York, Dekker, 1989. 4. Yoder, Opto-Mechanical System Design, Dekker, 1986. G. Smith, J.B. Schroeder, S.Navarro, Haldeman, "Development of an Integrated Diagnostic Strategy to Support Autonomic Logistics," Proc. of Air Force Logistics Symposium, March 1997.
5. R. Cowan, W. Winer, "Integrated Diagnostics", February 1997, DTIC ADA324130, Georgia Institute of Technology, Atlanta, GA, Office of Naval Research/XB Contract #N00014-95-1-0539.
6. Mil-STD-1814 “Integrated Diagnostics” 30 April 1991 pg 150-162.

KEYWORDS: Optical systems, optics maintenance, diagnostics, fault detection, fault management, fault isolation, optical path difference, photometric terms, aberrations, diffraction, data analysis tools, Airborne Laser (ABL), Space Based Laser (SBL), Ground Based Laser (GBL).

AF02-003 TITLE: Drilling 170 Micron Diameter Holes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a high-speed drilling process to be less labor and time intensive. The rapid drilling process must maintain hole quality and be non-invasive to thin metal plates.

DESCRIPTION: The ABL laser system uses a Singlet Oxygen Generator [SOG] to produce excited oxygen for its lasing process. Inside the SOG is an injector head that has to produce very fine droplets of Basic Hydrogen Peroxide [BHP]. The PDRR ABL has six laser modules, and each laser module has 20ea injector heads. Each injector head has 12,288 holes drilled, that are appx 170 micron in circumference. These holes are to be drilled into thin metal plates (~0.2 to 5.0 mm in thickness)which are made of metal alloys (see notes below). There are 6 modules for PDRR [1,474,560 holes] and 14 modules for EMD [3,440,640 holes]. For our Fully Operational system that consists of 7 A/C, it would require [24,084,480 holes]. Drilling this many very precise holes is very time consuming and labor intensive. The rapid drilling process must also be non-invasive to the thin metal plates.

PHASE I: Define the proposed system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component or system and laboratory demonstration to mutually agreed performance parameters. Demonstration drilling process must be capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable system hardware and a clear demonstration of the integrated high-performance system.

PHASE III DUAL USE APPLICATIONS: There is tremendous growth in the use of COIL technology, especially in commercial drilling and cutting. With this increase along with requirements of ABL and GBL a requirement is created for an effective and efficient drilling system. It is expected such a system will find an abundance of applications in the commercial and defense sectors. Also, the rapid drilling process may have many other applications for hole drilling in materials.

REFERENCES:
1) “Specifications for Rapid Hole Drilling,” by William P. Latham, Air Force Research Laboratory/Directed Energy Directorate, unpublished, copies of this document are available on request, contact Dr Latham, william.latham@kirtland.af.mil
2) "Short-pulse Laser Ablation of Solid Targets," C. Momma, B. N. Chichkov, S. Nolte, F. von Alvensleben, A. Tunnermann, and H. Wellig, Optical Communications Vol. 129, pp. 134-142, 1996.
3) “Microdrilling of Metals with Ultrashort Laser Pulses,” H. K. Tonshoff, et. al., in the Proceedings of the Laser Materials Processing Conference, ICALEO ’98, LIA Vol. 85, A-28 (1998).
4) “Laser Drilling of Small Holes,” W. E. Maher, in the Proceedings of the Laser Materials Processing Conference, ICALEO ’95, LIA Vol. 80, (1995).

KEYWORDS: Singlet Oxygen Generator, LASER, Basic Hydrogen Peroxide, Injector Head, Micro-hole Drilling, Lasing Process

AF02-004 TITLE: Beam Train Flexible Structure Control for Airborne/Space-Based Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Incorporate information about the structural modes of airborne/space-based platforms into controller design to improve feedback loop performance of optical acquisition, tracking, and pointing (ATP) systems.

DESCRIPTION: For airborne/space-based platforms, a lighter weight structure can lower total mission cost and increase acceleration capabilities, and thus improve performance of related Acquisition, Tracking and Pointing (ATP) subsystems. The choice of a lighter weight structure, however, comes at the cost of more challenging structure control problems - especially in cases where tracking and re-targeting performance enhancements are pursued in optical assemblies. Passive damping methods or structural redesigns can sometimes mitigate this problem, but for high performance systems this is not possible. In some examples, the coupling of slew maneuvers and noise sources with the flexible modes of the system can cause modal excitation and movement of optical components that can dynamically impact wavefront error. Solutions exist such as low bandwidth control that are reliable and robust but have limited performance, while model-based control designs have robustness and implementation issues such as plant migration and modeling errors. However, the number of tools available for solving and analyzing this problem has grown. Faster processors, thin-film PZTs, residual mode filter model-based control methods, scanning laser vibrometers for multi-point sensing, and integrated optical/structural modeling tools such as IMOS are all new technologies that can help to realize a system more capable at dealing with this problem. Approaches are sought that combine hardware choices with advanced control algorithms & system ID tools that can be applied to slewing ATP systems with nontrivial dynamic responses to allow fast retargeting without structural dynamics/control interaction effecting wavefront error.

PHASE I: Phase I tasks should be focused toward identifying structure control issues for representative airborne/space-based optical systems. Specifically, model-based data should be used to characterize sensitivities to line-of-sight retargeting, misalignment and tracking, while investigations into control algorithm methodologies such as reduced order model based-methods should be included. Models should allow for the characterization of the disturbance environment, both acoustic and vibration. Potential hardware approaches to be used in Phase II such as thin-film PZTs, actuated optical mounts or other possibilities should also be investigated in the models for applicability and design sensitivities.

PHASE II: Phase II tasks would be directed towards the evolution of the hardware/software solutions investigated in Phase I to a brassboard/breadboard test traceable to a large telescope systems such as ABL or SBL.for a flight demonstration on the ABL platform. The benefits of flexible structure control will be proven. . Finally, loop performance measures will be contrasted with those of conventional control approaches to assess the new technology.

PHASE III DUAL USE APPLICATIONS: Because most motion control problems have some flexible modes that impact controller design, this work can apply to a large number of problems. The step and settle problem is also ubiquitous in motion control problems. For pointing systems this can result in faster re-targeting times. Airborne and Space Based Laser will benefit from this tool along with other DoD systems employing a targeting system. Commercial applications of control with lightweight structure include large crane and small assembly gantries and astronomical telescopes. These applications involve minimizing structural mass (to maximize acceleration and minimize thermal time constants) while maintaining precision position control.

REFERENCES:

1. Mathur, M.S., et al., "Characterization of Containment and Limiter Materials," SPIE, v3413, 1998, pp.192-1982.
2. Wood, Gary L., et al., "Material Requirements for Optical Limiting," SPIE, v1692, 1992, pp.2-143.
3. Watkins, S.E., et al., "Mapping of Absorption in Optical Coatings," SPIE, v1624, 1992, pp.246-255

KEYWORDS: precision pointing, structural mode control, controller design, vibration suppression/compensation, high energy laser pointing, Adaptive Control, Flexible Structure Control

AF02-005 TITLE: Frequency-Agile Monolithic Micro-Laser with Ultra-Narrow Linewidth

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a compact, monolithic, ultra-narrow linewidth, frequency-agile, frequency-programmable, solid-state laser.

DESCRIPTION: Narrow linewidth, frequency-agile lasers have been of significant interest because of their wide applicability in different areas, including spectroscopy, frequency conversion, etc. It is a key supporting technology for a low cost laser tracking system to support ground, air or space based launch vehicle and satellite control operation. A variety of methods have been proposed and demonstrated for achieving tunable single-mode operation, including the use of non-planar ring oscillators, birefringent tuning filters, twisted-mode resonators, and microchip laser designs. Although all of these methods show promise in some areas, they all have some limitations in frequency tunability, scalability, ruggedness and/or ease-of-use. In particular, the tracking of fast moving objects require a wide tuning range and better single frequency control than can be achieved with existing single-frequency tunable lasers. Moreover, many on-board systems include the laser as a subsystem component and need an inexpensive micro-laser module in compact monolithic configuration. The goal of this program is to develop a monolithic micro-laser with a free-running frequency stability better than 1 kHz/s for both jitter and thermal drift, and a fast-controllable tunability in the range of 30 GHz/ms. A number of applications require an ultra-narrow linewidth with an adjustable frequency, fast frequency tuning of the laser system will be incorporated for locking onto an external reference.

PHASE I: Develop an innovative new concept for a compact, ultra-narrow linewidth, diffraction limited, rapidly tunable (greater than 30 GHz/ms over 30GHz), single-frequency laser with output power up to 1 W. The frequency output of the laser must be programmable. The development should place emphasis on frequency stability (< 1kHz/s jitter and drift), fast tunability, and monolithic configuration. At the end of Phase I, the feasibility of proposed design must be demonstrated, and a breadboard system must be built and tested for compliance with the requirements. The design must show clear superiority to state-of-the-art products currently available.

PHASE II: Fabricate the prototype laser unit designed in Phase I with the proven concept transitioned into a robust , compact, and monolithic package. Test the laser and compare the results to the performance objectives. Demonstrate fast and controllable frequency tuning, power stability, diffraction limited output, etc. Determine limiting parameters of its operation and characterize its performance sensitivity.

PHASE III DUAL USE APPLICATIONS: Numerous applications require or benefit from the use of scalable, frequency-stable, fast-tunable laser sources in a compact monolithic package. . Private sector applications include wavelength division multiplexing, spectroscopy, and high-density optical data storage. Military applications include remote sensing, range finding, target designation and illumination, satellite tracking, and satellite communication. The most expensive component of all these instruments is the laser. Currently available solid-state modules are difficult and expensive to maintain, mainly because of difficulties with keeping the alignment in the field. The laser module consists of many optical components each mounted separately in the resonator. Because of the complexity of its design, the laser cannot be re-aligned in the field and has to be sent back to the workshop or replaced. This is very costly and unrealistic. Development of the compact laser module with monolithic configuration will reduce costs and increase reliability. Such an approach leads to reduction of the number of components, mitigates laser complexity, and simplifies fabrication.

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2. A. Abramovici, "Minimal Nd:YAP laser configuration with single frequency output," Optics Communications, vol. 61, no. 6, p. 401 (1987).
3. V. Evtuhov and A.E. Siegman, "A Twisted-Model Technique for Obtaining Axially Uniform Energy Density in a Laser Cavity," Applied Optics, vol. 4, no. 1, p. 142 (1965).
4. J.J. Zayhowski and A. Mooradian, "Single-frequency microchip Nd lasers," Optics Letters, vol. 14, no. 1, p. 24 (1989).
5. W. Koechner, Solid-State Laser Engineering, Fourth Edition (New York: Springer-Verlag, 1996).

KEYWORDS: Monolithic laser cavity, Frequency-agile laser, Ultra-narrow linewidth, Wide tunable range, Fast-controllable tunability, Frequency stability.

AF02-006 TITLE: Solid State Low Energy Lasers for Space Based Lasers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop efficient space qualifiable solid state lasers for Space Based Laser systems at 2.7 microns.

DESCRIPTION: The Air Force Space Based Laser Directorate (SMC/TL) and the Research Laboratory's Directed Energy Directorate (AFRL/DE) are seeking new, innovative technology developments in solid state lasers in the average power range of 1-10 watts. These lasers can be continuous (preferred) or repetitively pulsed with a satisfactory pulse schedule. Technology must result in electrically efficient systems with excellent beam quality and with the potential for traceability to cost effective, compact, reliable, space qualifiable systems. The Space Based Laser used for the Integrated Flight Experiment (IFX) requires a Low Energy Laser (LEL) system to serve as a high fidelity surrogate for the High Energy Chemical Laser (HEL) during startup and optical alignment portions of test operations. As a surrogate, the beam characteristics and dimensions of a LEL developed laser device must be able to match those of the HEL beam. The LEL is intended to provide an end-to-end beam to align laser resonator optics, to align precisely the Laser Payload Element with Beam Control and Beam Director Elements, to allow testing and functional verification of beam diagnostics, and to allow low power testing and demonstrations of mission utility. The LEL operates at specified positions in the 2.6-2.9 microns wavelength regime or at the third harmonic of this regime. To date, no known laser systems approach 10 watt average power in either wavelength regime. In the infrared, one option may be scaling a diode pumped solid state laser such as a rare-earth ion-doped garnet or Nd:YAG, pumping a periodically poled lithium niobate crystal to operate as a optical parametric oscillator (OPO). An intracavity OPO scheme has reached 1 watt (Ref.1). At 0.9 microns, a Nd-based MOPA (master oscillator power amplifier) laser system might be considered (Ref.2). This laser device, at elevated peak and average powers, will enable diagnostics development for, as examples, chemical flows (Ref.3) and remote sensing applications.

PHASE I: Develop design of proposed solid state laser device, using appropriate design tools, past experience, and analyses to justify design. Propose approaches, possibly a demonstration or a brassboard to demonstrate the device feasibility and assess performance potential. Begin risk reduction tasks to support design.

PHASE II: Complete design and build prototype solid state laser. Demonstrate the laser and perform (contractor/Air Force mutually agreed) testing, with diagnostics, to assess laser power characteristics, beam characteristics, electrical efficiency, thermal management, and turn-on time behavior.

PHASE III DUAL USE APPLICATIONS: A successful laser is readily applicable to the Space Based Laser Beam Control Testbed and later Integrated Test Unit program. As a laser source at new wavelengths and power levels, the laser is readily integrated into applications for remote sensing, illumination and ranging, environmental pollution and contaminant monitoring, the development of combustion devices, such as jet, automotive, and rocket engines, non-equilibrium chemical and plasma flow research, and chemical lasers.

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2. Comaskey, B. et al. "A one kilowatt average power diode pumped Nd:YAG folded zigzag slab laser" Proceedings of the SPIE - Diode Pumping of Average-Power Solid State Lasers,1865, 9-16, 1993.
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KEYWORDS: Lasers, Solid state lasers, Optical parametric oscillators, Space Based Lasers, Directed energy weapons, Optics, Optical alignment techniques remote sensing, Lidar applications, Environmental monitoring, Chemical flow diagnostics

AF02-007 TITLE: High Energy Laser Diagnostics for Space Based Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop space qualifiable diagnostics for high-energy laser diagnostics

DESCRIPTION: The operation of a high energy laser in space as part of the Integrated Flight Experiment (IFX program) will require measurement of the various parameters characterizing the high energy, HF laser beam (2.6 to 3.1 microns) at various points. To make these measurements, a number of diagnostic instruments will be required. The present state of the art instruments for High Energy Laser (HEL) diagnostics are heavy, usually cooled, voluminous, manually aligned instruments with small dynamic range; in short, unsuitable as is for incorporation into an autonomous flight system design. The goal of this effort is to develop HEL beam diagnostics that are traceable to primary and secondary National standards. All diagnostics would be expected to be self aligning, capable of internal calibration, require no external cooling, and eventually space qualifiable. Diagnostics of this type, along with expected basic performance requirements, would include (but not limited to): spectrometers, with energy resolutions of at least 800, wavelength calibration of better than 1%; calorimeters, with uncertainty in total energy of less than 8%; power meters, with uncertainty in power of less than 8%; polarimeters, to determine the polarization state to less than 2% (equivalent error in Stokes parameters); wavefront sensors, capable of measurements of less than l/50; and tilt sensors, with resolution of sub-microradians. Also of interest are devices that can measure the properties of the HEL resonator optics, reflection, transmission, scatter, absorption, particulate contamination and ellpsometric properties in situ.

PHASE I: Design and prepare supporting traceability analyses for suitable diagnostic devices. The traceability analyses must be consistent with NIST (National Institute of Standards and Technology) and ISO (International Standard Organization) publications on the calculation of uncertainty.

PHASE II: Develop a prototype instrument or brassboard version of the device. Evaluate the prototype against the traceability analysis and compare to existing traceable instruments to verify its performance.

PHASE III DUAL USE APPLICATIONS: Diagnostics of this type will be insertable into all present and planned HEL programs, ABL (Air Borne Laser), THEL (Tactical High Energy Laser) and follow ons, SBL (Space Based Laser). Commercial uses include monitoring of industrial high energy (power) systems such as laser welders, drills and cutters.

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KEYWORDS: Spectrometers, high-speed laser power measurements, intensity profilers, polarimeters, calorimeters, wavefront sensors, centration sensors, tilt sensors, beam size determination.

AF02-008 TITLE: Active In-Situ Contamination Control

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop on-orbit cleaning technology for optical components used on satellites.

DESCRIPTION: The SBL Program Office and Air Force Research Laboratory (AFRL/DE) are interested in the development and eventual space qualification of technologies for cleaning optical components that are exposed to the high laser intensities within the Integrated Flight Experiment (IFX) and operational SBL systems. When a High-Energy Laser (HEL) beam is introduced into space-based beam control and beam director subsystems, as will be the case for SBL, the need for active contamination control is evident. Laser irradiated particles on component surfaces can be heated to high temperatures, causing local damage to high-reflectivity, anti-reflection and dichroic thin-film coatings.

Damage sites may later propagate across these surface coatings under subsequent HEL loading. Black body emission from the laser-irradiated incandescent particles may also optically saturate pixels within IR and visible cameras that are required to acquire and track targets. In addition to periodic on-orbit cleaning, an initial cleaning of critical optical surfaces may be required as a result of the release of large numbers of particles within the payload, following satellite launch. Unfortunately, no technique for removing particles from critical optical components has been validated on orbit. Prior work on ground systems indicates that two-phase CO2 jet-spray techniques outperform most conventional cleaning systems, removing sub-micron and micron-size particles from fragile surfaces, including many hydrocarbon films. The objective of the present SBIR task consists of two parts: 1) design, integration and qualification of cleaning system hardware that could be flown in a space demonstration that would support the IFX and operational SBL systems and 2) a laboratory demonstration of cleaning of actual SBL coatings (components to be provided by the Air Force) including measurement of contamination levels (pre- and post-cleaning) on the SBL-specific geometry coated components

PHASE I: Develop/design/construct a functional breadboard cleaning system. Prepare sample candidate SBL coatings, demonstrate cleaning of the coated (contaminated) surfaces, and determine resulting surface scatter by means of Bidirectional-Reflectance Distribution-Function (BRDF) measurements for the contaminated and actively cleaned surfaces. Quantify the possible build-up of electrostatic charge and subsequent development of discharge currents, and verify cleaning without microscopic damage to any of the multi-layer dielectric coatings tested. Products required at the end of Phase I (in addition to Final Report) is Phase II outline.

PHASE II: Finalize design, build, and test the cleaning system (selected as a result of Phase I activity) in a configuration suitable for space qualification. Verify cleaning of contaminated coated components, without surface damage or electrostatic breakdown. Utilize cleaning system to assist with space qualification of the active-cleaning ground hardware and software. Demonstrate component cleaning, without coating damage, and quantify the extent to which particles and surface contaminants are removed.

PHASE III DUAL USE APPLICATIONS: Assuming space qualification, the cleaning system would have wide application for future commercial/DoD satellites requiring on-orbit cleaning.

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2. J. L. Clark, M. Culpepper and P. T. Chen, "New Contamination Engineering Technology for Active On-Orbit Surface Cleaning," SPIE Conference, Session 2, Paper No. 4096-11, 2-3 August, 2000, San Diego, CA
3. W. Brandt, W. Cron-Schmidt and R. V. Peterson, "The Pathfinder Experiment on Particles After Jet Spray," SPIE Paper, Vol. 1754, p 306-315, 23-24 July 1992
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KEYWORDS: Active surface cleaning, Momentum impact cleaning, Two-phase jet flows, Scatterometer measurement of particulate contamination, Removal of hydrocarbon thin films, Dielectric coating damage, Electro-static charging and breakdown, Particle contamination generator, Shuttle Space Test Program (STF)

AF02-009 TITLE: High Temporal and Spatial Resolution Laser Beam Diagnostic Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Remote sensor development for measurement of high energy laser beam profile at a target.

DESCRIPTION: High power lasers are currently in development that are designed to engage ballistic missiles during their active boost phase. These weapon systems are designed to engage the pressurized propellant tank or motorcase of the missile, causing it to fail in a catastrophic manner. During the test phase of the Airborne Laser system, the aircraft will be propagating a High Energy Laser (HEL) through the atmosphere onto dozens of target missiles; however, only a limited number of engagements versus operationally realistic targets will occur. In order to extrapolate the results of these tests to the full spectrum of targets, a detailed understanding of the beam characteristics at the target is required. Instrumentation capable of capturing the parameters required is not currently available. The required characteristics include: 1) the HEL spot location of the target, 2) the dwell time of the HEL beam on target, and 3) the temporal and spatial characteristics of the laser beam profile at the target. The development of a calibrated sensor which can measure the beam profile at the target plane with a sampling rate of ~10-30 Hz and spatial resolution of ~1cm-4cm would significantly enhance the planned tests. Due to the anticipated safety keep out zones for the laser operation and the missile flyout, the sensor might need to be capable of being mounted on an aircraft or UAV that is many kilometers from the target

PHASE I: Initial research should determine the required performance of the instrumentation, identify potential solutions, and propose an optimal solution. The emphasis should be on off-board approaches that minimize the changes to target systems and comply with range safety considerations. The effort at a minimum shall address the target and engagement geometry; laser spot characteristics; sensor spatial, radiometric, and temporal resolution vs. laser spot characteristics; and calibration through the atmosphere. Hardware and software requirements should be determined.

PHASE II: Design, develop, calibrate, and demonstrate prototype sensor system. In addition, the system performance should be validated through realistic testing and demonstration.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed sensor technologies is future technology insertion into the Space-Based Laser (SBL) and Ground Based Laser tech (GBL Tech) programs. The potential commercial market includes industrial laser welding and cutting as well as long range thermal imaging.

REFERENCES:
1. J. Beraun, et al., " Airborne Laser Lethality Test Series, Volume I of II Subscale and Half Scale Targets," PL-TR-96-1051, Vol. I, Phillips Laboratory, KAFB, NM, June 1996. (Unclassified).

KEYWORDS: Laser Sensor, Directed Energy Weapons, Lasers, Ballistic Missile Lethality, Laser Reflectance, Laser Beam Diagnostics, and Infrared Radiometry

AF02-010 TITLE: High Temperature Target Failure Sensor

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Development of an onboard target failure sensor for High Energy Laser engagement with ballistic missile.

DESCRIPTION: Target vehicle response to laser weapon interaction is a critical parameter that needs to be well characterized. In a ballistic missile target that is being irradiated by a high energy laser (HEL), several parameters are of considerable interest. First, the temperature distribution on the wall is needed to determine the local strength distribution of the heated metal. Secondly, the fracture pattern is of interest to both verify catastrophic failure and validate modeling predictions1. While cost-effective failure indication sensors have been developed for hit-to-kill systems2, no such sensor exists for laser weapons. To this end a cost-effective solution to the development of a sensor array to measure the thermal distribution as well as fracture pattern on the tank wall. The sensor should be able to handle temperature >1000C. If externally mounted the sensor needs to have minimal interference with the incident laser beam and if internally mounted the sensor should be compatible with the fuel or oxidizer environment. A response time of the order of 100-200 msec is acceptable for the thermal portion of the sensor; however, the fracture pattern component data rates of up to 10 kHz will be required due to the rapid nature of the crack propagation1. Desired spatial resolution is in the range of 1 to 5 cm.

PHASE I: Efforts should focus in the area of research consisting of innovative concepts and establish measures of merit for selecting the best value concept. In addition, hardware and software requirements should be determined. Key features that need to be addressed are the harsh environment (thermal, mechanical, and possibly chemical) the sensor will be exposed to.

PHASE II: Design, develop and demonstrate prototype sensor system(s). In addition, the system performance should be validated through realistic testing and demonstration

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed sensor technologies is future technology insertion into the SBL and GBL tech programs. The commercial market includes the industries involving high temperature environments, such as space reentry vehicles and high power engines in addition to reactor vessels in chemical processing.

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1. Beraun, et al., " Airborne Laser Lethality Test Series, Volume I of II Subscale and Half Scale Targets," PL-TR-96-1051, Vol. I, Phillips Laboratory, KAFB, NM, June 1996. (Unclassified)
2. "Navy Proves Kinetic Warhead Capability for Theater Defense," Missile Defense, 9 Aug 1999.

KEYWORDS: High Temperature Sensor, Directed Energy Weapons, Lasers, Fracture Mechanics, Ballistic Missile Lethality, Thermal Profiling

AF02-011 TITLE: New Thermal Sensors for Use with Inverse Heat Conduction Problems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop thermal sensor that can measure directly the rate of change of temperature with time and/or the rate of change of heat flux with time.

DESCRIPTION: The Air Force Research Laboratory Directed Energy Directorate is interested in investigating advanced concepts to develop novel sensors that can directly measure the rate of change of temperature with time and/or the rate of change of heat flux with time. This rate of change measurement is particularly important for determining thermal response and properties at the inaccessible or hostile locations such as the surface of a structure exposed to a directed energy beam, a wall exposed to fire or explosion, the outer surface of a reentry vehicle, or the surface of a combustion chamber.Because inverse problems of heat conduction are ill-posed, their solutions do not satisfy the general requirements of existence, uniqueness and stability under small changes to the input data. Thus the solutions obtained for inverse heat conduction problems can be extremely sensitive to the type of data acquired and to noise and lack of resolution in those data1. Typically, in addressing such problems, temperature or heat flux2 are measured at other locations in the body of interest and various analytical techniques are used to attempt to infer the information desired. It has been suggested recently that temperature is not the best type of data to use for solving many inverse heat conduction problems. Therefore, novel concepts and techniques are needed to address the inverse heat conduction problems.

PHASE I: Investigate and demonstrate the concepts and techniques for resolving the ill-posed heat conduction problems and designing thermal sensors for such purposes. The sensor(s) should be compatible with both metal (steel and aluminum) and composite structures, be able to handle temperature approaching melt of the structure, and heating rates from 50 to 1000 W/cm2.

PHASE II: Develop, fabricate and demonstrate prototype thermal sensors. The proposed demonstrations should verify the performance of these sensors on a class of inverse heat conduction problems for both metal and composite structures.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed technologies for inverse heat conduction problems and thermal sensors is future technology insertion into the SBL and GBL tech programs. The commercial market includes the industries involving high temperature environments, such as space reentry vehicles and high power engines. In addition, any application where the heated surface can not be directly measured yet conditions of that surface need to be determined would benefit from such a device.

REFERENCES:

1.R. Keltner, B. L. Bainbridge, and J. V. Beck, "Transient Temperature Measurement Errors," ASME paper 83-HT-86, 1983.
2. J. M. Hager, L. W. Langley, S. Onishi, and T. Diller, "Microsensors for High Heat Flux Measurements," J. Thermophysics and Heat Transfer, Vol. 7, No. 3, p.531, 1993.
3. J. I. Frankel, "Inverse Heat Conduction and Data Type Issues for Advanced Diagnostic Analysis," J. of Shanghai Jiaotong University, Vol. E5, No. 1, p. 321, 2000.

KEYWORDS: Thermal sensors, Inverse heat conduction problems, Thermophysical property, Directed energy beam, Heat flux, Transient thermal response

AF02-012 TITLE: Active Target Tracking through Deep Atmospheric Turbulence

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Conceptualize, simulate and demonstrate an active tracking system capable of improving active tracking performance in deep turbulence at high bandwidth.

DESCRIPTION: The Air Force is interested in active tracking in deep atmospheric turbulence - Rytov parameters greater than 0.75. Such turbulence causes a track image to be highly scintillated and distorted, when viewed at the tracker focal plane. Typically, isoplanatic angles are smaller than the diffraction-limited angle and the track requirements are less than the isoplanatic angle. Conventional and time-tested tracking paradigms do not provide maximum tracking accuracy for these cases. We seek an investigation of algorithms, together with a hardware implementation, that makes optimal use of a-priori information, such as knowledge of target shape, noise statistics, and information from other sensors, such as higher order aberrations, etc. We believe that improved tracking accuracy may require use of information that is not found in the last frame of tracker data - information such as past data, knowledge of atmospheric and scintillation statistics, and information from other sensors. Our thoughts for other sensors specifically include wavefront sensor information. However we do not rule out other approaches which may add sensors, such as a pupil plane imager, or which combine the adaptive optics and the track problem. In addition, we have recently been impressed by imagery from the medical imaging community in which difficult target information has been extracted in very tough environments.

PHASE I: Develop and investigate active track algorithms that promise improvement in tracking capabilities over the usual algorithms such as centroid, correlation, etc. Simulation and analysis will be performed to determine viable candidates for implementation. Select one or more candidates for implementation in Phase II.

PHASE II: Perform final high-resolution simulation of tracker algorithms developed in Phase I and down select to an algorithm(s) that promises considerable tracking enhancement in the deep turbulence regime. Develop and test a prototype tracker implementing such algorithms.

PHASE III DUAL USE APPLICATIONS: A tracker which is capable of performing accurate track in deep turbulence will have wide application in the DOD community, where long-range tracking through extended atmospheric paths is required. A primary application is for the Airborne Laser System. However, the technology will benefit any laser projection or imaging system that has stringent track requirements and must also operate in deep turbulence. Such systems include THELF, ATF, and SBL when operating in a look down mode. Other applications areas include airborne imaging and shipboard tracking of long-range targets through extended atmospheres. Strictly commercial applications include tracking for imaging systems for TV news helicopters and helicopter imaging systems for power-line-insulator damage detection.

REFERENCES:
1.Andrews, L. C. and Phillips, R. L., Laser Beam Propagation through Random Media, SPIE Optical Engineering Press, Bellingham, 1998.
2.Brown, W.P., "Simulation of Laser Propagation on Long Stratospheric Paths", Proceedings of SPIE, Aerosense, 3065, Orlando, FL, 23-25 April, 1997.
3.Merritt, P., Cusumano, S., Kramer, M., O'Keefe, S., & Higgs, C., "Active Tracking of a Ballistic Missile in Boost Phase", Proceedings of SPIE, Acquisition, Tracking and Pointing, 2739, 1996.
4.Roggemann, M. C., and Welsh, B, Imaging through Turbulence, CRC Press, New York, 1996.5.Steiner, T., Butts, R., "Airborne Laser Advance Technology Testbed (ABLE ACT)", Proceedings of SPIE, Aerosense, Airborne Laser Advanced Technology, Orlando Fl, 13-17 April, 1998.

KEYWORDS: Tracking, High Scintillation, Sensor Fusion, Track Algorithms, Lasers, Atmospheric Compensation, Adaptive Optics

AF02-013 TITLE: Develop Coatings that Repel Contamination

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop coatings for high-energy laser mirrors and windows that repel contamination while not affecting the transmission of the high-energy laser beam.

DESCRIPTION: Research and develop a coating process that can maintain strict cleanliness requirements for use with high power lasers and optical systems. The applied coating should repel contaminants such as water and various kinds of particulate matter. The coating must be Very Low Absorbtion (VLA) with regard to laser beams in visible and near infrared regions of the spectrum. The coating must be very thin to prevent aberrations in the beam path. The film or coating must be reliable and durable enough to withstand the high-energy laser energy that will pass across the coating/film. Processes and equipment to inspect and maintain optical elements must support, and in fact provide for cleanliness factors. This includes changes in temperature, humidity, and pressure experienced by the system.

PHASE I: Define the proposed coating concept, specify system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype coating process for high-energy laser mirrors and windows that repels contamination with a laboratory demonstration that meets mutually agreed upon performance parameters. Demonstration processes and coating must be capable of supporting ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be a deliverable coating process and a clear demonstration of the integrated high-performance system with an expected lifetime no shorter than the optical surface to which the coating is applied.

PHASE III DUAL USE APPLICATIONS: The technology could be used in Airborne Laser (ABL), Ground Based Laser (GBL), Space Based Laser (SBL), Space Based Infrared System (SBIRS), and NASA SOPHIA programs. Examples of commercial applications include optical systems (telescopes, for instance) or window coatings for commercial (and other) buildings.

REFERENCES:
1. Kevin F. Fitzgerald, et al., "Mass Modeling for Electrically Powered Space-Based Yb:YAG Lasers," Gas, Chemical and Electrical Lasers and Intense Beam Control and Applications, Santanu Basu, Steven J. Davis, Earnest A. Dorko, (eds.), Proceedings of SPIE Vol 3931 (2000).
2. W. S. Watt, "Solid-State Laser Technology: Status Report Dr. Dwight Dustin, BMDO," July 29, 1997.

KEYWORDS: Ultraviolet irradiation , hydrophobic surface, oleophilic coating, optical systems, optical coatings, optical materials, optics maintenance, high energy lasers, contamination control.

AF02-015 TITLE: All-Optical High-Energy-Laser Beam Control

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/demonstrate passive phase-conjugation for end-to-end correction of HEL phase aberrations/jitter.

DESCRIPTION: The recently completed AF/BMDO HEL Affordability and Architecture Study mandated by USD (A&T) concluded that high-bandwidth, high-control- authority HEL beam-control systems provide an important means for reducing the cost of future space-based HEL systems for use in national and theater missile defense. The Study found that a 10-fold improvement in beam-control performance would enable short-wavelength HELs and large-aperture SBLs, potentially reducing the cost of SBL systems from over $100B to under $70B. Similar cost savings may be possible for other HEL systems, such as Airborne Laser and Ground-Based Laser systems. Both the SBL Program Office (SMC/TL) and Air Force Research Laboratory (AFRL/DE) are interested in development of passive nonlinear phase conjugation (NPC) technologies or alternate technologies for end-to-end clean up of optical beams produced by high-power multi-line chemical and solid-state lasers. For example, NPC technologies possess far greater bandwidth and control authority than adaptive optics technologies that are used in current HEL beam control systems. Novel and innovative NPC concepts that are based on four-wave mixing and/or stimulated scattering (SBS or STS) are of special interest. In general, these methods will use a double-pass oscillator-amplifier geometry in which a master oscillator (or illuminator target return) injects a backward-directed reference wave of high optical quality into the beam director, beam control, preamplifier, and amplifier laser elements. The reference wave is modulated by all of the optical-train and laser-induced wave-front errors and jitter sources. The backward wave is "phase conjugated" at the focus of a nonlinear medium by formation of an optical grating, where the beam is reflected and its wave front is reversed. The reflected beam, in turn, retraces precisely the incident path, systematically unraveling the wave-front errors and jitter that were imposed on the beam during the backward pass. Technical challenges for tailoring the NPC or alternte process to multi-line chemical laser systems include master oscillator isolation, high conjugation fidelity/reflectivity, out-coupling the forward-directed high-power amplifier beam, and pointing the HEL beam at a thrusting target with proper lead ahead. In principle, the NPC process can perform wave-front error/jitter corrections with temporal and spatial frequencies that represent orders of magnitude improvement over conventional adaptive-optical (AO) systems. In addition, weight and cost savings associated with the relaxation of requirements for vibration isolation, active optical- figure control, and control of laser-medium inhomogeneities should be significant. In addition to the requirement for simplicity and high performance relative to conventional AO techniques, the proposed concept must be lightweight, efficient, compact and space qualifiable. For the NPC example, prior work has emphasized beam clean up of solid-state pulsed laser sources (Ref. 1). A program to demonstrate beam clean up of a continuous-wave chemical laser beam is in progress at TRW using an SBS process (Ref. 2). A Russian group has recently demonstrated a single-line approach for end-to-end clean up of a laser system consisting of a laser payload element and beam director element (Ref. 3).

PHASE I: Develop a detailed design of the NPC demonstration or alternate concept that will be performed during the Phase II effort. Include model descriptions, simulation results, supporting data (when available), and other technical analyses that justify the hardware design and its ability to control chemical-laser wave-front error and beam jitter. Where necessary, risk reduction activities should be conducted to support critical aspects of the proposed design. Products that are required at the conclusion of Phase I should be a critical design review, Phase II proposal, and final Phase I report. This effort will require innovative R&D not just design work.

PHASE II: Fabricate, integrate and assemble the NPC or alternate approach test bed and diagnostic apparatus. The use of long-pulse chemical-laser amplifiers, preamplifiers, and master oscillator to simulate a high-power continuous-wave chemical laser is acceptable for the Phase II demonstration. Characterize the ability of the NPC or alternate concept to correct phase errors and jitter at the spatial and temporal frequencies associated with high-power chemical laser systems. Conjugation thresholds, reflectivity, and conjugation fidelity of the clean-up process should be measured, experimental data should be compared with theory, and any performance limitations associated with the clean-up process should be established. A method for including the beam director in the conjugation process should be demonstrated that includes acquiring and tracking a thrusting target at long range, accounting for the effects of target lead ahead.

PHASE III DUAL USE APPLICATIONS: The NPC concept or alternate process demonstrated herein would readily support applications that do not involve high-power lasers. These applications include imaging through aberrated media (for example, the atmosphere), precision auto-tracking of satellites and other targets, and imaging through opaque media (clouds, water). Other important applications include high-bandwidth laser communications with satellites, high-resolution imaging through large optical telescopes, and acquisition and tracking in general of targets with lead ahead (for example, by means of adjusting the angle of the four-wave mixing "pump wave").

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2. J. Betts, et al., Long Pulse Stimulated Brillouin Scattering in High Pressure Xeno, CLEO '91, Baltimore, MD, May 1991.
3. L. S. Vasilenko, et al., Pis'ma Zh. Eksp. Teor. Fiz. Vol. 12, 1997.

KEYWORDS: Passive phase conjugation, Nonlinear optics, Laser beam clean up, Four wave mixing, Stimulated Brillouin scattering, Phase compensation, Jitter compensation, Image compensation, Lead ahead compensation, Remote imaging

AF02-017 TITLE: Coatings for Large, Lightweight, Compliant, and Scalable Deployable Space Optics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a method to use stress coatings to shape compliant optics into a parabolic net-shape, with the ability to measure various characteristics of the coating.

DESCRIPTION: AFRL is interested in technologies that will lead to large space-based optical telescopes. There has always been a need for coating optical surfaces to protect the surface or what resides behind the surface. In the past, dielectric coatings were applied to thin glass surfaces to improve the reflectivity. Unfortunately, in many cases the glass or coating would deform, crack, or delaminate after many layers of coatings were applied. Yet, the coating was still not thick enough. The source of the glass breaking is due to stresses (compressive or tensile) created during the coating process. Many years were spent trying to eliminate or reduce the stress induced by these coatings. However, the Membrane Mirror Team has discovered these coatings could be used for shaping flexible, compliant materials into a net-shape, specifically concave.· The shaping of flexible, compliant materials or membranes could revolutionize the future of space optics. Through the use of shaping membranes with a stress coating, a much larger satellite, with the capability to be “folded and deployed”, can be designed for many space applications. The end purpose would be to create larger telescopes in the 30-50 m class. · The requirement calls for developing a stress coating method to shape an optical quality compliant material, currently available on the commercial market. A parabolic net-shape is desired since the main purpose is for space telescope applications. Currently, a stress coating is applied to the surface to maintain the shape of the cast membrane. · Since membrane manufacturing is relatively undeveloped, the surface quality contains hills and valleys, which reduces the optical characteristics and abilities of the membrane. A possible method to correct for these aberrations is to apply a coating to essentially fill in the valleys, so the whole surface has little local tilt error. The method described would greatly increase an already high-quality membrane in production today.· For both methods, material and mechanical properties of the coating or other process would need to be researched, including, but not limited to, uniformity, thermal management of the application and laser effect to surface.· Without a uniform coating, the stress induced could cause warping in the surface; therefore, producing membranes with an unacceptable shape and low optical quality. Different material types should be researched to resolve which one will have the best across-the-board characteristics. A few materials should be used during the testing process to prove through experiments, which will actually meet the requirements.· In reference to other optical characteristics, different properties deemed important should be researched and if necessary, tested. Some of these include, but not limited to, the lifetime of the coating in different environments, the resistance to cracking or peeling during different conditions and its reaction with the membrane material. The percent stress induced by the coating is highly critical, because the coating stress has to balance with the membrane to hold its parabolic shape. The membrane and coating combination must be able to be folded and "spring" back to its original shape without appreciable memory shape loss.This SBIR is searching for fundamental technologies that will supply structural support to a compliant material by an optical coating.

PHASE I: The contractor shall model their selected approach to show the shape control of the coating. This modeling should include the details of the mechanics and at some level the expected non-uniformities caused by the coating and its processing. Coupon or small scale material testing will be used to establish or validate the appropriateness of the model. Scalability and applicability of the concept to the space environment must be addressed.

PHASE II: The contractor shall use the results of Phase I to build, test, and refine a 1-meter test article.

PHASE III DUAL USE APPLICATIONS: These coatings have many general uses, including, but not limited to the following: Creating lightweight communication satellites and inexpensive methods to shape compliant structures for optical systems.

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2. M. T. Gruneisen, D. V. Wick, T. Martinez, and J. M. Wilkes, "Correction of large dynamic aberrations by real-time holography using electro-optical devices and nonlinear optical media," in Artificial Turbulence for Imaging and Wave Propagation, J. D. Gonglewski and M. A. Vorontsov, eds., Proceedings of SPIE 3432, pp. 137-150, 1998.
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KEYWORDS: Membrane Optics, Optical Quality Reflectors, Space Capable, Thin Films, Reflectors, Large Aperture, Solar Collectors, Thin Film Structures, Compliant Structures.

AF02-018 TITLE: Application of Quantum Cascade Lasers to High Explosive Detection

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Fabricate a frequency agile or broad frequency laser source array detection device in order to detect effluents emitted from high explosive (HE) compounds commonly used by terrorists.

DESCRIPTION: The growing threat of terrorist attack in both military and civil environments and the ready availability of compounds to produce high explosive devices indicate a need for suitable high explosive detection devices. Preliminary inquiries to DOE, Army, FAA, and industry have highlighted a gap in our knowledge of what kinds of compounds are emitted by the candidate high explosives. The U.S. Air Force, U.S. Navy, Defense Threat Reduction Agency (DTRA) and Federal Aviation Administration (FAA) have placed high priority on the ability to sense high explosive compound effluents from standoff distances to determine safety for our personnel against terrorist strikes. The required detection capability would come in the form of a fixed site, ground based unit capable of monitoring areas surrounding deployed forces as well as docked naval assets. Remote sensing technologies suitable for counter-drug, counter-terrorism or counter-proliferation applications could provide early warning of a threat in ample time to evacuate a facility, relocate an asset, or disable the device prior to its implementation. Detection ranges from 30m up to 1km are required to satisfy user requirements. Desired technologies include (1.) Amplification of laser power in order to detect effluents from high explosive compounds. Possible methodologies are packaging of Quantum Cascade (QC) lasers into arrays or fiber coupling medium and short wave laser sources. Techniques for amplifying laser output to higher powers while maintaining good beam quality and wavelength stability are also of interest.

Emphasis will be placed on system size and weight, cost, reliability, and maintainability. (2.) Ability to achieve advanced wavelength stabilization for improved detection as well as significantly higher unit output power without monumental impact to system size.

PHASE I: Define the proposed concept and develop key component technological milestones and preliminary design of system or components that address one or more of the above desired capabilities. The system approach is desired in order to ensure that the components developed have utility in meeting the requirements defined above and can be suitably field-tested with existing government furnished equipment or hardware (GFE) in Phase II.

PHASE II: Complete component design, fabrication and laboratory characterization experiments. Define field test objectives and conduct limited testing with available GFE, if needed.

PHASE III DUAL USE APPLICATIONS: With the added ability to detect high explosive compound effluents, this lidar system could be used by both military and private sectors for troop insertion area monitoring as well as counter-terrorism purposes, without modification.

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2. Gittins, C.M., E.T. Wetjen, M.G. Allen, and W.J. Marinelli, "A Low Peak Power Differential Absorption Light Detection and Ranging (LIDAR) System for Remote Characterization of Chemical Vapor Plumes" (SBIR Phase I report available in DTIC)

KEYWORDS: high explosives, high explosive detection, chemical sensing, stand-off detection, fiber coupling, differential absorption lidar (DIAL)

AF02-019 TITLE: Real Time Adaptive Signal Processors for On-line Performance Optimization of Adaptive Optical Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Demonstrate real time adaptive signal processor that can implement an adaptive reconstructor for an adaptive optical system.

DESCRIPTION: The Air Force is interested in the propagation of laser beams from airborne platforms over long atmospheric paths. We are specifically interested in the Airborne Laser (ABL) system, but note that innovation for this system will also apply to GBL, relay mirror, airborne imaging, low elevation SBL and remote sensing. These systems require operation in engagement geometries with high relative wind velocities (due to relative motion of the aircraft and target, or due to satellite slew) and other forms of anisoplanatism. In environments such as these, the servo lag and data latency become critical design drivers, often severely limiting the performance of the system. Adaptive / predictive estimation schemes that compensate for data latency have shown potential to provide significant performance improvements in such conditions (Ref 1, 2). The difficulty with adaptive estimation schemes is the complexity of the processing, typically requiring on-line modification of the matrices used to compute deformable mirror commands from multiple sensor measurements. The goal of this effort is to produce a scalable software and hardware architecture for implementation of adaptive signal processors for on-line optimization of adaptive optical systems. While simulations of adaptive optical systems using an adaptive filter have used the lattice filter described in Reference 3, it may be that other forms of RLS filtering - fast QR methods or Givens rotations - may prove more amenable to hardware implementation. The hardware and software architecture should be flexible enough for other applications requiring high-speed, high-dimensional adaptive filtering.

PHASE I: Create a software architecture and hardware design to implement a fast (> 1 kHz.), high-dimensional (200 by 200) adaptive filter to perform tasks such as described in References 1 and 2. Since these criteria are difficult to meet, the contractor is expected to provide an innovative solution that matches the chosen filter architecture to advance hardware concepts. The contractor will also provide a plan for a feasibility demonstration of the approach and outline a sound set of demonstration success criteria. A design review will cover the hardware and software architecture and planned evaluation of the feasibility demonstration.

PHASE II: Fabricate and demonstrate the adaptive processing architecture developed in Phase I and show that it leads to improved Strehl in imaging or laser projection systems. The offeror may test the concept at his/her facility, or, at the offeror's request, the AFRL may arrange to conduct the test at the ABL Advanced Concepts Laboratory operated by

MIT Lincoln Laboratory or at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed located at the White Sands Missile Range North Oscura Peak Facility. These facilities will be provided to the contractor at no cost to the contractor or the SBIR Program. It is expected that this phase will provide a new wavefront reconstruction capability that is sufficiently validated to readily facilitate transition to systems such as the Airborne Laser.

PHASE III DUAL USE APPLICATIONS: It is expected that an adaptive optics subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise atmospheric compensation through turbulent media. These applications include ABL, Relay Mirror, remote sensing, and atmospheric imaging programs. The commercial market includes such areas as astronomy, communication, power beaming, and surveying. Clearly a hardware architecture that optimally implements a high-bandwidth, high-dimensional lattice filter would have numerous applications outside of the adaptive optics community. These applications include: Image tracking and prediction; active vibration and noise control; adaptive channel identification, deconvolution, and equalization in various radar systems. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

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1. B. L. Ellerbroek and T. A. Rhoadarmer, "Real-time adaptive optimization of wavefront reconstruction algorithms for closed-loop adaptive optical system," SPIE Proc. Vol. 3353-78, Adaptive Optical Systems Technologies, Kona, Hawaii, March 1998.
2. J. S. Gibson, C.-C.-Chang, and B. L. Ellerbroek, "Adaptive optics: correction by use of adaptive filtering and control," Applied Optics, Optical Technology and Biomedical Optics, No. 16, p. 2525.
3. S.-B. Jiang and J. S. Gibson, "An Unwindowed Multichannel Lattice Filter with Orthogonal Channels," IEEE Transactions on Signal Processing, vol. 43, no. 12, pp. 2831—2842, December 1995.
4. J. S. Gibson and C.-C. Chang, "Parallel Control Loops Based on Spatial Subband Processing for Adaptive Optics," 2000 American Control Conference, Chicago, IL, June 2000.

KEYWORDS: adaptive optics, wavefront reconstruction, adaptive control, beam control

AF02-020 TITLE: Tracking Through Laser-Induced Clutter for Air to Ground Directed Energy Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop HEL tracking algorithms to deal with background clutter. The effort should include target and aimpoint identification, and tracking.

DESCRIPTION: Future combat airborne directed energy programs have a need to actively track slow moving ground targets in a changing scene environment. Target recognition algorithms have shown promise in some conditions at picking out objects during acquisition, but scene variations due to laser effects make the problem significantly more difficult. Laser induced scene problems such as operating under different weather conditions, smoke conditions, under camouflage conditions, during thermal blooming or with background reflections can make acquisition and aimpoint selection difficult over the duration of the engagement. Other fire-control issues such as anisoplanatism of the track point to the aimpoint also reduce the overall effectiveness of these systems. This effort looks at proposing new innovative methods to address these problems and ultimately build a set of tools to solve the downlooking ground target acquisition, engagement tracking, and aimpoint problem as it relates to background clutter.

PHASE I: Identify new and innovative techniques and methods for addressing the overall problem of acquisition, tracking, and pointing a combat laser beam in an air-to-ground scenario under different ground clutter conditions. This will include during different weather conditions (clouds, fog, etc.), smoke conditions, camouflage conditions, vegetative covers, etc. The effects of anisoplanatism and thermal blooming must also be addressed. Initial screening of existing algorithms is desired. After identifying the new concepts, the effort should create a validation plan that leads from computer simulations , to laboratory experiments, to field validations. AFRL will potential scenarios that require engaging targets against background clutter prior to Phase I kickoff for the contractor to use. For each scenario, a preliminary evaluation will be performed to determine if passive or active sensing for tracking best meets the requirements for that mission. Innovative methods using radar, pulsed vs. continuous wave lasers, selection of frequencies, etc. should be considered for the different parts of the problem. Algorithms and tests using a sensor developed in the DARPA Three Dimensional Imaging Sensors program or similar sensor developed by MIT/LL could be a valuable enhancement to the effort, but is not required.

PHASE II: During Phase II continue development of the algorithms such that implementation issues and any minor technical issues are addressed. Testing of the algorithms in a realistic, non simulation environment, such as the AFRL-funded Advanced Compensation Lab or other facility will also be performed. Tests will be conducted according to the plan developed in Phase I. Preliminary demonstration of algorithms at the AFRL North Oscuro Peak (NOP) facility or other non-brassboard site will also be conducted. If needed, use of the NOP test facility will be provided at no cost to the contract or to the SBIR Program.

PHASE III DUAL USE APPLICATIONS: Tracking or observing objects through smoke and fire conditions has been always been a problem for firefighters as well as vehicles attempting to navigate through fog. Infrared scanners are often deployed on large forest fires, but only provide pertinent information on the actual fire line underneath the smoke. The acquisition portion of this project could lead to a considerable increase in information from the overflights-such as location of equipment and personnel. Infrared-based look ahead systems are already available on some cars but imaging through clutter is still a problem that could be expanded under this effort.

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KEYWORDS: Tracking, High Scintillation, Clutter, Track Algorithms, Lasers

AF02-021 TITLE: Periodically Poled Stoichiometric Lithium Tantalate for Nonlinear Optical Frequency Conversion

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a process to produce large-size optical-quality stoichiometric lithium tantalate crystals for nonlinear frequency conversion.

DESCRIPTION: Frequency-agile laser sources have important military applications, including infrared counter-measures, remote sensing of environmental chemicals, lidar, and guide-star generation for adaptive optics. While recently developed periodically poled ferroelectric crystals such as periodically poled lithium niobate (PPLN) and periodically poled KTP isomorphs (PPKTP) have greatly enhanced the possibilities for nonlinear frequency conversion, these materials are not well-suited for some applications. Recently a process was developed by which large-size (45 mm diameter, 50-85 mm length) nearly stoichiometric single-crystal boules of lithium tantalate could be grown. This growth was accomplished using a double-crucible Czochralski method which did not cause damage to the crucibles when the melt solidified. Periodically poled stoichiometric lithium tantalate (PPSLT) has optical and poling properties far superior to the usual congruently grown material. This PPSLT was used to make an optical parametric oscillator. PPSLT (unlike PPLN) is transparent to the third harmonic of the Nd:YAG laser. It may be possible to pole stoichiometric lithium tantalate samples as thick as 5 mm (1 mm is the maximum commercially available thickness for PPLN). Because dn/dT in PPCLT is less than 5% of the value in PPLN, thermal lensing and disruption of phase matching in PPCLT at high average power should be much less severe than in PPLN. This SBIR topic is aimed at fostering the development of a commercial source of PPSLT.

PHASE I: Design, build, and test apparatus for growth of large-size, high-purity, nearly stoichiometric lithium tantalate. Perform preliminary evaluation of crystals (size, purity, absorption spectra, resistance to photorefractive damage, economics of large-scale production).

PHASE II: Carry out periodic poling of stoichiometric lithium tantalate with various grating periods and wafer thicknesses. Make accurate measurements of the extraordinary refractive index, which may differ significantly from that of congruent lithium tantalate. Make improvements to the crystal growth process to optimize crystal properties for applications from the infrared to ultraviolet. Make PPSLT crystals suitable for Air Force frequency-conversion applications.

PHASE III DUAL USE APPLICATIONS: Because of its ultraviolet transparency, PPSLT has potential applications to photolithography and laser medicine. It may be possible to use dual-grating PPSLT together with resonant enhancement to efficiently generate the important third harmonic of the CW Nd:YAG laser. Optical parametric oscillation using PPSLT could be used to produce multiple wavelengths in the infrared or visible for military applications and for color projection. Infrared parametric oscillation, pumped by Nd:YAG lasers or Yb fiber lasers, could be used to generate tunable eye-safe wavelengths for remote sensing and lidar. PPSLT offers the potential for good performance at high average power for frequency conversion of both CW and pulsed sources if long, large-aperture, high-quality crystals can be produced economically.

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KEYWORDS: stoichiometric lithium tantalate, stoichiometric LiTaO3

AF02-022 TITLE: Artificial Dielectrics for High Power Microwave Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop lightweight artificial dielectrics for High Power Microwave (HPM) source lens designs.

DESCRIPTION: This effort will develop lightweight artificial lens materials that can be used to design and fabricate high power microwave lenses for use in either narrow band or ultra wideband (UWB) microwave antenna applications. Current lenses utilize polyethylene for the lens material with a resulting severe weight penalty. An artificial dielectric material that can be used for these lenses is desired. One possible approach is based on approaches utilized for microwave communications applications. A similar approach may be feasible for wideband time domain applications. The current microwave lens approach incorporates small dielectric spheres with a conductive coating suspended in a lightweight holding material. For UWB applications the artificial dielectric material should be effectively dispersion less and loss-less over a frequency from 200 megahertz to 2.0 gigahertz. Whether this concept can be extended for UWB applications is not clear. However, other new and innovative solutions that will produce a lightweight lens material that is dispersion less over this bandwidth are needed and encouraged.

PHASE I: Investigate the concept of using different dielectric spheres or spheres and/or tubes filled with fluids suspended in some type of lightweight foam or similar material to create an artificial dielectric material. Determine the feasibility of the concept and define the possible dielectric materials and the potential range of artificial dielectric characteristics possible with this type of an approach. Estimate the physical and electromagnetic properties of such artificial dielectrics for use in lenses and provide a sample product with actual measured results. Develop an initial commercialization concept and plan.

PHASE II: Complete the research initiated in Phase I and develop prototype artificial dielectric materials. Design and demonstrate a prototype system for limited production of such dielectrics and demonstrate the feasibility of the process. Conduct experiments and measurements of the physical and electromagnetic properties of the artificial dielectric materials. Develop business and commercialization plan for a Phase III engineering development and marketing program. This plan shall be required to address the real world issues associated based on actual business planning procedures, sources and methods of securing venture capital for production engineering and marketing, and not just a superficial discussion of possible approaches and possible customers.

PHASE III DUAL USE APPLICATIONS: Military uses of this technology include dielectric lenses for HPM narrow band and UWB antenna systems and communication systems. The civilian sector has similar requirements in the field of communication systems and especially in the newly emerging time pulse position technology for cellular phone and other similar applications.

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KEYWORDS: Dielectrics, Artificial, Antenna Lenses, Microwave, High Fields, Light Weight

AF02-023 TITLE: Grating Surface Emitting Semiconductor Laser Incoherent Array with High Average Power

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a high-average-power semiconductor laser source with increased brightness. This will increase the optical intensity that can be coupled into solid-state lasers and the power that can be coupled into fiber lasers.

DESCRIPTION: Any method, that will result in the development and commercialization of semiconductor laser sources with power levels of several hundred watts and with increased brightness over sources that are currently available, is sought. One method for accomplishing this would be to make an array from grating surface emitting (GSE) lasers. GSE lasers can be made to be very long with an output power per unit length that is comparable with that of typical edge emitting lasers. This provides the potential for a one-dimensional array of emitters that is comparable in power with an array made of stacked bars. If beam-shaping techniques were applied, the brightness would be much higher due to the fact that the array would be one dimensional. The array could consist of narrow-stripe individual lasers or of wide-stripe lasers. Even with lasers that were far from being diffraction limited in the lateral dimension, such an array could be much brighter than a conventional array of stacked bars. Innovative research would be required to develop chips that: (1) minimize loss of light caused by bi-directional emission; (2) include efficient heat transfer from the active region to the heatsink; (3) allow uniform current injection and low resistance. Another method for accomplishing the objective would be to make an array from stacked bars of edge emitting lasers, with individual lasers having improved beam quality or increased output power. Innovative research would be required to develop lasers with good beam quality at high power and with stable modes.

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations for the individual lasers or subsystems to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth development and refinement of laser source. Fabricate prototypes to show a maturity of technology toward potential commercial and military applications. Deliver prototypes to the Air Force.

PHASE III DUAL USE APPLICATIONS: Military applications for high-power high brightness laser sources such as those resulting from this proposal are principally weapons-related. Examples of commercial applications for a high-brightness, high-power source include: pumps for fiber lasers; laser cutting, machining, and welding of plastics or thin metals; materials processing; medical applications and any other area where a compact, efficient and mechanically robust source of intense infrared radiation is required.

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KEYWORDS: diode laser, semiconductor laser, array, grating

AF02-025 TITLE: Novel Low-Noise Extra High Frequency Amplifiers

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop the technology and infrastructure for manufacturing micro-vacuum tube low-noise amplifiers for space applications.

DESCRIPTION: Improvements in sensitivity of RF receivers in satellite systems offer a number of benefits, i.e. relaxation of size and weight demands on the receiving antennas and enhancement of the overall system reliability. Reducing the noise floor in the first amplifier stage is generally regarded as a highly effective means of increasing RF receiver sensitivity. This topic seeks innovative ideas of reducing amplifier noise through the use of a Micro-Vacuum Tube (MVT) as the low-noise front end of the first stage. Recent developments indicate that micro-triodes fabricated from chemical vapor deposited diamond micro-tip cold cathode emitters and self-aligned grids offer, in addition to low noise, high input impedance, high gain, and extremely high operational frequency. The thermal noise generated in these devices should be much less than traditional vacuum tubes since cold cathode electron emission occurs at room temperature or below if required. Unlike semiconductor low-noise amplifiers, MVTs have vanishingly small grid capacitance and extremely high input impedance, making them ideal for very high frequency (>30 GHz) and low-noise pre-amp applications. The goal is to develop a novel low-noise amplifier technology for applications in space systems. The initial phase of this effort calls for the development of prototypes to demonstrate the benefits of low-noise MVT amplifiers for K-band and above. The goal is to develop low-noise amplifiers that will be significantly better than the current state-of-the-art counterparts.

PHASE I: Demonstrate the merits of MVTs as used in low noise amplifier applications. Measurements on noise, gain and bandwidth will be made and compared with the current state-of-the-art counterparts. Address radiation hardness issues (total ionizing dose, dose rate, single event phenomena). Demonstration of the feasibility of developing an integrated multi-stage amplifier with a low- noise MVT front end is crucial for Phase II funding.

PHASE II: Design and fabricate an integrated multi-stage low-noise amplifier circuit with an MVT first stage. The emphasis of the Phase II effort is on verifying the performance of the developed integrated amplifier circuits based on actual measurements of gain, bandwidth and noise floor. An additional Phase II product is the definition of the infrastructure required for the production of MVT low-noise amplifier circuits. The circuit must meet adequate radiation tolerance requirements for usage in space by major USAF programs.

PHASE III DUAL USE APPLICATIONS: Low-noise, high gain and wide bandwidth RF amplifiers should have numerous applications in the commercial communication markets, (both space-based and terrestrial) such as cellular telephony, mobile data linkage and space/ground satellite communication. The knowledge and experience gained in Phase I and II will be used to develop products for both commercial and military applications.

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KEYWORDS: Low-noise amplifiers, LNA, Micro-vacuum tubes, Diamond micro-tips Micro-triodes, Cold cathode emitters

AF02-026 TITLE: Dynamic DC Source and Load System with Energy Recycle Capability

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop electronic DC source/load system that significantly reduces cost of power conversion system testing.

DESCRIPTION: Conventional testing/validation costs of power conversion systems designed for high power applications dramatically adds to the overhead cost of product development. Because the test load consumes 100% of the input energy, the heat generated from the testing increases the power consumption of the test facility. This further contributes to the overhead expenses of the whole organization. This is the motivation behind the concept of a "smart electronic load" (SEL) that absorbs the electrical energy delivered from the "system under test" (SUT) and passes the energy back to the DC power source providing the input voltage to the SUT. The SEL is simply a highly efficient DC-DC converter that can be programmed to have different characteristics, as needed, i.e., a resistive, a constant current-sink, or a constant power load. The DC power source (providing input voltage to the SUT) is a highly efficient AC-to-DC converter processing the AC utility power into a well-regulated output voltage with sufficient energy storage - such as a set of bulk filter capacitors terminated across the source output. This energy storage is capable of holding and filtering the energy transferred from the utility grids and the recycled energy from the SEL so that the power quality at the input of SUT remains acceptable especially during line and load transients. The AC-to-DC converter can also be designed to behave like a resistive load to the utility grid; thereby, yielding almost unity power factor and low harmonic contents in the line current.

PHASE I: (1) Determine technical feasibility of selected SEL testing approach (that yields high power factor and low harmonic contents). Identify a testing architecture best suited for medium and high power systems under test. (2) Determine SEL system design guidelines to achieve system stability/reliability. (3) Develop SEL design showing system interconnection of the AC-to-DC converter, the SUT, the electronic load, and their respective controllers. (4) Validate the design concepts through results from computer simulation and analyses of the system response.

PHASE II: (1) Finalize design of the power system/components: the AC-to-DC, the electronic load converter, and their controllers. (2) Simulate final design through the computer simulation/analysis. (3) Construct breadboard SEL system and demonstrate contractor/Air Force mutually agreed basic concepts

PHASE III DUAL USE APPLICATIONS: As the computer and communications industries continue to increase their markets there will be an increased need to better utilize electric power used in the production of these electronic products. At the same time the nation's electric utility supply grid is seeing an marked increase in the demand for electric power to operate the internet and in the manufacture of the electronic devices which make up this system. The ability to accurately measure the performance of each power processing component to verify that power processing parameters are within specified tolerances with a minimal use of electric power should provide a significant commercial market for this device.

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KEYWORDS: Dynamic DC Source, Load System, DC-DC Converter, Energy Recycle,Power Electronics Test Equipment, AC-to-DC converter

AF02-027 TITLE: Multifunction Phase Array Antennas

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate high efficiency, phased array antenna with integrated energy storage and enhanced array pointing precision.

DESCRIPTION: Current spaceborne communication and surveillance spacecraft employ sophisticated, single purpose phased array antennae for transmission (and/or reception) of RF energy. Integral to the performance of these devices are the separate power and thermal management subsystems, typically developed independently as part of the spacecraft bus. Precise pointing requirements for both communications and surveillance require precise knowledge and control of dimensional tolerances that are adversely affected by thermal distortions induced by waste heat from RF components. Because phased array antennas typically occupy large areas that tend to radiate heat rapidly in space, keeping transmit/receive modules warm enough is usually of more concern than keeping them cool. Power distribution for large phased array antennas may entail power transmission over relatively large distances that in turn lead to high power distribution losses and inefficient spacecraft operation. The combined effect of pointing requirements, thermal management and power distribution tend to increase the overall weight of the ‘assembled’ spacecraft. Significant reductions in spacecraft weight may be enabled by direct integration of power and thermal management functions at the component level of the phased array. The objective of this project is to develop technology that enables energy storage and thermal management at the components level of transmit/receive antenna modules. Potential system level benefits of this technology would be mass reduction and/or affordability improvement through higher level integration of payload with supporting technologies.

PHASE I: Develop and demonstrate innovative electronic packaging concepts to enable the integration of energy storage and thermal management is conventional phased array transmit/receive antenna subsystems that will provide significant overall spacecraft mass reduction. Invent, develop, and demonstrate of proof-of-principle breadboard designs that enable integration of energy storage and thermal management into transmit/receive antenna module (TRAM) devices. Conduct concept designs, thermal analysis and energy management/thermal vacuum experiments (if appropriate and as needed) to 1) demonstrate applicability of the multifunctional phased array antenna architecture to communications and surveillance systems of interest to the Air Force and DoD, 2) validate concept viability in representative operating environments through appropriate modeling and/or experiments, and 3) demonstrate system level benefit in terms of antenna mass/unit area of the proposed multifunctional phased array antenna.

PHASE II: Develop and demonstrate prototype RF transmit/receive phased array antenna incorporating integrated energy storage and thermal management modules. Validate RF performance using appropriate ground simulation and testing.

PHASE III DUAL USE APPLICATIONS: Application of this technology would permit next generation commercial satellite communication systems to display higher efficiency RF operation and higher transmitted output with existing energy generation technologies.

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KEYWORDS: Phased Array Antennas, Multifunctional Structures, Energy Storage, Power Distribution, TRAM, Space-Based Radar (SBR)

AF02-028 TITLE: Next-Generation 35-40% Efficient Multijunction Solar Cell

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop/demonstrate single-crystal multijunction (3-4 junction) space solar cells with 35+% conversion efficiency..

DESCRIPTION: An increasingly higher level of electrical power is needed to run increasingly complicated and diversified satellites that are assigned longer and more complex missions. Next-generation large satellite demands include increased power on orbit, while increasing power system specific power (W/Kg) to increase satellite payload mass and power budgets. Satellite power generation is provided by solar photovoltaic cells (solar cells). Advanced 35-40% efficient multijunction solar cells promise to reduce SOTA solar array size and mass by 50-60% and enable significant power level scale-up from SOTA 15kW to ~25kW. The multijunction solar cells contain multiple layers of light sensitive semiconductor material that optimize solar energy-to-electrical power conversion. Each layer in the solar cell stack optimally absorbs and converts a different part of the solar spectrum into electricity. High performance solar cells are required to provide added power for space missions without increasing the solar arrays' size or weight. This program will investigate new semiconductor material systems and solar cell device designs capable of achieving 35-40% efficiency Air Mass Zero(AM0) to increase space solar cell efficiency by 50% (over recently developed AF ManTech 24% solar cells). The chosen material system must be current matched for two-terminal operation.   While the preferred configuration is monolithic tandem, mechanical stacked approaches are also acceptable. Also, while a large area (>20cm2) 1-sun cell design is preferred, concentrator solar cell designs are of interest. Advanced 3- and 4-junction single-crystal multijunction solar cell designs will 1) Enable scale-up of military and commercial satellite power levels to >25kW from the current maximum practical power level of <15kW, 2) Significantly reduce solar array mass via increased solar cell efficiency; solar array size, mass, stowage volume and cost decrease with increasing cell efficiency, 3) Increase solar array power for constant solar array mass or size, and 4) Provide a high volume, cost-effective production capability for space solar cells two generations ahead of any production solar cells available abroad (UK,19-20%;Germany,20%, Japan, 17-20%)

PHASE I: Develop and validate innovative approaches for producing a 3- and/or 4-junction space solar cell design having theoretical efficiencies greater than 35% (AM0, space spectrum). Build on existing 26-28% efficiency multijunction solar cell designs and production capability. Solar cell modeling and design may be based on a wide range of semicondcutor bandgaps, including ~2.0, 1.4, 1.0, and 0.7 eV material combinations. Appropriate bandgap values must be selected to insure current matching. While lattice-matched material systems are desired, lattice-mismatched systems are may also yield good candidates.

PHASE II: Develop a prototype/demonstration of the high efficiency multijunction, single crystal solar cells. Develop/document requirements/plans for high volume production processes.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of cost-effective high-efficiency single-crystal solar cells which are of interest for both DOD and commercial spacecraft as well as for new terrestrial concentrator applications.   The outlook for commercial space based arrays would be very strong.

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KEYWORDS: High-Efficiency Solar Cells, Multijunction Solar Cells, Space Power, Solar Arrays, Photon Absorption, Single-Crystal Solar Cell

AF02-029 TITLE: Phased Array Antenna Power Amplifier Modules

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop high efficiency solid-state power amplifier modules for application in multi-carrier components for spaceborne phased-array transmit antennas.

DESCRIPTION: This program addresses the need for simultaneous transmission of multiple carriers in RF power amplifier chains through the development and implementation of discrete power amplifier modules). Discrete power amplifier modules (PAM), suitable for being implanted in microwave integrated circuit (MIC) structures, will be used to demonstrate the desired performance enhancement. The power output of interest is between 0.1 and 1.0 watts with an input power of approximately ten milliwatts. Future applications will include military satellites such as Advanced EHF (extremely high frequency) and future surveillance systems such as Space-Based Radar, as well as commercial satellites operating in the 20 GHz transmit (downlink) band. Since multiple modulated carriers will be applied to the modules, the reduction of inter-modulation products is thought to be one of the key issues and should be considered. Potential voltage peaks that could cause device degradation as a consequence of beat frequencies should also be considered a one of the reliability issues. Compensation techniques may be required to meet performance goals. The compensation techniques to be considered include but are not limited to the following: 1) automatic gain and level control to maximize efficiency with minimum intermodulation products, 2) a predistortion network to improve linearity and phase matching, 3) wideband characteristics to enhance phase matching, and 4) temperature compensation circuits

PHASE I: Develop innovative approaches to enable high efficiency solid-state amplifier modules for future spaceborne phased-array transmit antennas. Demonstrate viability of developed approaches via modeling, simulation and/or brass-board experimental techniques. Conduct supporting system analysis to ‘qualify’ potential benefit to both military and commercial communication systems.

PHASE II: Validate proposed approaches via appropriate design, simulation and fabrication of prototype components to demonstrate performance capabilities of new approaches. Build the necessary PAM/MIC hardware and perform adequate demonstrations/testing to show that the contractor has achieved a significant improvement in amplifier performance with regard to efficiency, linearity, phase matching, temperature stability, and reliability through the use of compensating circuitry. Transition of program results to microwave monolithic integrated circuit (MMIC) technology in order to show compatibility with current module developments may be described and considered if appropriate within the scope of a phase II effort.

PHASE III DUAL USE APPLICATIONS: Phased arrays are receiving considerable attention in both the military and commercial space communications communities. The downlink transmit band at approximately 20 GHz is allocated to both types of service. Accordingly, the effort proposed is directly applicable to many systems under serious consideration for future deployment that involve multiple carrier transmission and in which the reduction of inter-modulation products is a key requirement.

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KEYWORDS: Solid-state Amplifiers, Linearizers, Phased Arrays, Antennas, Inter-modulation Products, Microwave Integrated Circuit, Space-Based Radar (SBR)

AF02-030 TITLE: Miniature Traveling Wave Tubes for Space Application

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop the technology and infrastructure for miniaturizing traveling wave tubes for space communication applications.

DESCRIPTION: Traveling wave tubes (TWTs) are commonly used to amplify microwave power for satellite communication systems. Fabrication of these tubes required intricate assembly practices and highly skilled manual labor. Progress toward higher frequency operation is hampered by the ability of present manufacturing technology to reduce the dimensions of critical components, such as helices and electron guns. An enabling technology is needed so that TWTs can be made to operate at higher frequencies. Advancement in this area will offer new mission capabilities and support the development micro- and nano-satellites. This topic solicits innovative ideas for miniaturizing TWT components by drawing upon the recent developments in microelectronics and micro-electro-mechanical systems (MEMS) technology. The goal is to develop a novel manufacturing technology to build TWTs to operate at frequencies at or above 100 GHz with a target output of 5 watts per subsystem.Incorporation of advanced MEMS fabrication techniques to the manufacturing process is encouraged. The initial phase of the program calls for the demonstration of concepts to be used to miniaturize critical TWT components. Concepts that can offer the potential of fabricating the entire system by MEMS technology are encouraged. Demonstrated ability to produce miniaturized prototype components is an essential Phase I product.

PHASE I: Establish an effective and viable miniaturization approach for TWTs and their components. Phase I objective is to establish a feasible approach required to demonstrate the feasibility of a TWT system which can meet Phase II requirements.

PHASE II: Design and build miniaturized TWTs to operate at frequencies at or above 100 GHz. The emphasis of Phase II is on verifying performance of miniaturized TWTs to demonstrate feasibility of producing 5 watts per subsystem at >/= 100 Ghz. In addition to developing the needed manufacturing technology, a critical part of the Phase II effort will be devoted to developing/documenting the infrastructure required to construct miniaturized TWTs in a Phase III activity.

PHASE III DUAL USE APPLICATIONS: Small, compact microwave power amplifiers, operating at high frequencies, offer enormous opportunities for creating new markets in the bandwidth-intensive commercial communication arenas, such as cellular telephony, wide band mobile communication and high-speed space/ground data transfer. The knowledge and experience gained in Phase I and II will be used to develop products for both commercial and military applications.

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KEYWORDS: Travel wave tubes, TWT, Microwave tubes, Miniaturization, MEMS, Micro-electro-mechanical system, advanced RF packaging,

AF02-031 TITLE: Lightweight Primary Mirror Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design and develop high-stiffness, ultra-lightweight, scalable mirror fabrication/production techniques.

DESCRIPTION: Current light-weighting approaches to mirror fabrication using glass-based substrates are limited in achieving an optimal solution to both structural and optical requirements. Primary considerations in mirror design are optical performance (both static and dynamic), while secondary considerations include weight, minimum risk in fabrication, handling and polishing considerations, and the constraint that costs be kept at an absolute minimum. These secondary considerations have the effect of making mirror production rates exceedingly slow, with procurement times and costs that do not scale well with the mirror aperture. By fully utilizing new technologies, more structurally efficient mirror systems (i.e. less parasitic weight that serves no structural purpose) should be obtainable, while at the same time cutting cost, fabrication times, and reducing risks from handling.

PHASE I: Investigation of advanced, high payoff approaches to high-structural efficiency mirrors is desired. The advantages of the approaches investigated with regards to structural efficiency, optical quality, manufacturability, scalability, and environmental requirements should be demonstrated by analysis or historical data.

PHASE II: Finalize Phase I design and based on final design, develop a prototype component or system. Design and conduct laboratory demonstration based performance parameters derived from a military or militarily-relevant commercial application.

PHASE III DUAL USE APPLICATIONS: Due to the current high activity levels in both government and industry related to both the SBL and ABL programs, there are many opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DoD prime-contractors will be pursued towards this end. In addition, while government applications will receive the most direct and immediate benefit from a successful program, terrestrial optics also stands to benefit from the results of this program. In particular, high-structural efficiency steering mirrors could reduce complexity of any optical system with pointing requirements, including ground-based telescope applications, Printed Circuit Board photoetching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, Inspection mirrors, military & commercial aircraft mirrors, commercial and civilian remote sensing applications, and optical communications systems.

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KEYWORDS: Lightweight, Mirrors, Manufacturing, Structures, Optics

AF02-032 TITLE: Electrodynamics of the High-Latitude Ionosphere

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an efficient, accurate software package that specifies and predicts the electrostatic potential, currents and Joule heating rates in the high-latitude ionosphere.

DESCRIPTION: The near-earth space environment has a direct and, sometimes deleterious effect on military operations. Systematic variations and perturbations in ionospheric density can adversely affect military and civilian communications, spacecraft charging, navigation systems, radar surveillance, and geolocation. Changes in the upper atmosphere modify the orbits of satellites and degrade our ability to predict their position and reentry. Between the altitudes of 80 and 1500 km, the upper atmosphere has two components: a neutral component -- the thermosphere -- and a charged component -- the ionosphere. Both form a strongly coupled system. At high latitudes, electric fields, currents and Joule heating rates constitute the key parameters of this coupled ionosphere-thermosphere environment. The objective of this SBIR is to devise innovative algorithms to characterize and predict these parameters. Being able to specify and forecast these electrodynamic parameters in near real time will significantly improve the accuracy of operational space weather models being developed for use by the Air Force and the Department of Commerce. Accuracy of tailored space weather products relies on validated and computationally efficient models for specifying and forecasting the space weather environment. They are needed to identify and predict communication outages, navigational errors experienced by GPS single frequency receivers, surveillance radar malfunction, power grid disruption, and electric blackouts. The supplied electrodynamic software package will be a specification and forecast model that is driven by a mixture of data, theoretical modeling and climatology. It is intended to be used as an input to high-latitude ionospheric specification and forecast models, which are the basis for a number of application codes that generate parameters to support DoD and civilian missions.

PHASE I: Design a prototype software package that models the high latitude electric field, currents and Joule heating. This shall be accomplished in coordination with government personnel. Phase I activities shall include the following tasks: (1) Review relevant models of electric fields, ionospheric currents and Joule heating rates, as well as their limitations. (2) Design innovative concepts to specify the high latitude electrodynamic parameters. These concepts shall be based on state-of-the-art measurements, models, computer algorithms and assimilative techniques. (3) Based on these innovative concepts produce a workable design for an accurate and efficient software model of electric fields, currents, and Joule heating rates. (4) Formulate a thorough validation procedure including identification of necessary data sets, and definition of an appropriate set of metrics. (5) Write a Software Design document.

PHASE II: Develop an advanced specification and forecast software model of the high latitude electrodynamic parameters. This shall be accomplished in coordination with government personnel. Phase II activities shall include the following tasks: (1) Revise electrodynamic model Phase I concept. (2) Produce an accurate, efficient and validated high latitude electrodynamic specification and forecast algorithm. (3) Demonstrate its capability to enhance the performance of operational physics-based space weather models. (4) Demonstrate its capability to enhance the performance of tailored products that are based on the space-weather models. (5) Identify the required inputs -- such as data, physical models and empirical models -- that are required to generate the output. (6) Produce the Functional and the Software Requirements Documents.

PHASE III DUAL USE APPLICATIONS: Because this software package will be used as an input to space environment models, it has direct applicability to commercial vendors who develop tailored products for specific navigation and communication customers. Civilian users of single frequency GPS receivers require realistic ionospheric corrections to achieve accurate navigation position information. HF wave propagation prediction users are the largest customers for NOAA's Space Environment center forecast services, which requires realistic ionospheric models. Potential commercial uses include systems to assess the status of satellite communication channels, and electric power grid control centers to re-route circuit elements when major increases in the ionospheric electrojet are imminent. Thus, this software package is expected to have significant dual-use potential. Successful completion of this SBIR effort would favorably position the contractor to market a key component of a near real time space weather forecast model that would provide communication outage advisories, improved GPS navigation systems, and electric power grid decision aides. Other marketing opportunities and commercial uses will emerge from the algorithm's value and relevance to the US National Space Weather Program where the Nation's emerging space weather forecast capability is being coordinated and showcased.

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KEYWORDS: Space Weather, HF Communications, Electric fields, Magnetic fields, Joule heating, Ionospheric Scintillation

AF02-033 TITLE: Power Efficient Space Computer

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design, fabricate and demonstrate a power efficient space computer

DESCRIPTION: Power consumption for mainstream microprocessors is increasing at an alarming rate. Semiconductor roadmaps predict that by 2005 microprocessors will operate at over 2GHz and may consume over 100 Watts – and in 2001 technology is almost there already. This suggests that space based high throughput processing will require active cooling in the near future. The associated penalties in reliability, complexity, and weight may be unacceptable for space use. For power-constrained use, including terrestrial battery-operated applications, new architectures and processes are being envisioned. This SBIR topic is intended to investigate techniques that go beyond conventional processor architectures, and discover new power-optimized architectures and processes for commercial and space use. Some possible approaches include simplified hardware using very long instruction words (VLIW), software-assisted hardware, and dynamic clock control. Reference 3 indicates some approaches used by the Caruso processor; no doubt there are other techniques that can be used when one breaks free of the traditional processor paradigms. Some of these techniques could also be appropriate for Application Specific Integrated Circuits (ASICs) as well as microprocessors. Other issues to be considered for space use include ionizing radiation and effects of single energetic particle strikes (Single Event Effects).

PHASE I: Provide evidence, through analysis and/or hardware demonstration, that key technology innovations can achieve improvements over current practices in power efficient design and architecture and can be used in relevant environments. Develop initial concepts and designs for products, whether microprocessors or ASICs, using the proposed technical innovations. Develop and describe a strategy to implement the innovations in a demonstration application. Identify key challenges to extending the innovations to space applications, including environmental effects, and propose solutions to overcome these challenges.

PHASE II: Implement and test Phase I innovations at a demonstration level. This demonstration need not be a full-scale or flight-level system, but should validate the key elements of the system.

PHASE III DUAL USE APPLICATIONS: Power efficient processing has broad applications for all battery-operated electronics. As energy use decreases, the single event effects concerns for space will increasingly apply to terrestrial electronics, particularly high altitude commercial avionics. This type of product would also be applicable to commercial space (as well as military space).

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KEYWORDS: Portable computing, microprocessor, low-power, VLSI, Central Processor Unit, space computer

AF02-034   TITLE: High Temperature Polymer Substrate for Thin Film Solar Cells

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a High Temperature low density material suitable for use as a substrate for thin-film photovoltaic devices.

DESCRIPTION: Future space missions will require photovoltaic devices having specific power ratings in excess of 1000w/kg. Conventional crystalline photovoltaic technology cannot provide these specific power ratings due to the fact that the solar input is only 0.135 w/cm2 and the mass of crystalline devices is approximately 0.125g/cm2. Thus crystalline photovoltaic devices, even with 40% efficiency, have specific power ratings of approximately 400w/kg. Thin film devices, which have an area density equal to the substrate upon which they are deposited, have the potential of providing higher specific power ratings. Presently thin film photovoltaic devices are fabricated using vacuum deposition processes which grow the photovoltaic devices at relatively high temperatures (500 to 600oC). To accommodate the high temperatures required for high efficiency devices (greater than 10% AM0 [Air Mass of zero]) the underlying substrate which has proven to be workable is stainless steel. The use of stainless steel as a substrate for thin film photovoltaics has a number of drawbacks which adversely impact the overall specific power of a solar array. Two of these are: 1) the high density of stainless steel foils limits the maximum specific power rating and 2) the use of stainless steel precludes the implementation of an integrated interconnect system. Amorphous silicon photovoltaic devices have been produced for the terrestrial market using a polyimide substrate, and an integrated interconnect system. This process is limited to a maximum temperature of 400 oC during the deposition process. The maximum efficiency that has been obtained for the production devices using this process is approximately 5% AM1.5. The specific power for these devices is approximately 300w/kg at AM0. To obtain a specific power rating of 1000w/kg an AM0 efficiency of approximately 15% is required. Significantly higher efficiencies could be obtained for thin film photovoltaic devices (fabricated on high temperature low density substrates) if the deposition process could be raised to 600 oC. Moderate improvements in cell efficiencies could be obtained with low density materials capable of surviving temperatures of 500oC. For phase I efforts, a strong emphasis should be placed on experimental and theoretical methods for validation of the design. Government/commercial test and evaluation facilities may be available; via documented requests (to appropriate organizations) to secure these facilities. Based on the results of these tests/evaluations, the performance of the thin film solar cells on low density material substrates should be estimated and improvements quantified.

PHASE I: Develop/validate innovative processes for producing space based, long life, high specific power (1000w/kg) thin film, solar cells fabricated at high temperatures (>500 oC) on low density substrates. Provide appropriate demonstrations of the products resulting from the selected processes

PHASE II: Develop/provide a laboratory based prototype demonstration of the solar cell array resulting from the finally selected production process.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of low cost high efficiency thin film solar cells which could be used for terrestrial/space applications. The market place for commercial space based/terrestrial solar arrays is strong and growing at a rapid rate.

REFERENCES:

1. Basol, Bulent M., Kapur, Vijay K., Halani, Arvind, and Leidholm, Craig , "Copper Indium Diselenide Thin Film Solar Cells Fabricated on Flexible Foil Substrates," Solar Energy Materials and Solar Cells, 29 (1993) 163-173.2. Basol, B. M., Kapur, V. K., Halani, A., Minnick, A. and Leidholm, C., The Twenty-Third IEEE Photovoltaic Specialists Conference - 1993, Louisville, KY, May 10-14, 1993, pp 426-430.3. Basol, Bulent M., Kapur, Vijay K., Leidholm, Craig R., Halani, Arvind, and Gledhill, Kristen, "Flexible and Light Weight Copper Indium Diselenide Solar Cells on Polyimide Substrates," Solar Energy Materials and Solar Cells, 43 (1996) 93-98.

KEYWORDS: High Temperature Polymer, Thin Film Solar Cells, Specific Power, Solar Arrays, Polymer Substrate, Photovoltaic Devices

AF02-035 TITLE: Reconfigurable Logic for Space

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/demonstrate innovative concepts for applying the advantages of reconfigurable logic to satellite electronics.

DESCRIPTION: With the advent of reconfigurable Field Programmable Gate Arrays (FPGAs) it is reasonable to conceive of insertions of this technology on board spacecraft where size and weight are almost always at a premium. The ability to dynamically reconfigure logic circuits allows the same component, an FPGA, to serve in several different functional capacities. While the potential for application of reconfigurable logic (circuits) is obvious, ways to leverage this potential are not fully explored. Many spacecraft on-board processing functions are fixed and in continuous use. These functions would not be good candidates for reconfigurable logic insertion. Good candidates include (among others) periodic/intermittent functions. Offerors should assume that space qualified reconfigurable FPGAs will be available when needed. Development of these components is not part of this topic. A proposal in this area should begin to address a number of problems not faced by conventional (non-dynamic) FPGA use. Such problems might include the design and testing of reconfigurable systems, the development of new architectures better suited to reconfigurable logic, and the issues of error detection and fault tolerance for reconfigurable systems.

PHASE I: Based on a proposed concept for an innovative set of generic applications of state-of-the-art reconfigurable logic to satellites, detail the functions and architectures necessary for actual implementations. Demonstrate (by analysis) size, weight, and (if applicable) power reductions achievable over standard (i.e., non-reconfigurable logic) approaches. Provide analytical demonstrations based upon at least two proposed reconfigurable logic concepts. For each such demonstration, compare similar analytical results produced from: 1) the "standard" approach implemented by state-of-the-art non-reconfigurable FPGAs, and 2) the "standard" approach implemented by state-of-the-art Application Specific Integrated Circuits (ASICs) which are presumed to be of higher density than the FPGAs. Define in detail representative functions and implementing architectures to be designed and implemented in Phase II.

PHASE II: Implement a hardware demonstration of one or more of the most promising and innovative generic applications of reconfigurable logic (from Phase I) to satellite functions. While a demonstration of complete functions is preferred, demonstrations of complex functions can be partial if truly representative of the benefits of a full implementation. Implement the same functions in non-reconfigurable state-of-the-art FPGAs and demonstrate actual reductions in overall size/weight/power achieved (e.g., taking into account total chips required for the non-reconfigurable logic and for the reconfigurable logic approaches.

PHASE III DUAL USE APPLICATIONS: This technology is equally applicable to commercial satellite systems which face many or most of the same reliability, environmental, size/weight/power, and performance needs as military systems. As an enabling technology for integrated electronics, it has broad potential for significantly improving the performance and characteristics of most future military space systems, including MILSATCOM/SBIRS/GPS/etc. programs.

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KEYWORDS: Reconfigurable, logic, satellite, Field Programmable Gate Arrays, electronics

AF02-036 TITLE: Multi-functional Polymer Optical Interconnect Technologies for Wireless Satellite Data Communications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/validate designs for multi-functional polymer optical interconnect technologies for wireless satellite data communications.

DESCRIPTION: Integration of modern microelectronic devices (e. g., microprocessors, digital signal processors, field programmable gate arrays, etc) has increased to the point where external data transmission by electrical relay is constrained by the low number of possible input-output (I/O) channels that can be integrated on-chip. New schemes for I/O must be considered for such devices in order to avoid a more severe data extraction bottleneck on future devices that will be even more heavily integrated. In an effort to overcome these limitations, systems designers have been exploring the use of optical/optoelectronic interconnects. The integration of photonic devices (i. e., transmitters and receivers) on-chip allows data transmission chip-to-chip at rates exceeding 10 gigabits per second and avoids many of the bottlenecks associated with current system architectures. Data is transferred either through waveguides (e. g., optical fibers) or by free-space transmission. Use of optical/optoelectronic interconnection schemes in conjunction with microelectronic devices will require the development of polymer waveguide structures suitable for integration on-chip. Application/integration of optical/optoelectronic interconnects to applications of greatest utility to USAF satellite programs including MILSATCOM, SBIRS, etc., are of high interest.

PHASE I: Develop and validate innovative schemes for the use of on-chip polymer waveguide optical/optoelectronic interconnects in conjunction with microelectronic devices for military applications. Proposals should focus on the development of on-chip optical approaches (e.g., polymer waveguides and structures) to enhance fanout and/or facilitate dynamically-reconfigurable architectures for chip-to-chip, board-to-board, and system-to-system communications. These efforts should include proof-of-principle validation of the survivability and performance of optical/optoelectronic interconnects for systems consistent with the use of microelectronic devices for applications of interest to military programs.

PHASE II: Design, fabricate, and perform experimental validation/optimization of microelectronic devices utilizing optoelectronic interconnects suitable for military satellite application. Our expectation is an overall improvement of off-module and bisectional bandwidth relative to wire-based approaches. Demonstrate the resulting device(s) to (Air Force/Contractor mutually agreeable) criteria.

PHASE III DUAL USE APPLICATIONS: Photonically interconnected microelectronic devices will certainly be of interest to designers of DoD, NASA and commercial systems including satellites, aircraft, ships, armored vehicles, etc. Photonic interconnects applicable to military satellites can be cost effectively redesigned for commercial use.

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KEYWORDS: Interconnects, Polymer, Wireless, Data communications, Optical , Photonic.

AF02-037 TITLE: Novel High Current Switch for Spacecraft Power Bus Control

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop technology and infrastructure for manufacturing novel high current switches for spacecraft power control applications.

DESCRIPTION: The ability to eliminate high current spikes in spacecraft power bus can provide additional safety margins to system power design. Solid state electrically activated switches have been used in many spacecraft power bus control circuits. For this type of device, the switching time can be an issue at high current levels. A large array of micro-triodes fabricated from chemical vapor deposited diamond micro-tip cold cathode emitters and self-aligned gates will have very high current handling capability, fast switching time, and low grid voltage characteristics. This SBIR topic seeks innovative concepts for developing novel high current switches based on micro-triode array technology. The goal is to develop small, compact (1.25 cm in diameter) switches that can handle 1,000 amperes and have a switching time less than 1 nanosecond with a cut off voltage less than 10 volts. The initial phase of the program calls for the development of prototypes to demonstrate the feasibility of the proposed concepts to meet the critical spatial and electrical requirements. Proposals should include provisions to test and determine the long-term reliability (space qualification) of the developed switches.

PHASE I: Design and build prototypes to demonstrate the ability of the proposed switches to turn off a maximum amount of current in a minimum amount of time. The desired goal is to switch off 1,000 amperes in less than 1 nanosecond, using a switch of less than 10 volts. Development of a protocol to test the developed switches for eventual space qualification is a critical Phase I product.

PHASE II: Finalize switch design and develop an infrastructure for the production of the switches. The emphasis of the Phase II effort is on verifying the performance of switches based on the phase one concept. Establishing a path for space-qualification will be critical part of Phase II effort.

PHASE III DUAL USE APPLICATIONS: Ultra-fast switches that can handle high currents will have many commercial applications in pulsed power circuits and power bus conditioning and surge arresting devices.

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KEYWORDS: Power bus control, Spacecraft power bus, Micro-vacuum tubes, Diamond micro-tips, Mrico-triodes, Cold cathode emitters

AF02-038 TITLE: Integrated Thin Film Solar Array and Phased Array Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a combination thin film solar array/integrated phased array antenna on the same substrate.

DESCRIPTION: Conventional antenna arrays and power systems utilize separate structures to mount the solar array and antenna subsystems. This results in increased weight for the additional support structures. Thin film solar arrays, because of their low conversion efficiencies, can require large areas to provide sufficient power. A portion of this area, however, could be utilized as a distributed phased array antenna by laying down multiple antenna patterns through some means such as etching an antenna printed circuit pattern (or by some other technique on) the polymer substrate of the solar array. Connection to both the thin film solar array and the antenna could be done through separate multilayer flexible circuitry embedded in the same polymer substrate of the thin film solar array.

PHASE I: Phase I activities shall include (but not be limited to): 1) investigate appropriate antenna pattern designs and related RF frequencies that would be applicable to integration into a thin film solar array substrate, 2) develop a feasible technique for applying the antenna pattern to the thin film solar array substrate, 3) develop a computer simulation of the resulting assembly, 4) demonstrate the operation of the unit by simulation and appropriate level demonstrations.

PHASE II: Phase II activities/deliverables shall include: 1) design/build a functional model of a thin film solar array/integrated antenna circuit assembly 2) develop a functional block diagram for simultaneous/parallel multi-unit operation, 3) demonstrate simultaneous solar cell/antenna operation to mutually acceptable target specifications and operational scenarios.

PHASE III DUAL USE APPLICATIONS: A combination antenna/power system assembly is applicable/advantageous to DoD/commercial space vehicles. It is expected that the first applications of a thin film solar array/integrated antenna circuit will be in small experimental satellites. Terrestrial dual use applications might be in lightweight portable communication devices where a combination of solar and battery power would provide extended usage.

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KEYWORDS: Solar Cells, Phased Array Antenna, Micro-Circuits, Polymer/Polyimide Materials, Multilayer Flexible Circuitry, Antenna Printed Circuit

AF02-039 TITLE: High Efficiency Non-Vacuum Processed Thin-Film Photovoltaics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop/validate innovative design concepts for forming thin-film photovoltaic devices on polymer substrates

DESCRIPTION: Future DoD/commercial space missions will require photovoltaic devices having specific power ratings in excess of 1000w/kg. Conventional crystalline photovoltaic technology cannot provide these specific power ratings due to the fact that the solar input is only 0.135 w/cm2 and the mass of crystalline devices are approximately 0.125g/cm2. Thus crystalline photovoltaic devices, even with 40% efficiency, have a specific power rating of approximately 400w/kg. Thin film devices (which have effective area density equal to the substrate) have the potential of providing higher specific power ratings. Presently thin film photovoltaic devices are fabricated using vacuum deposition processes, which grow the photovoltaic devices at relatively high temperatures. Stainless steel substrates accommodate the high fabrication temperatures required for high efficiency devices (greater than 10% AM0 [Air Mass of zero]); however, the use of stainless steel as a substrate for thin film photovoltaics has a number of drawbacks which adversely impact the overall specific power of the resulting solar array. Two drawbacks are: 1) the high density of stainless steel foils and 2) stainless steel substrates preclude implementation of an integrated interconnect system. Amorphous silicon photovoltaic devices have been produced for the terrestrial market using a polyimide substrate with an integrated interconnect system. Maximum efficiency obtained for polyimide substrate production devices is approximately 5% AM1.5. The specific power for these devices is approximately 300w/kg at AM0. To obtain a specific power rating of 1000w/kg an AM0 efficiency of approximately 15% is required. There has been some promising work using a Sol-Gel-like process for forming high efficiency (greater than 10% AM0) thin film photovoltaic devices at low temperatures. This process may allow the use of a wider variety of polymer substrates, which may have lower densities than the polyimides. Devices formed using this process would be capable of implementing an integrated interconnect system. 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 should be considered. Government/commercial test and evaluation facilities may be available; via documented requests (to appropriate organizations) to secure these facilities. Based on the results of these tests/evaluations, the performance of the thin film solar cells on polymer substrate should be estimated and improvements quantified.

PHASE I: Develop/validate innovative processes for producing space based, long life, high specific power (1000w/kg) thin film, solar cells fabricated at low temperature (<300oC) on low density polymer substrates. Provide appropriate demonstrations of the products resulting from the selected processes.

PHASE II: Develop/provide a laboratory based prototype demonstration of the solar cell array resulting from the finally selected production process.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of low cost high efficiency thin film solar cells which could be used for terrestrial/space applications. The market place for commercial space based/terrestrial solar arrays is strong and growing at a rapid rate.

REFERENCES:

1. Basol, Bulent M., Kapur, Vijay K., Halani, Arvind, and Leidholm, Craig , "Copper Indium Diselenide Thin Film Solar Cells Fabricated on Flexible Foil Substrates," Solar Energy Materials and Solar Cells, 29 (1993) 163-173.
2. Basol, B. M., Kapur, V. K., Halani, A., Minnick, A. and Leidholm, C., The Twenty-Third IEEE Photovoltaic Specialists Conference - 1993, Louisville, KY, May 10-14, 1993, pp 426-430.
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KEYWORDS: Energy Conversion Efficiency; Thin Film Solar Cells; Specific Power; Solar Arrays; Polymer Substrate.

AF02-040 TITLE: Parallel-Connected Converters with Innovative Control

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop the control circuitry necessary to provide expandable converter power systems for spacecraft applications

DESCRIPTION: As the need for flexible, scalable space-based power requirements increases, and in an effort to avoid redesign of spacecraft and electric propulsion power systems, a number of concepts have emerged to provide expandable, parallel-connected power converters employing techniques such as maximum power tracking. Such approaches then allow a variety of options with the rest of the power system such as employing standard, modular, power converters that can be connected in parallel. The goal is to provide a single power system design that can meet a range of power requirements for spacecraft and/or electric propulsion power systems. For such a flexible and scalable power system, a need exists for control of such functionality. Depending on the concept, risks of power system failures exist due to a variety of circumstances. Under any circumstance that causes the output voltage of the power system to lose regulation, techniques such as maximum power tracking ensure that the power delivered to the load is at the maximum available power from the solar arrays. Thereby, the control prevents the complete drop out of the system output voltage. Under normal sun insolation and healthy conditions of the array source, the control will not interfere with the regulation of the system output voltage because the load demand is below the maximum available power of the array source. The expansion capability of the system with such a control provides long-term cost/schedule benefits to the electric propulsion and spacecraft power systems of the next generations. In many cases, Commercial Off-the-Shelf (COTS) power converters [ref. 2] can be employed with such control circuitry to meet space needs.

PHASE I: (1) Determine technical feasibility of existing control designs such as maximum power tracking for use with a shared-bus parallel-connected converter power system. Select, modify, and/or design an existing or novel approach that is best suited for controlling the power system architecture using parallel-connected converters. A primary goal of the approach should be to limit the array voltage ripple to a pre-determined amplitude [ref. 2] at a low fundamental frequency that allows for ease of compliance with conducted/radiated emission requirements. (2) Based on the control approach, determine the system guidelines to achieve robust system stability and reliability. (3) Develop the power system architecture/design to accommodate the interconnection of the power converters, the stable and nearly uniform current-sharing control, and the controller. (4) Validate the concept of the proposed power system architecture and control design with the results achieved from computer simulations and analyses of the system response.

PHASE II: (1) Finalize design of the power system and components (the individual converters, the current-sharing control circuitry, and the controller). (2) Simulate the system design and circuits through computer simulation and/or other analysis, to validate the design feasibility down to component level. (3) Generate the detailed schematic diagram of the designed and validated power system (with the current-sharing and control) and document all the design and simulation results. Construct a breadboard system and demonstrate (Air Force/Contractor) mutually agreed basic concepts.

PHASE III DUAL USE APPLICATIONS: The demonstrated feasibility of a highly reliable, cost-effective, high-power, active-controlled, COTS parallel-connected power converter system will attract DoD and commercial industry to apply the concepts in a wide range of future space power system and electric propulsion system applications.

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KEYWORDS: Power Converters, Electric Propulsion, Spacecraft Power Systems, Solar Arrays, Parallel Connected Modular Converters

AF02-041 TITLE: Advanced 10 Kelvin Cryogenic Cooling Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop 10 Kelvin cryocooler technology and multistage cooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in low temperature cryogenic cooling technology. Advanced infrared cooling systems will take advantage of the developments in doped silicon focal plane technology for improved system performance. However, to utilize the doped silicon FPAs, strides must be made toward advanced, space qualifiable and affordable 10 Kelvin cooling systems. Although numerous technologies have shown the capability to reach 10 Kelvin and provide periodic to continuous useful cooling, these devices are not suitable for space use - i.e. too massive, too inefficient, too unreliable and unable to meet mission lifetime requirements. Examples include periodic (duty cycle) closed cycle hydrogen sorption coolers, continuous closed cycle Stirling cycle coolers, and pre-cooled closed cycle Joule-Thomson cycle coolers. To efficiently achieve 10 Kelvin, many techniques utilize multistage cryocooler and multistage cryogenic cooling methodologies that offer large potential gains in cooling efficiency and cryogenic system optimization. Multistage cooling differs greatly from typical single stage cryogenic coolers and has a host of technical difficulties associated with the development of robust cryocoolers. Current systems reley on state of the art (SOA) technology that employs cooling at a single cryogenic temperature, necessitating the need for multiple coolers for the different cooling requirements such as the sensor, aft optics, and fore optics. If redundancy is required, then the number of cooler needed doubles to six and imposes significant system mass and power penalties on the spacecraft. One multistage cooler would potentially be capable of performing the same function as several single stage coolers. Improvements in current SOA technology range from reduction in overall system mass, large reductions in system power consumption, and large system reliability improvements by reducing the number of coolers needed and offering unique system redundancy schemes. In addition, technology challenges over the SOA such as temperature stability, variable loading, manufacturability, robustness for space application, and longevity increase the difficulty of the development of multistage cryogenic cooling systems. Examples of cooling technology include, but are not limited to, advanced multistage Stirling, pulse tube, reverse Brayton, multi-component multistage vapor compression, and Joule-Thomson thermodynamic cooling cycles that have the ability to absorb multiple continuous (100% duty cycle) cryogenic heat loads at different temperatures and reject heat to a single heat sink (300 Kelvin). Continuous cooling loads of interest include 0.25 to 1.0 Watts at 10 Kelvin with multistage cooling loads at 35 Kelvin, 60 Kelvin, and 95 Kelvin. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include cmos (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
2. R. C. Bowman Jr., B. D. Freeman, et al., "Design and Evaluation of Hydrogen Joule-Thomson Sorption Cryocoolers," Proceedings of the International Absorption Heat Pump Conference, New Orleans 19-21 Jan 1994, p. 265-271.
3. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, 10 Kelvin, Infrared Sensors, Cryogenics, Thermal Management, Low Temperature, Multi-stage

AF02-042 TITLE: Advanced Component Technology for Next Generation Cryocoolers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop advanced heat exchanger, regenerator, and long-life, high-pressure ratio compressors for advanced cryogenic cooling systems.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Many different techniques have been reported that have potential for marked improvement in cryogenic cooling technology. Examples include use of microelectromechanical systems (MEMS) technology, hybrid thermodynamic cooling cycles, highly effective and miniaturized counterflow heat exchangers, low temperature - high capacity regenerators, and long life, high pressure ratio DC flow compressors. MEMS technology and advanced manufacturing techniques have potential for use in minaturized coolers and as advanced heat exchangers that have applications in many cooling concepts including advanced reverse Brayton coolers, Joule-Thomson coolers, and hybrid expansion cycle coolers. The enabling characteristics of the heat exchangers are high effectiveness (>0.99) combined with low pressure drop and minimal mass and volume. Regenerators are utilized in Stirling cycle based cryocooler technologies (includes pulse tube technology). Low temperature regenerators suffer from the lack of heat capacity compared to the working gas at very low temperatures. It has been demonstrated that materials with magnetic phase transitions at low temperature offer potential benefits to regenerator technology, however new improvements in material science, manufacturability, robustness, and optimum geometry still need to be explored. In addition, high capacity regenerators for applications such as high capacity cooling at 10 Kelvin (500mW to 1W) and 35 Kelvin (3-10W) require innovative designs to enable efficient regeneration for the larger capacity heat loads. Long life (> 10 years, 100% duty cycle), high pressure ratio (4-6:1), DC flow (unidirectional flow) compressors are needed to enable the use of hybrid cooling systems that utilize a higher temperature cryocooler for pre-cooling and cool to low temperatures via a Joule-Thomson or other expansion cooling cycle. These key technology developments will enable future cryogenic cooling technologies and offer significant leaps in efficiency, performance, low temperature capability, and lifetime. Candidate technologies and concepts should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. These technologies are essential to meet future cryogenic cooling goals for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Regenerator, Infrared Sensors, Cryogenics, Heat Exchanger, Low Temperature, Compressor

AF02-043 TITLE: Advanced Multi-stage Cryogenic Cooling Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop multistage cryocooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Multistage cryocoolers and multistage cryogenic cooling methodologies offer large potential gains in cooling efficiency and cryogenic system optimization. Multistage cooling differs greatly from typical single stage cryogenic coolers and has a host of technical difficulties associated with the development of robust cryocoolers. Current systems reley on state of the art (SOA) technology that employs cooling at a single cryogenic temperature, necessitating the need for multiple coolers for the different cooling requirements such as the sensor, aft optics, and fore optics. If redundancy is required, then the number of cooler needed doubles to six and imposes significant system mass and power penalties on the spacecraft. One multistage cooler would potentially be capable of performing the same function as several single stage coolers. Improvements in current SOA technology range from reduction in overall system mass, large reductions in system power consumption, and large system reliability improvements by reducing the number of coolers needed and offering unique system redundancy schemes. In addition, technology challenges over the SOA such as temperature stability, variable loading, manufacturability, robustness for space application, and longevity increase the difficulty of the development of multistage cryogenic cooling systems. Examples of cooling technology include, but are not limited to, advanced multistage Stirling, pulse tube, reverse Brayton, multi-component multistage vapor compression, and Joule-Thomson thermodynamic cooling cycles that have the ability to absorb multiple continuous (100% duty cycle) cryogenic heat loads at different temperatures and reject heat to a single heat sink (300 Kelvin). Emerging multistage cooling needs range from dual load requirements such as 2 Watt at 35 Kelvin and 6 Watts at 85 Kelvin or 6 Watts at 80 Kelvin and 10 Watts at 150 Kelvin to three or more stages of cooling to meet system requirements for advanced infrared sensing and cooled optic systems. Phase I of the program should focus on exploitation, design, and breadboard demonstration of advanced technology with the potential for refinement in Phase II and III. Phase II and III will focus on achieving minimal to no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, and high reliability. All of these system attributes are essential to meet multistage cryocooling goals for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the development and demonstration the innovative technology in a breadboard format. This should include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler or as a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct an operational prototype device or cooler. This device may not be optimized to flight levels, but should demonstrate the ability of the working prototype device to meet mutually (Air Force/contractor) agreed operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Multi-stage, Infrared Sensors, Cryogenics, Thermal Management

AF02-044 TITLE: Advanced Thermal Integration Technology for Space Cryocoolers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop cryogenic and ambient thermal integration technology to enable efficient system integration of space cryocooler technology.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryogenic and ambient temperature cooling needs will require revolutionary improvements in thermal storage, thermal switching, high cryogenic and ambient heat flux applications, and thermal transport. Specific examples of thermal transport issues include very long cryogenic transport distances of 1-3 meters and flexible cryogenic and ambient heat transport technology to enable cooling across advanced 2 axis gimbals. Cryogenic applications involve locating the cryocooler remotely on the main body of the spacecraft and cryogenically cooling across an advanced 2 axis gimbal to cool optics or sensors. Ambient applications include removing ambient temperature waste heat from coolers or electronics on gimbal, across the 2 axis gimbal, and transporting the heat to radiators located on the main body of the spacecraft. Technology requirements include the capability for reliable long life operation (10 million+ full gimbal motion cycles), +/- 200° azimuth, +/- 90° elevation, induced torque < 10 in-oz, cryogenic heat transport of 10-20 Watts at 95 Kelvin or 3-6 Watts at 60 Kelvin, ambient heat transport of 200-300 Watts at 300 Kelvin. High heat flux applications include cooling 10s of watts at 35 Kelvin and up to 150 watts at 100 Kelvin with cooler interfaces of < 9 cm^2 and ambient cooling applications where 600 – 1000 watts of waste heat at 300 Kelvin must be extracted from interfaces with < 200 cm^2. Potential technology candidates include loop heat pipes, capillary pumped loops, heat pipes, active pumped loops, heat pumps, reverse Brayton cooler technology, and hybrid Joule-Thomson cooling systems. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. Flexible cryogenic and ambient cooling is essential to meet emerging requirements for advanced systems and is enabling technology for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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KEYWORDS: Heat Pipe, Space, Cryogenic Refrigerator, Flexible Lines, Infrared Sensors, Loop Heat Pipe, Thermal Management, Low Temperature, Capillary Pumped Loop

AF02-045 TITLE: Large Focal Plane Array Cryogenic Integration Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop cryogenic integration technologies to enable use of large format focal plane array sensors.

DESCRIPTION: Advanced space based infrared sensing systems will require significant advances in cryogenic integration technologies. Emerging mission requirements for large format or tiled focal plane arrays for infrared sensing applications are driving future cryogenic cooling and integration requirements. These large arrays, potentially 1026 x 1026 pixels and beyond, will require high capacity cooling and a host of cryogenic integration technologies including thermal storage, multiple interface cryogenic links, passive and active cryogenic heat transfer systems, fine temperature stability, low temperature gradient, and fine temperature control across large cryogenic interfaces. Examples of potential cryogenic integration requirements for thermal storage include modular and integral thermal storage units with potential aluminum or beryllium thermal interfaces that are capable of 1500 Joules at 10 Kelvin, 50000 Joules at 35 Kelvin, or 150000 Joules at 60 Kelvin. System needs also include multiple cryogenic interfaces with technical hurdles such as large interfaces (potentially 625 cm^2), tiled FPA assemblies each requiring cooling, low thermal resistance thermal interfaces, and highly flexible thermal interfaces. Cryogenic heat transfer needs include robust, long life potential technology that can accommodate redundant systems with minimal parasitic heat penalties, peak heat loads at 10 Kelvin of 1.5 Watts, peak heat loads at 35 Kelvin of 10 Watts, or peak heat loads at 60 Kelvin of 20 Watts. This also includes temperature stability of < 0.1 Kelvin per minute and temperature gradients of < 0.1 Kelvin gradient across the FPA. Cryogenic integration technology is enabling for exploitation of emerging concepts for future space based infrared systems. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. Cryogenic integration technologies capable of meeting advanced requirements are essential to support future Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include cmos (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

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KEYWORDS: Cryogenic Heat Transfer, Space, Cryogenic Refrigerator, Cryogenic Integration, Infrared Sensors, Cryogenics, Thermal Management, Low Temperature, Thermal Storage

AF02-046 TITLE: High-Performance HgCdTe VLWIR Photovoltaic Detectors

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative methods to decrease the dark current and improve the detectivity of HgCdTe very long wavelength infrared (VLWIR) photovoltaic detectors.

DESCRIPTION: HgCdTe VLWIR (14 micron and longer cutoff wavelength) photovoltaic detectors with high performance are necessary for a variety of US Air Force missions. For this reason, at the present time many organizations are actively pursuing research and development 1-3 of HgCdTe VLWIR photovoltaic detectors. However, the performance of these detectors rapidly decreases as the cut off wavelength is increased, due to rapid increase in the dark current. Hence there is a need to develop innovative methods to decrease the dark current and improve the detectivity of HgCdTe VLWIR photovoltaic detectors.

PHASE I: The contractor will explore one or more innovative solutions to decrease the dark current and improve the detectivity of HgCdTe VLWIR photovoltaic detectors operating at 40-77K. Conduct laboratory scale experiments to demonstrate the viability of the proposed solution.

PHASE II: The contractor will pursue the innovation found to be most promising in phase I, in order to develop HgCdTe VLWIR photovoltaic detectors exhibiting performance better than current state-of-the-art. The contractor will develop demonstration devices and small arrays, and evaluate their performance.

PHASE III DUAL USE APPLICATIONS: Military applications of HgCdTe VLWIR detectors include improved space surveillance and threat warning capabilities, where the ability to detect faint objects at great distances is critical. Commercial applications include industrial and auto- emission monitoring, tumor detection, environmental monitoring, fire and volcano detection etc.

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KEYWORDS: HgCdTe, VLWIR, Infrared, photovoltaic, dark current, detectivity

AF02-048 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of innovative algorithms to optimize detection, identification and tracking of objects in structured environments.

DESCRIPTION: The Air Force Research Laboratory's Advanced Optical Technologies Branch (AFRL/VSBT) solicits innovative algorithms for the mitigation of clutter effects in order to optimize the performance of space-based optical (visible and infrared) reconnaissance and surveillance systems. It is expected that new, signature-based, object-detection algorithms will be developed and tested. Figures of Merit in assessing algorithm effectiveness include improvements in material identification, enhanced probability of object detection in structured backgrounds and reduced probability of false alarms.

PHASE I: Develop advanced algorithms for clutter mitigation / contrast enhancement, using optical data (visible and infrared) from airborne and space-based sensors, to optimize detection, identification and tracking of objects of interest in structured environments. Validate and optimize algorithms. Compare and contrast the candidate algorithms developed.

PHASE II: Demonstrate the efficacy of the algorithms developed in Phase I for detection, identification and tracking of objects in structured environments using field data. Develop and demonstrate an automated, near-real-time, prototype processing system to assess the effectiveness of the target detection, identification and tracking algorithms developed and validated using real-world data sets.

PHASE III DUAL USE APPLICATIONS: The novel algorithms and processing techniques developed under this effort will find application in Phase III in military systems requiring autonomous stand-off detection of objects in the presence of sensor clutter induced by scene structure and the data-collection process, and by spectral interferences. The algorithms will potentially also be useful in non-military applications requiring autonomous detection of objects of interest under similar conditions of scene-induced and sensor-induced clutter and noise, and spectral interferences. Potential commercial applications include processing systems for object detection, and characterization and tracking in fields such as medicine, industrial processing and quality control.

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KEYWORDS: Multi-spectral, Hyper-spectral, Ultra-spectral, Visible, infrared, Data analysis, Data processing, Algorithms

AF02-050 TITLE: Small Launch Vehicle Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative Small Launch Vehicle technologies that provide cost effective Spacelift solutions for Small-Sat architectures.

DESCRIPTION: As satellite micro-miniaturization technologies show increasing promise in improved mission capability at significantly reduced spacecraft weight and cost, a complementary need will undoubtedly exist for a responsive, cost effective Small Launch Vehicle (SLV). Innovative technologies are being sought that address SLV cost reduction in the areas of avionics, propulsion, airframe and structures, manufacturing, integration, and/or operations. A vehicle focus provides for a structured SBIR technology program: i.e. overarching system requirements that define supporting technology needs. This topic seeks to accomplish the development of enabling technologies for future, cost competitive SLVs capable of deploying small satellites (100-1000lbs.)

PHASE I: Develop a suborbital vehicle conceptual design, traceable to a SLV, whereby specific technology requirements are identified for Phase II cost reduction demonstrations. Develop a cost reduction technology risk mitigation plan that addresses identification, rationale, conceptual design, and test exit criteria of high-risk component(s) that will be ground tested under Phase II.

PHASE II: Refine the design of the suborbital vehicle and carry on the research and development of the selected technology up through the prototype phase. The prototype hardware shall emphasize cost reduction technologies, possessing sufficient design information to fabricate, integrate, and operate the advanced component(s). The contractor shall perform prototype ground test and evaluation of the enabling component (s) per the Phase I technology risk mitigation plan. Phase II shall demonstrate critical cost reduction component(s) that sufficiently demonstrate required subsystem performance and reliability. The government will evaluate this information to determine whether a follow-on Air Force funding Phase III suborbital flight program is warranted.

PHASE III DUAL USE APPLICATIONS: Dual use applications include target vehicles, sounding rockets, and strap-on boosters. Enabling technologies that evolve from this program are directly traceable to a future, low cost SLV. A low cost SLV would enhance the launching of military tactical satellites for theater Intelligence, Surveillance and Reconnaissance (ISR). A low cost SLV would also enhance the deployment of commercial LEO Communications Constellations (e.g., Store and forward paging communication systems) when compared to the current cost of existing SLVs. Other dual use variants of this technology include booster and/or upper stages systems for larger launch vehicles. If Phase II technical exit criteria are met and commercial and/or government (non-SBIR) program funds are identified for Phase III, the contractor shall design, fabricate, integrate, and flight-test the sub-orbital vehicle as defined under Phases I-II.

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KEYWORDS: Launch Vehicle Design, Sub-Orbital Vehicle, Satellite Micro-miniaturization, Technology Risk Mitigation, Flight Test and Evaluation, Small Launch Vehicle

AF02-051 TITLE: Small Shuttle-Compatible Propulsion Module

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop technologies that emphasize improvements in orbit transfer propulsion safety, performance, and cost reduction that are applicable to a small Propulsion Module (PM) deployed from the Space Shuttle.

DESCRIPTION: The Air Force Space Test Program (STP) requires the ability to raise the orbit of small experimental satellites, deployed from the payload bay of a Space Shuttle, to achieve longer, more useful missions. A critical need exists to develop innovative propulsion technologies that simultaneously address NASA Shuttle Hitchhiker Experiment Launch System (SHELS) safety and STP orbit transfer propulsion performance requirements. Due to current technology limitations, no experimental payload has ever been propulsively boosted to higher orbits when deployed from SHELS. The problem is that existing propulsion technologies either do not meet Shuttle safety or STP performance requirements. The objective of this project is to develop propulsion technologies that satisfy SHELS safety while achieving the minimum STP prerequisite orbit transfer performance requirements. Additional technology considerations necessitate modular, cost effective, and operable propulsion solutions that are commensurate with the SHELS secondary payload environment. The Air Force STP has a minimum propulsion system technology goal that will raise the orbit of a181 kg small payload from a 352 km to a 704 km circular orbit. Of the 181 kg payload, 125 kg is allocated for the experimental satellite, leaving no more than 56 kg for the PM.

PHASE I: The contractor shall develop obit transfer propulsion technologies that are derived from a conceptual PM system design that meets NASA and STP requirements. The contractor shall perform PM performance prediction based on parametric studies for selected technologies and propellant combinations that address the optimal design solution for safety, performance, and cost. A PM technology safety and performance risk analysis is required that: 1) identifies critical propulsion component technologies to be demonstrated in Phase II and 2) a technology risk mitigation plan with discernable exit criteria for government evaluation of high-risk PM components.

PHASE II: The contractor shall design, fabricate, and ground test prototype high-risk PM components identified under Phase I. Contractor PM components will be evaluated against Phase I exit criteria, Shuttle safety, and STP performance requirements.

PHASE III DUAL USE APPLICATIONS: Dual use applications include development of safe, low cost upper stage and orbit transfer technologies for the private sector, while the Air Force STP obtains new operational capabilities for increasing the life span of experimental spacecraft deployed from the Space Shuttle. If Phase II PM components meet all requirements identified in Phase I/II, and government program (non-SBIR) and/or commercial funding is available for a Phase III award, the contractor shall design, fabricate, integrate, and ground test a flight-representative PM. The contractor shall present to the government the PM system design and qualification test results for STP flight approval.

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3. Spartan Lite Propulsion Study, Revision 1, Dated 1 October, 1998; CoverLetter 860.G, Goddard Spaceflight Center, Dated 5 October, 1998.
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5. Design Considerations for Orion Satellite Structure Propulsion & Attitude Control Systems for Small Satellites, A. W. Boyd, Naval Post Graduate School, ADA193837

KEYWORDS: Space Shuttle, Propulsion Module, Orbit Transfer, Spacecraft, SHELS

AF02-052 TITLE: Payload Adapter for Satellite Missions Launched using ICBM-derived Launch Vehicles

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop Payload Adapter Technologies for Satellites that will reduce Spacecraft Launch Costs by enabling multiple payload manifests.

DESCRIPTION: The DoD is interested in developing new low-cost launch vehicles using deactivated ICBMs. The Atlas II, Titan, Taurus (Peacekeeper Stage 0), and Minotaur (Minuteman II Stage 1,2) vehicles are examples of this trend. One of the problems with this approach is that the payload accommodations typically used in ICBMs are designed to hold re-entry vehicles and are inadequate to support satellites. The objective of this project is to develop low-cost, lightweight, modular, payload adapters to manifest multiple satellites on these new launch vehicles. The adapter shall accommodate one large satellite (2000 lb class payload) and have flexibility to carry secondary payloads as well (free-flyer satellites, parasite payloads, and subsystems such as attitude control, power, etc.). Key technologies include, but I are not limited to, material and manufacturing related technologies. Existing materials and composite manufacturing technologies will not be able to meet the structural and mechanism support requirements of satellites/payloads that would be mounted on these new vehicles. The contractor should explore new composite materials, composite materials manufacturing processes, composite/metal joining techniques, re-configurable design issues, and strength/weight optimized composite structures. The contractor is encouraged to identify key technologies that this SBIR topic has not specifically addressed. Technologies developed need to address issues such as reliability, safety, weight, reduced part count, low cost manufacturing, integration, and the configuration flexibility to meet the requirements of a variety of spacecraft/payloads. Associated technologies include payload environmental isolation, low-shock satellite release systems, and accommodations for various subsystems (attitude-control, power, etc.). These technologies are the subject of other AFRL-funded projects already in work. This proposed SBIR project will allow us to incorporate these other technologies into a capability that will facilitate technology transfer of all projects.

PHASE I: Identify materials and manufacturing methodologies compatible with a conceptual design for the multiple payload adapter. Establish a program plan that identifies high-risk technologies that will be demonstrated in Phase II and outlines a strategy to integrate these key technologies into a prototype payload adapter system. The program plan should also include projected costs, and a test plan with discernable exit criteria for government evaluation of high-risk payload adapter components. Key technology risk mitigation efforts should include subscale proof-of-concept demonstrations and analysis that paves the way to scale the technology to a full-scale system. Evaluation of the payload adapter concept will be based upon review of the following parameters : system safety, adapter manufacturing costs and associated touch labor, system mass and volume, launch vehicle integration efficiency for a range of existing launchers, satellite integration efficiency, launch/acoustic/shock load survival.

PHASE II: Design, fabricate, test and demonstrate prototype hardware for the payload adapter system identified in Phase I. The prototype adapter should incorporate as many of the key technologies as possible, depending on available funding. A detailed performance analysis of the technology is also required. If funding allows, the contractor shall support potential launch and integration activities thereof. The demonstration’s success will be evaluated in accordance with Air Force specifications, performance, manufacturability, and cost guidelines. A strategy to transition the technologies developed for current and future spacecraft is strongly encouraged.

PHASE III DUAL USE APPLICATIONS: Currently, there are a growing number of small/micro satellites being launched by the government and universities to support small space experiments. However, industry has not adapted to this sudden shift in paradigm from the large single payload to several small payloads. In order to reduce soaring launch costs, DOD, NASA, and the commercial sector has a need to launch small multiple satellites on a single launch vehicle. Military applications include programs such as TechSat 21, XSS-10, and the Air Force's Space Test Program, commercial applications include the small/micro satellites university payloads and experiments that are now being launched. The basic technologies explored in this project (space-qualified composite materials, modular design, composite/composite and composite/metal joining, etc.) have a high potential for spin-off into other aerospace-related programs such as modular satellite structures.

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KEYWORDS: Multiple payloads, Multi-functional, Spacecraft, Low-cost, Mechanisms, Deployment, Separation, Composites

AF02-054 TITLE: Insulated Stainless Steel or Molybdenum Substrate for Thin Film Photovoltaics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: The goal of this SBIR effort is to develop and enable monolithic integration of thin film photovoltaic cells into series connected strings of cells and likewise enable incorporation of monolithic diode protection into solar arrays.

DESCRIPTION: As a result of the promise of much lower cost per watt and the lower mass per watt produced as compared to monolithic crystalline solar cell technologies, the U.S. Air Force is developing thin film photovoltaic cells and modules for use on high power satellites. For example, one of the key technologies with high potential for satisfying the cost/watt and the watt/kg figures of merit for thin film photovoltaics are the copper indium gallium di-selenide (CIGS) technologies. Thin film solar cells are much less costly than their crystalline counterparts when compared at the cell level, but substantial costs savings can also be realized with thin films by producing large area cells and by monolithically integrating rolls of cells, directly from the fabricating machine, into strings of interconnected cells, thereby eliminating the expensive touch labor that will be required to actually cut cells and weld them together in cell strings. A monolithic production capability will also positively impact yields and provide a more robust cell string, eliminating the human factors present in touch labor processes. Presently, CIGS technologies require relatively high processing temperatures that are too high for optimized processing on polyimides, therefore device fabrication takes place on stainless steel or molybdenum foils. This precludes monolithic device integration such as series connection of solar cells and incorporation of bypass and blocking diodes, processes that are analogous to crystalline solar cell panel and array fabrication and accepted industry practice, because the device is produced on a conductive substrate and simple etching procedures cannot expose an insulating or conductive layer to isolate or interconnect cells with relative ease. The key to implementing monolithic processes is incorporation of an insulating layer between the active cell and the substrate. Monolithic device fabrication has been an extremely difficult feature to incorporate into thin film cells while maintaining performance. There are two distinct avenues to monolithic integration of thin film cells, one is to produce sufficiently high efficient cells on a polyimide, a process that has met with mediocre success to date as a result of low process temperatures, the other is to develop an insulating layer on the metal foil on which cells are presently manufactured. This second method allows thin film cells to be manufactured to the full potential of the technology since all substrate layers must be able to withstand full process temperatures. The use of polyimides could offer the same potential performance of thin film cells on metal foils since even if efficiencies are compromised the substrate mass could be sufficiently reduced to achieve competitive cost per watt and watt per kilogram performance data. Regarding the technical risk of the effort, this can be measured by past efforts of industry to develop and incorporate an insulating layer in the CIGS on metal foil technologies. The risks have been shown to reside in the ability to match the coefficient of thermal expansion between the insulating layer and the CIGS, providing a pinhole free layer over a large area, and in providing a layer that resists de-lamination. Thin film, low cost photovoltaic devices are becoming increasingly attractive to consumers as an alternative to obtaining power from the grid. Recent events in California where power costs have skyrocketed due to the ever increasing demand for power and the difficulty of power companies to obtain building permits for new power stations due to environmental regulations have resulted in no new plants being built for a long period of time, and any new plants will take years to build. This has created a vacuum in power production that thin film photovoltaics could fill if the price is right. Success in efforts such as this one that drive the cost of production down and result in robust cell strings will create significant revenues for an enterprising business. Roll to roll manufacture of thin film technologies have been successful to date, however, there is still much touch labor in making strings of cells to produce high operating voltages and as always, this labor is expensive and efforts prone to mistakes. This represents a very good opportunity for a small business to enter this market and make a large impact.

PHASE I: A suitable endeavor for phase one would be to identify candidate insulating layers that can be deposited on a stainless steel or molybdenum substrate that show good promise for use as a large area pinhole free insulating substrate with minimum tendency to de-laminate under all operating conditions.

PHASE II: The goal of phase II is to fabricate a string of monolithically integrated cells showing proof of principle, incorporation of diode protection for thin film cells is of secondary importance since it has yet to be shown that such protection is necessary as a result of the soft characteristics of thin film photovoltaics. Using devices of areas consistent with the state of practice:1) Demonstrate large area devices with pinhole free insulating layer. a. Determine de-lamination potential under operating conditions. b. Determine operating characteristics at various temperatures for mismatched CTEs. c. Perform light and dark I-V measurements of cells with insulating layer to ensure that performance has not been compromised. 2) Demonstrate monolithic integration of cells into a string of series connected cells of sufficient number to show proof of concepta. Produce light and dark I-V characteristics of string.b. Operate under simulated array conditions and observe nature of cells in reverse bias conditions. c. Place string under mechanical tension similar to what will be placed on a space based array (information provided by government program manager upon request) and observe operation.Also, it would be ideal, if sufficient funding is available, to demonstrate monolithic construction of bypass and blocking diodes.

PHASE III DUAL USE APPLICATIONS: Commercialization efforts would be focused upon transitioning the laboratory scale processes developed in Phase II to a prototype manufacturing capability. The government application of this technology would be devoted to enabling efficient, cost effective and robust production of cells for the Power Sail and Techsat 21 programs, and the insulating layer can be envisioned for a number of high temperature growth processes for use with sensors and other thin film electronic devices. The commercial application of the results of this program would be to drive the cost of manufacture of thin film photovoltaics down to the point where it is commercially competitive to power from the grid thereby tapping enormous markets. Further, commercial applications for high temperature insulating thin films should be numerous and will depend on the innovativeness of the entrepreneur.

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KEYWORDS: Solar Cells, Power Conversion, Photovoltaics, Solar Cell Arrays, Conversion Efficiency, Flexible Thin Film Photovoltaics

AF02-055 TITLE: Star Trackers Based Upon Advanced Sensor Technologies

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a star tracker based upon space-qualifiable advanced focal plane array technologies

DESCRIPTION: Modern star trackers are based primarily upon Charge-Coupled Device (CCD) image sensors. CCDs are sensitive to the space radiation environment and may degrade rapidly under the influence of energetic particles and photons. Recently, new types of image sensors have been developed that show promise of being more radiation-tolerant than CCDs. These include arrays of various types of photodetectors including photocapacitors, pin-photodiodes, and pn-photodiodes. These devices are sometimes called Active Pixel Sensors (APS) because, in contrast to CCDs, the individual pixels can be addressed. Nonetheless, no commercially available star tracker has been built based upon these devices. The hardware and software required will be substantially different than for star trackers based upon CCDs in order to take advantage of the capabilities of these modern focal plane arrays. For example, photodetector image sensors based upon Complimentary Metal-oxide Semiconductor (CMOS) processing may include features such as on-chip analog-to-digital converters, on-chip correlated double sampling, and addressability of individual pixels. Proposals should indicate how their approach will enable features not currently available on star trackers. Development/integration of star trackers based upon modern focal plane arrays (not including CCDs) to applications of greatest utility to USAF satellite programs are of high interest.

PHASE I: Develop concepts and models for the hardware and software necessary for the operation of a modern focal plane array (not including CCDs) as star trackers to facilitate features such as on-chip analog-to-digital conversion, on-chip correlated double sampling, and addressability of individual pixels. Phase I activity should consider innovative concepts for the survivability and performance of star tracker components for systems consistent with the use of microelectronic devices for applications of interest to military programs.

PHASE II: Design, fabricate, and perform experimental validation, and optimization, of a prototype star tracker utilizing an advanced radiation tolerant APS focal plane array.

PHASE III DUAL USE APPLICATIONS: Radiation-tolerant star trackers will support a broad range of DoD, NASA, and commercial satellite systems, as well as NASA deep space missions. Advanced star trackers applicable to military satellites can be cost effectively redesigned for terrestrial commercial use.

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KEYWORDS: Star tracker, Focal plane array, Active pixel sensor, Pin-photodiode array, pn-photodiode array, Radiation effects.

AF02-057 TITLE: Polarization Phenomenology Modeling and Simulation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop new polarization modeling software or develop new polarization instrumentation for use in understanding polarization phenomenology.

DESCRIPTION: AFRL is engaged in research and development to further the understanding of optical polarimetric phenomenology. One advantage of using polarization is that it can improve contrast for a number of object detection and discrimination applications. Emissive polarization can possibly be used to detect an object from background in an isothermal scene where conventional infrared sensors would detect little or no contrast. Of particular interest are the spectral polarization signatures of objects measured passively in outdoor environments. Polarization phenomenology investigations must first start with an understanding of the raw polarization signatures from objects of interest. The emitted and reflected portions of the polarized light depend on the material characteristics of the object, such as surface roughness, index-of-refraction, and object geometry. The overall phenomenological studies must also take into account environmental variables that affect the polarization signal measured by a detector. Sky illumination is the most significant environmental variable that changes the apparent object signature, but influences of atmospheric propagation may also be present. Because the environment can have a great effect on polarization signatures, modeling and simulation, incorporating material characteristics and environmental variables, will be used to develop a better theoretical understanding of the physics behind measured signatures and to predict polarization signature outdoors. With this in mind, the ability to perform object-to-sensor simulations of polarization measurement scenarios is required. Data from a controlled environment, showing raw polarization signatures, and field data, showing environmental effects, are being collected to validate specific models and the overall simulation. AFRL is requesting proposals in two related areas. First is the development of new polarization modeling software packages that can be used in investigating polarization phenomenology. This package would aid in predicting polarization from surfaces, the atmosphere, or be an integrated predictor of the total polarization measured by a sensor. Second, AFRL is requesting novel approaches to building polarimeters for use in phenomenology studies. The needed polarimeters include full polarization, spectral capability, measure polarization simultaneously, and can be accurately calibrated. Since accurate data is needed for phenomenology, part of the potential effort would include investigating the calibration of the polarimeter system.

PHASE I: Develop approaches for a polarization modeling software package or conceptual designs for a polarimeter suitable for phenomenology studies.

PHASE II: Develop applicable and feasible prototype models, software, or instrumentation using the Phase I results and demonstrate a degree of commercial viability.   Prototype software would be used to compare predicted polarization to some measured results.   Prototype sensors would demonstrate capabilities and include a detailed plan for calibration.

PHASE III DUAL USE APPLICATIONS: Many military applications will benefit from using optical polarization, and thus will take advantage of the successful completion of the Phase II effort. Remote sensing with polarization has potential applications in the commercial market as well, particularly in improved environmental assessment.

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KEYWORDS: Polarization, Polarimetry, Remote Sensing, Modeling, Simulation, Validation Experiments, Spectral Polarization

AF02-058 TITLE: Geophysical Interpretation of Digital Ionosonde Signatures

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate software and hardware techniques implementing innovative algorithms for extracting key geophysical parameters from digital ionosonde data

DESCRIPTION: Accurate determination of ionospheric conditions including the electron density altitude profile, electric fields, plasma irregularity locations, and irregularity spectral characteristics is essential for the development and reliable operation of many modern ground and space-based communications, navigation, and radar systems, in both military and commercial applications. These geophysical parameters are also critical inputs to space weather monitoring and forecast models developed and operated by the DoD and civilian government agencies. Radio frequency sounding using ionosondes has historically been one of the most versatile and cost-effective means of obtaining ionospheric information, but interpretation of ionosonde data has traditionally required labor-intensive analysis by experienced observers to accurately determine even basic parameters such as the bottom-side density profile. This proposal calls for the development and application of modern digital data acquisition and processing technologies to greatly expand the geophysical information content extracted from the ionospheric sounding process. Basic research has shown that electric fields, waves, neutral winds, neutral composition, horizontal electron density gradients, D region densities, particle precipitation, and both large- and small-scale irregularities are all critical parameters having observable signatures in digital ionosonde data, but this valuable information remains unexploited and unavailable due to the lack of suitable computer algorithms to analyze the data or by limitations in the hardware used to obtain the data. For example, ionospheric irregularities under high latitude patch and equatorial spread-F depletion conditions could be detected, imaged, tracked and characterized in terms of their location, intensity and spectral characteristics. Precipitating particles in the high latitudes generate ionospheric signatures that can be related to the energy flux of the incoming particles. Development of computer algorithms to extract additional ionospheric parameters or improve the reliability of currently available parameters is a complex task requiring an innovative approach likely to result in development of valuable new signal processing algorithms and enhanced measurement techniques. Software modules implementing these techniques could be incorporated into new sounder systems or licensed for use with the large number of existing ionosondes in operation around the world. Hardware developments could be marketed as a next generation ionosonde. The DoD has significant investment in the field of ionospheric measurement, including archived and current data, field sites, digital ionosonde hardware, and validation sensors. These resources can be made available for adaptation and use in research, testing, and validation of products developed under this topic.

PHASE I: Develop innovative algorithms for automated identification and quantification of significant geophysical parameters from digital ionosonde data. Design any necessary new hardware or hardware modifications.

PHASE II: Produce prototype hardware and software modules implementing the algorithms and techniques produced in Phase 1 and demonstrate their ability to process actual data from high-, mid- and low-latitude ionosondes. Validate the output parameters by comparing to other sensor data where possible.

PHASE III DUAL USE APPLICATIONS: Products based on successful developments in Phase II are expected to greatly enhance the utility, increase operational effectiveness and decrease the cost of existing ground-based ionosonde networks operated by the DoD and allied nations by enhancing hardware and data archives to provide additional parameters for input to space weather models and forecast products. In the civilian and commercial sector, which accounts for 80% of the ionosondes operated worldwide, the technologies could be adapted or ported for incorporation into real-time operating software for new ionosondes, modified and licensed for use with hundreds of existing sounders operating around the world, form the basis for a new generation of advanced ionosondes, or marketed independently of sounder hardware for use in processing ionosonde data archived in global data centers worldwide. The availability of reliable software capable of accurately extracting multiple geophysical parameters from ionosonde data can be expected to boost worldwide demand for ionosondes as the primary ground-based sensors for space weather monitoring and forecast networks. This will benefit the U.S. government as well as other organizations.

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KEYWORDS: ionosonde, plasma, ionosphere, signatures, space weather, radio propagation

AF02-059 TITLE: Smart Membrane Structures

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Model, develop, and demonstrate novel ultra-lightweight curved structures capable of optical precision.

DESCRIPTION: Innovative approaches are sought for developing ultra-lightweight structures capable of optical precision for 10m and greater diameter optical systems. Of primary interest is the blending of ultra-lightweight structures such as membranes with highly innovative sensing and control approaches such as those based on the latest smart materials developments. The ultimate goal is to develop large (10m or greater) optical systems which are lightweight (1kg/m^2 or less areal density), stowable within existing small to medium launch systems, reliable, and cost-effective.Geometric nonlinearities cause large flexible membranes to deviate from an ideal parabolic shape upon deployment. Techniques that have been used to 'correct' the shape have included piezo-polymer (PVDF) films, electrostatic actuation, and net-shape casting of membrane structures. It is envisioned that a newer class of smart materials such as shape-memory films and piezo-ceramic fibers could enable full-surface actuation with greater control authority. The 'Smart Membrane Structure' should also be able to correct itself for mission induced thermal excursions and incorporate active damping.The eventual goal of this technology development is to enable optical imaging, therefore micron or submicron level of surface accuracy is desired, depending on the use of secondary image correction techniques. The ability to detect surface accuracy for very large structures to these levels of precision is also a part of the design challenge for the successful implementation of the technology. Analytical tools employed towards these goals should be capable of adequately modeling the physical phenomena and correlate with the metrology tools used to validate the models and implement the system.

PHASE I: Analyze recent developments in smart materials and structures to develop a concept appropriate for a smart membrane mirror. Design the necessary deployment, actuation and metrology system. Demonstrate feasibility through analyses and scaled testing.

PHASE II: Finalize the Phase I conceptual design and then based on that design, develop and demonstrate a subscale smart membrane engineering development unit for testing at the Air Force Research Laboratory. Demonstrate traceability of the technology to >10meter diameter optical systems.

PHASE III DUAL USE APPLICATIONS: Large lightweight mirrors will enable space based imaging with significantly greater resolution (few centimeters from LEO orbit). Improved resolution will also address the future needs of NASA's ORIGINS program.

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KEYWORDS: composite, structures, membranes, smart structures, smart materials

AF02-060 TITLE: Long-Stroke Isolation System for Large Flexible Space Structures

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a lightweight, articulated boom concept for connecting two spacecraft that isolates the spacecraft dynamics while allowing for slewing.

DESCRIPTION: Future concepts for deployment of very large solar arrays and antennas require the dynamic isolation of these large flexible structures from the host spacecraft. This isolation systems will have to meet many demanding requirements including: accommodation of large slewing motions of both spacecraft (e.g. solar arrays tracking the sun, scanning of antennas, etc.), maintain position knowledge and relative placement of spacecraft for collision avoidance, capable of incorporating high-power transmission and data lines, and have efficient packaging and on-orbit deployment.Preliminary analysis has shown that use of lightweight, flexible umbilical connections for isolation and power and data transfer have an inherently high level of risk concerning positioning and the possibility of collision/entanglement between the array/antenna and host spacecraft. To address these shortcomings, a new connection scheme is required to enable attachment of large solar arrays without the risk of collision or entanglement. This concept must be able to not only isolate the flexible dynamics of the large, lightweight structures from the host spacecraft as well as accommodate the large-stroke motions that are generated from the disturbance differential of the spacecraft, but it must also provide a level of certainty in connection position to prevent inadvertent collision during solar array or host spacecraft operations. One possible solution is a multi-link articulated boom with actively controlled joints that is capable of transmitting power and data from the array to the host spacecraft. Such a connection scheme is expected to enable long-stroke motion and isolation of flexible dynamics, as well as provide a means of configuration control.

PHASE I: Establish concept feasibility for lightweight articulated boom capable of positioning and dynamically decoupling a large flexible structure from a host spacecraft. Through modeling and simulation establish rough suitability for space applications based on cost, mass, survivability in space environment, ability to accurately control boom configuration, degree of isolation of flexible dynamics from the flexible structure to the host spacecraft, and compact packaging. Compare the articulated boom concept to traditional array attachment and isolation approaches. Develop a program plan that shall incorporate an implementation strategy/methodology for the new technologies, projected system and subsystem level payoffs, a detailed technical challenge breakdown, risk mitigation strategy, proposed program schedule, and estimated costs. The primary result of Phase I shall be a well-defined Phase II development and demonstration plan.

PHASE II: Develop and demonstrate prototype hardware for the concept identified in Phase I. Tasks shall include a detailed proof of concept demonstration of key technical parameters, which can be accomplished at a subscale level. A detailed performance analysis of the technology is also required. The demonstration’s success will be evaluated in accordance with Air Force specifications, performance, manufacturability, and cost guidelines. A strategy to transition the technologies developed for current and future spacecraft is strongly encouraged.

PHASE III DUAL USE APPLICATIONS: There is significant interest by commercial satellite manufacturers for dramatic increases in on-orbit power. Increased power would increase the number of transponders on each spacecraft resulting in increased profits. The ability to dynamically isolate these arrays is critical in allowing for continued array growth. This technology would also apply to other attached flexible structures such as antennas and to on orbit docking and servicing.

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KEYWORDS: Articulated boomSpacecraft IsolationFlexible Structures ControlSpace Power Generation

AF02-062 TITLE: Autonomous Satellite Cluster Data Fusion

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop technologies to enable the assimilation of multiple information sources across a satellite cluster and provide intelligent reasoning.

DESCRIPTION: The concept of using clusters of microsatellites to replace large monolithic satellites is a relatively new idea. With this new concept comes many new challenges which include how information is shared across the cluster and how communication with the ground is handled. At the present time there is very little automation on-board Air Force satellites as relates to surveillance payload missions. Large amounts of data are collected from each satellite and downlinked to the ground where a variety of independent techniques are used to assess whether there exists any information of value. In addition there is virtually no collaboration between satellites with respect to each other’s position or knowledge about detected objects of interest. The amount of data collected and downlinked could be drastically reduced if more intelligence is placed on-board which has the ability to process, detect, and interpret information on-board the cluster and adjust and/or configure sensors accordingly based on sensor data. The objective of this research effort is to develop an architecture which will enable knowledge sharing across a cluster of satellites. Each satellite in a cluster would have its own on-board satellite manager which would manage activities on-board its own satellite. A higher level cluster manager would reside at a higher level and manage the overall cluster activities. Each satellite’s on-board controller would operate autonomously in cooperation with executive controllers on-board other satellites as well as ground-based controllers. Each of these controllers would act as top level intelligent agents. A key to this research effort is the ability of the individual spacecraft managers to cooperate with one another. For example an agent residing on one satellite may detect some object of interest and react accordingly. To optimize information processing, relevant information can be made available to a second satellite such that when the object comes within its field of view it can already be configured to optimize observation of the object in question. The notion of an intelligent cluster manager can be extended to include health and status related satellite autonomy.

PHASE I: Provide a detailed design and description for the architecture which will enable information fusion across a satellite cluster. This will include but not be limited to the following, (1) mechanism by which knowledge is shared, and (2) means by which a situational assessment is made based on the status of information sources. A demonstration of the proposed architecture is highly desired.

PHASE II: Do a detailed implementation of the design generated in phase I and to provide an in depth demonstration of its capability. The architecture should be designed such that it can be easily extended to incorporate new agents as needs arise. Demonstration of this extensibility/flexibility is desired. Demonstrating this technology in an actual flight experiment is ideal, however if time and cost prevent this then the demonstration should be as realistic as possible with an easy migration towards a flight experiment.

PHASE III DUAL USE APPLICATIONS: The concept of data fusion of heterogeneous information sources is not specific to satellite autonomy but has applicability to any number of different domains. Any process which involves monitoring a number of different entities from different sources and providing a situational assessment based on all of these entities could benefit from such an intelligent architecture.

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4. Agent Technologies HomePage, www.agenttech.com 5. Ballard Dan, “Intelligent Agents and Agent Communication Languages for Mission Operations”, Phase I SBIR Final Report by Reticular Systems, Contract #NAS5-33264, Jun 1996.

KEYWORDS: Satellite Autonomy, Intelligent Decision Making, Cluster Management, Information Fusion

AF02-063 TITLE: Remote Satellite Diagnostics

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Determine the condition of a satellite from external means.

DESCRIPTION: The Air Force is developing technology for future on-orbit maintenance and servicing as well as increased space situational awareness. One of the needs is the ability to remotely or externally diagnose a satellite. What is desired is the ability to determine if satellite subsystems are operating normally. If they are not, one would like to know how they are out of spec and what the cause may be. The capability would be applied to a satellite that did not have sufficient capability for self-diagnostic built in or one where the satellite was unable to communicate to the ground for some reason. Once the problem is determined, a course of action can be planned. The capability would also be useful for determining if other countries satellites were operating as they were reported. For instance, if a country says its satellite has died, the AF could then verify if this is true or not. The types of subsystem information that is desired includes: (if the solar arrays are operating and at what power level, if ACS thrusters are operating as expected, if momentum wheels are operating and are they saturated, what the power draw on the satellite is from its thermal or RF emissions, are the communication antennas operating and what are they broadcasting, what is the activity of the processor and spacecraft electrical bus, what is the level of fuel remaining, what is the condition of payloads such as communication antennas or imaging sensors.) There are a number of means to sense this information. Examples information that may be used includes thermal signatures and gradients, RF signatures, spacecraft motion and jitters, field variations, center of mass changes, and analysis of spacecraft vents, out gassing, and thruster exhaust. This information could be obtained from close from the ground, from close proximity, or from a robotic operation that touches the satellite. The first two options would be preferred. What is sought are innovative concepts and means to perform the remote diagnostic or a piece of the diagnostic. This topic includes new sensors and ways to use sensors to measure the physical characteristics such as RF emissions, field variations, etc. This topic also includes methods and concepts for assimilating the physical information and determining the subsystem and system operating performance.

PHASE I: Define the concept and technologies needed as well as a description of how it will address the military mission. The basic fundamentals will be analyzed and used to determine expected effectiveness and capability of the concept.

PHASE II: Develop the technology and build prototype sensor systems that can be tested in representative environments. Ideally, the phase II effort would include ground testing of the hardware against a real satellite and demonstration that the data synthesis algorithms can diagnose the current operating state.

PHASE III DUAL USE APPLICATIONS: The commercialization potential will be significant for both use as a diagnostic on commercial satellites and for similar uses on earth. The technology could also be used to monitor terrestrial systems that are difficult to reach.

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KEYWORDS: Satellite Maintenance, On-Orbit Servicing, Telerobotic Maintenance, Remote Diagnostics

AF02-064 TITLE: Ground-based Daytime Optical Imaging of the Ionosphere

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate optical imaging instrumentation for observing ionospheric structure from the ground under daylight and twilight conditions.

DESCRIPTION: Optical imaging is one of the few means available to determine the structure of the ionosphere over large areas. However, all-sky imagers and other traditional ground-based optical instruments are limited to operation during periods of complete darkness. In contrast, regions where instability precursor signatures or formation of density irregularities might be observed are often illuminated by daylight or twilight. These situations include generation of plasma plumes over the magnetic equator near sunset and formation of polar cap patches in the cusp on the day side of the auroral zone. Satellite measurements at ultraviolet wavelengths are able to detect aurora and other ionospheric features from space, but are limited by spatial resolution, the revisit rate, and cost of spacecraft operations. Innovative diagnostic instrumentation to allow ground-based imaging of ionospheric structure under daylight and twilight conditions is sought to aid Air Force efforts to monitor and forecast scintillation and other ionospheric effects on communications, navigation and radar systems. Secondary considerations for a successful diagnostic system include instrument portability, reliability, ease of operation and maintainability, remote or automated operation, and the use of commercial off-the-shelf components when available.

PHASE I: Develop a concept for extracting useful ionospheric parameters from the total dayglow signal under realistic ionospheric conditions. Produce a detailed design for an imaging instrument and estimate the sensitivity and temporal and spatial resolution for anticipated observation modes and ionospheric parameters.

PHASE II: Construct and deliver a prototype system, including operating manuals and software. Analyze actual system capabilities and conduct a field test comparing observations with parameters from radars or other ionospheric measurements.

PHASE III DUAL USE APPLICATIONS: A successful instrument developed in Phase II could be used to provide ground-based measurements for C/NOFS or other ionospheric monitoring/forecast systems under development by the DoD. In the commercial sector, the instrument or variants might be expected to find extensive use in environmental monitoring and atmospheric pollution measurements, in addition to direct applications in atmospheric, space, and astronomical research.

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3. Sridharan, R., D. Pallam Raju, R. Raghavarao, and P. Ramarao, Precursor to equatorial spread-F in OI 630.0 nm dayglow, Geophysical Research Letters, Vol. 21, No. 25, p. 2797, December 15, 1994.

KEYWORDS: airglow, dayglow, ionosphere, thermosphere, upper atmosphere, optical, imaging, plasma density, irregularities

AF02-067 TITLE: Deployable Ceramic Oxygen System

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop an efficient and reliable ceramic oxygen generating system to support aeromedical and On-Board Oxygen Generating System (OBOGS) uses.

DESCRIPTION: Exploratory research will be conducted to advance ceramic oxygen generating technology. The effort will involve research focused on a device for separating oxygen from air using an ion-conducting membrane driven by electric power. Ceramic oxygen generation appears to afford critical advantages for economic and reliable production of high purity oxygen (99.0%). Primary goals of the effort are miniaturization, and power and weight reduction.

PHASE I: An experimental ceramic oxygen generator will be designed, fabricated, and operated to characterize and optimize a small-scale breadboard device. Advanced electrolyte materials capable of operating below 750ºC will be explored. These advanced materials will be pursued because of their lower power requirements and superior separation efficiency when compared to conventional materials, such as zirconia. Electrical interconnect designs will be evaluated with the goal of minimizing electrical resistance/losses. The experimental device will be examined to improve understanding of the general technical issues. Issues to be investigated are: increasing oxygen production, increasing operating pressure, decrease operating temperature, decreasing power required, decreasing size and weight, and improving reliability.

PHASE II: A breadboard ceramic oxygen system will be designed, fabricated, evaluated, and optimized for miniaturization, and power and weight reduction. An effective thermal management approach will be incorporated into the system. The system will be tested and/or analyzed to evaluate oxygen production efficiency, delivery pressure, oxygen purity, long term electrolyte degradation, weight, size, power, producibility, affordability, and reliability. Contract deliverables would include the breadboard system and a final report.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include upgrades to the Deployable Oxygen System currently being developed. Other military uses are replacements for currently deployed on-board oxygen generating systems (OBOGS). Phase III commercial applications include medical applications and industrial applications for high purity oxygen. These would include hospital and home medical use as well as light welding applications.

REFERENCES:

1. Operational Requirements Document, Deployable Oxygen System (DOS), Air Mobility Command, 5 Jan 01 (DRAFT).

2. CRC Handbook of Solid State Electrochemistry, edited by P.J. Gellings and H.J.M. Bouwmeester, CRC Press, 1997.

KEYWORDS: oxygen generation, ceramics, ceramic oxygen generation, life support, ion-conducting membrane, deployable oxygen system, on-board oxygen generating system, OBOGS

AF02-068 TITLE: DMT Training Requirements and Capability Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Streamline and optimize the TSRA process and associated database to support Distributed Mission Training federation development.

DESCRIPTION: To live up to potential, DMT needs a mission-oriented analysis system that will determine the training impacts of federation additions and changes, and impact of proposed training system enhancements in such areas as visual systems. Current standards allow federation players to interact, but cannot guarantee that interactions will provide effective training and avoid negative transfer of training. The effectiveness of interactions is a function of the accuracy of the models of individual aircraft, sensors and weapons used in the DMT, the accuracy of the representation of the environment through which the players interact; the characteristics of visual systems used on various simulators used in DMT and the fidelity of the force cues provided by these simulators. Since it is not possible to fully reproduce the real world in DMT, the impact of this practical limitation should be understood before new players are added to the Federation or new enhancements are funded. If the impacts of new players or enhancements can be determined, practical requirements can be placed on their real, virtual, or constructive representations. Current Training System Requirements Analyses (TSRAs) do not adequately integrate training needs and technical capability. Current TSRAs are too detailed and complex to provide timely data for accurate DMT decisions.

The new process will (1) rapidly evaluate the training capability of proposed DMT federation players; (2) determine impacts of new or modified players on the performance of current federation members and the overall training system federation; (3) forecast whether specific mission tasks can be trained in current, proposed, and enhanced system configurations (4) enable detailed technical analysis data to be converted to mission task impacts understood by higher level decision-makers.

PHASE I: Develop methodology, establish metrics required for a demonstration database and provide a prototype TSRA relational database tailored to DMT. Provide a Phase I report on the methodology and operation of the database. Demonstrate the database using the F-15 WST federate integration as an example.

PHASE II: Update parametric and performance requirements for the database, including pre-programmed queries. Complete the database for existing entities such as the F-15, F-16, or AWACS to establish a baseline for future additions. Cover all interactions appropriate to DMT. Apply an addition to the DMT scenario, such as A-10 to help establish entity representational requirements and effects on existing entities.

PHASE III DUAL USE APPLICATIONS: Process and database will be expanded to cover all aspect of TSRA for any aircraft missions as well as into commercial applications supporting the Federal Aviation Administration (FAA) by providing a tool to optimize simulator hardware requirements to better meet training needs. Expand into civilian applications such as commercial and private vehicle operator training requirements for ships, trains, trucks and automobiles. . The databases and their processes could then be productized and sold commercially.

REFERENCES:

1. Department of the Air Force (1997). Distributed Mission Training Operational Requirements Document (CAF [USAF] 009-93-I-A). Washington, D.C.

2. AFHDBK 36-2235, Information for Designers of Instructional Systems -Vol 3 Application to Acquisition, (Chapter 5) (1993). Washington, D.C.: Hq United States Air Force.

KEYWORDS: Distributed Mission Training (DMT), Training Systems Requirements Analysis (TSRA), Mission-Oriented Training and Metrics, Air Force Task List, Measures of Effectiveness (MOEs) or Performance (MOPs).

AF02-069 TITLE: Aircrew Bladder Relief Capability

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate a novel bladder relief capability for both male and female aircrew members flying in aircraft that have no toilet facilities. The proposed solution must significantly improve the capability of all aircrew members to obtain relief on long-duration missions without adverse side effects.

DESCRIPTION: Present bladder relief capability for male aircrew consists of a plastic tubing and bag assembly that depends on gravity to collect the urine. Females use commercially available adult diapers. Both of these solutions have serious drawbacks. Male F-16 aircrew often put the aircraft into a dive to ensure that urine does not leak onto their clothing. Additionally, they have to partially undress in order to use the device. High-g maneuvers assure that females will have wet clothing. The new solution must resolve the problems of leakage and adverse aircraft orientation for use and also address the issues of fit and comfort. The proposed solution should be a full-dress solution (in other words, it should provide hands-free operation). The proposed device should be easy to don, comfortable to wear and remove, and fit so that leakage is eliminated. It should also be compatible with current aircrew protective ensembles, such as the Advanced Technology Anti-G Suit (ATAGS). The design should use as much commonality as possible between the male and female systems. A single device is preferable but proposals for seperate devices will be considered.

PHASE I: Laboratory demonstrations will be conducted to indicate the feasibility of the method proposed to improve bladder relief capability. Specifically, the new approach shall focus on designs for the male and female systems and materials that demonstrate acceptable levels of comfort. It should also address issues of capacity (enough to handle current long duration missions for fighter aircraft), flow rates and other performance factors.

PHASE II: Provide prototype systems for both male and female and test those systems under various flight conditions. Tests shall address comfort of wear and removal, ease of installation, leakage prevention, and performance issues such as flow rate and capacity. Different materials and designs may be tested to determine which provides the best solution. A final prototype and technical documentation will be delivered.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include use by both male and female aircrew especially on long duration missions. Phase III commercial applications include medical applications for non-ambulatory patients. Commercial applications could also include replacement of diapers for incontinent adults.

REFERENCES:
Operational Requirements Document (ORD) CAF(USN 033-94)-I-A for a Female Aircrew Member Bladder Relief Capability, Air Combat Command

KEYWORDS: life support, bladder relief, urine, aircrew comfort, long duration flights

AF02-070 TITLE: Time Critical Targeting Cell (TCTC) for Team Training and Evaluation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop a synthetic team task environment representing a Time Critical Targeting Cell (TCTC) for training and evaluation of command and control strategies and operations.

DESCRIPTION: Due to the nature of military operations, training systems are required to produce command and control (C2) personnel who are error free in perceiving and comprehending the battle theater as well as capable of coordinating a plethora of time critical missions of the Air Force. The Warfighter Training Research Division of the Air Force Research Laboratory (AFRL/HEAI) conducted a front-end analysis of C2 operations centers. The analysis found that the fast tempo of military operations, high turnover rates of operators and trainers, and technological advances in C2 systems place an enormous significance on teamwork. Trainers and trainees are frequently not fully prepared for their tasks and trainees are not certain how their task fits into the overall goals of the team. In addition trainees are not sure how information must be communicated and coordinated with other teammates, and there is limited opportunity to train and conduct training and certification activities in concert with other members of the Air Force. Based on the requirements of the Aerospace Command and Control Intelligence Surveillance and Reconnaissance Center (AC2ISRC), training needs to involve a convenient, realistic, team-based C2 environment in which operators practice C2 operations and develop team coordination, communication, and cohesion. Distributed mission training has begun to address these issues for the airframe community and can now look to address these issues for the C2 community. The domain represented by the synthetic team task environment would be flexible to accommodate a variety of team tasks, though the initial domain would represent the generic operations of a TCTC. The environment would be distributed over the internet or local area network, accommodate large teams, and permit collection and evaluation of team communication and coordination data. The environment would include automated or intelligent entities representing targets and teammates, yet permit these entities to be operated by humans via network connectivity. Design and development will be in accordance with the Advanced Distributed Learning (ADL) initiative, launched by the Department of Defense (DOD) and White House Office of Science and Technology Policy (OSTP) in Nov 97.

PHASE I: Identify critical teamwork skills and develop design specifications for a synthetic team task environment for training and evaluation of team functionality within the context of a Time Critical Targeting Cell.

PHASE II: Design and develop a prototype of a synthetic team task environment for training and evaluation of teamwork communication and coordination of C2 strategies and operations in a TCTC.

PHASE III DUAL USE APPLICATIONS: Although the prototype targets the TCTC, synthetic task environment should be flexible enough to permit training and evaluation of teamwork skills in a variety of military and nonmilitary domains. Possible nonmilitary domains include commercial air traffic control, emergency dispatch, and disaster relief operations.

REFERENCES:
1. Advanced Distributed Learning Initiative, http://www.adlnet.org/

2. Defense Information Infrastructure (DII) Common Operating Environment (COE) Integration and Runtime.

3. Specification (I&RTS) Version 3.0 (Draft), January 1997, Joint Interoperability and Engineering Organization, Defense Information Systems Agency.

KEYWORDS: Distributed training, Time Critical Tareting Cell, TCTC, Command and Control, C2, Advanced Distributed Learning (ADL), Synthetic Training Environments, Team Training

AF02-071 TITLE: Distributed Interactive Training for the C2 Aerospace Operations Center (AOC)

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop interactive training tools to facilitate a working knowledge of the information processes and procedures associated with the Aerospace Operations Center (AOC).

DESCRIPTION: The AOC is the weapon system (personnel, capabilities and equipment) through which the Joint Forces Component Commander (JFACC) exercises command and control of aerospace forces. It provides the control capability enabling the JFACC to decisively command these forces. The AOC, as the senior element of the Theater Air Control System (TACS), enables the JFACC to exercise the art of command and the science of control to make effects based decisions. The mission of the AOC is to plan, execute, and assess aerospace operations. Each of these functions is performed through the integration of numerous aerospace disciplines and specialties in both a vertical and horizontal fashion. Horizontal integration is the seamless linkage of lateral elements, to optimize personnel, functional and support systems capabilities. The AOCs horizontally integrated functions funnel developed options vertically to the decision maker to flexibly respond to a dynamic battlespace environment. Vertical integration is the seamless linkage of superior and subordinate elements within the TACS, joint force, and external agencies to optimize personnel, functional, and support system capabilities. The Air Force Command and Control Training and Innovation Group (AF C2TIG) is the primary organization tasked to provide a standardized training program for AOC personnel at the operational level. At present, the training provides a broad overview of the AOC in terms of its organization and structure. The need exists, however, for training that addresses the horizontal/vertical processes or flow of information through the AOC. Such training would provide the user a cognitive framework for assessing the importance and relevance of the information flow to the overall processes that occur within the AOC. In addition to process flow training, students must learn how to use the application in a context they will need to apply them in the AOC. The training system will be implemented via an internet/intranet environment allowing ease of access to any and all students, whenever and wherever needed. Training design and development will be in accordance with the Advanced Distributed Learning (ADL) initiative, launched by the DoD and White House Office of Science and Technology Policy (OSTP) in Nov 97.

PHASE I: This phase will focus on demonstrating the feasibility of designing and developing an interactive scenario-based process training system to address the horizontal and vertical processes or flow of information through the AOC. Define/design (a) cognitive models or framework to depict horizontal/vertical integrated functions within and throughout the AOC; (b) instructional strategies to teach the integrated functions; and (c) preliminary system architectural specifications. Develop technical report documenting Phase I effort.

PHASE II: Design and develop a functional and operationally evaluated training prototype to demonstrate the horizontal/vertical flow of information through the AOC, with the objective to produce fully functional product to commercialize in Phase III. The system will be implemented via an internet/intranet environment allowing ease of access.

PHASE III DUAL USE APPLICATIONS: This technology will benefit current/future military and civilian programs requiring a cognitive framework for assessing the importance and relevance of information flow. Examples include the Joint Battlespace Infosphere, the Global Information Grid, and other military and commercial communications and information systems, where an enhanced understanding will lead to increased operational effectiveness and efficiency.

REFERENCES:
1. AFI 13-109, Vol. 3. Aerospace Operations Center Operational Procedures, Jun 1998.

2. Advanced Distributed Learning Initiative, http://www.adlnet.org/

3. Defense Information Infrastructure (DII) Common Operating Environment (COE) Integration and Runtime Specification (I&RTS) Version 3.0 (Draft), January 1997, Joint Interoperability and Engineering Organization, Defense Information Systems Agency

KEYWORDS: Distributed training, Aerospace Operations Center (AOC), Command and Control (C2), Aerospace Forces, Advanced Distributed Learning (ADL), interactive training systems

AF02-072 TITLE: Integrated Satellite Operations Training and Rehearsal for Multiple Satellite System Ground Control

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a high-fidelity integrated operator training and rehearsal environment for multiple satellite system ground control.

DESCRIPTION: There is a significant need for the development of an integrated simulation-based operator training and rehearsal capability for multiple satellite system ground control. Satellite systems have traditionally consisted of a master control system for one primary satellite constellation performing a specific mission. However, future generations of military satellites should logically use a common ground system which will operate several disparate satellite constellations within a mission area (e.g., MILSATCOM CCS-C which is under development now; MILSTAR legacy system, Advanced EHF (AEHF), and WGS systems along with DSCS). Given the breadth of the proposed systems such a common system could host, there is a substantial payoff in conducting the research necessary to support a common training and rehearsal capability for next generation satellite operations. Moreover, at the present time, there is no common or integrated training, rehearsal or operational architecture that would permit multiple space systems operation and control. The diversity of space systems and the lack of a common control station architecture severely limits the capability of the space community develop mission-ready operators in a timely fashion. As personnel move from one operational system to another, the differences in user interfaces and the underlying functional capabilities of the different systems precludes training and operational transfer of knowledge and skill from one system to the next. This effort will conduct research to define and represent common and unique mission and user requirements across multiple satellite systems, will develop and evaluate alternative approaches to information display and management and will explore innovative approaches for the development of a common architecture and exemplar for training and rehearsal. The exemplar would permit a single operator to be able to operate different satellite systems with minimal spin-up or retraining as they move from system to system. The developed environment can serve as the baseline architecture for both upgrades to current operational systems and to the design of operator and training consoles for future systems.

PHASE I: Phase I activities will result in proof-of-concept methods for defining and representing common and unique critical satellite operator knowledge and skill requirements across two current operational satellite systems. Phase I will also assess the feasibility of matching knowledge and skill representations with alternative training and rehearsal principles of learning and delivery methods and will develop specifications for a prototype integrated common architecture for cross-platform training and rehearsal for a multiple satellite system ground control capability.

PHASE II: Phase II activities will result in a proof-of-concept of the methods for defining and representing common and unique critical satellite operator knowledge and skill requirements across the systems identified in Phase I. Phase II will also demonstrate a capability for matching knowledge and skill representations with alternative training and rehearsal principles of learning and delivery methods and will develop and demonstrate the prototype integrated common architecture exemplar for cross-platform training and rehearsal for a multiple satellite system ground control capability.

PHASE III DUAL USE APPLICATIONS: This effort will provide an innovative toolset and technology for defining and representing satellite operator knowledge. Knowledge representation is typically a time consuming process that yields substantial data for use in training design and delivery as well as performance evaluation. The value of such a toolset is significant given that it will permit the rapid specification of common and unique operator competencies that will drive a streamlined training and rehearsal development process. As the number of disparate satellite constellations continues to grow, the need for a common, tailorable, high-fidelity and instructionally valid training and rehearsal simulation architecture will increase significantly. Considerable public and private sector savings will be realized if common training, rehearsal and operational architectures are fielded. Finally, mission readiness rates can be dramatically increased using common approaches while on-the-job error rates – which could result in the loss of satellite functions or the entire vehicle - and operational downtime – which typically means revenue for a private company – can be reduced significantly.

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KEYWORDS: Competency-based training and rehearsal, Human performance, Knowledge representation, Modeling and simulation, Satellite operation and control, Training effectiveness evaluation

AF02-073 TITLE: Advanced Runway Lighting Technology for Portable Applications

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop efficient and reliable temporary runway lighting systems to improve the ability of pilots and vision augmentation systems installed in aircraft. The goal is to land aircraft more safely at secondary landing sites with atmospheric attenuation from man made smoke, clouds, and rain.

DESCRIPTION: The need exists to evaluate developmental technology efforts in lighting components and their potential contribution to the portable lighting system mission. Developing new measures of effectiveness and evaluating the application of these technologies to new efficient and reliable system design while considering the operator and maintainer human element may also be necessary. We must identify and quantify the potential improvements offered by radical, advanced lighting systems from emerging laboratory technologies. The objective of this applied research is to obtain a safe, reliable and efficient runway lighting system concept that is portable and suitable for operation at austere or unimproved airfields.

PHASE I: Effort in this phase will concentrate on defining the proposed concept, outlining the basic principles and technologies, and determining potential solution candidates. In addition, an example of the advanced performance that will result from the technology will be presented and quantified by analysis. This analysis will also determine potential risks and document the extent of the improvement over current, conventional methods. A proposal for the next phase of development of the selected concept will be provided.

PHASE II: This phase will concentrate on selecting a single lighting concept and developing a portable runway lighting system based on the selected concept. A prototype system will be assembled to demonstrate the advanced technology under actual operational conditions, including flight operations. Emphasis should be placed on developing hardware that is: easy to transport and deploy, safe, reliable, lightweight, energy efficient, and self supporting. A conceptual analysis of the life cycle cost improvements resulting from using emerging technologies should also be prepared.

PHASE III DUAL USE APPLICATIONS: The application of new technologies to improve portable runway lighting systems would benefit multiple military services. Conventional portable systems use the same technologies from those in use 40 years ago. The highest commercial payoffs could result from wider adoption by national and international civil runway lighting systems and emerging augmentation systems. Companies in the United States, Canada, Germany, Sweden, France and others have been recently active marketing interim conventional portable runway lighting systems.

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KEYWORDS: Aircraft Landings, Airports, Lighting Technology, Optics, PLS (Precision Landing System), ILS (Instrument Landing System), JPALS (Joint Precision Approach and Landing System), All Weather Aviation, Terminal flight facilities, fronts (Metrology), FAA Integrated Terminal Weather System (ITWS), Parametric Analysis and optimization, Emergency Airfield Lighting, Lighting Technology, Light Emitting Diode (LED) technology, high reliability LED array technology.

AF02-078   TITLE: Messaging Interaction Simulation

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop an intelligent simulation training environment to support the instructor and student interaction of a subscriber terminal.

DESCRIPTION: Advances in the understanding and application of student and instructor interaction has made rapid progress due to the technological changes in education and training. However, these advances have not been applied to the majority of space system training and education, nor have these advances been explored for potential application to space training. Currently, there is a desperate need for innovative applications from research to apply to space programs that would facilitate the student and instructor interaction of subscriber terminals without intervention into the operational environment. A simulation capability is needed to replicate the operational unit messaging system. The need for training is apparent in the deficiency of operator capability to interpret data and send an operational status message to all within the network. The intelligent simulation approach should allow space operators a high fidelity, mission-oriented training capability to enable instructor and students to communicate via terminals through an unclassified path on the current subscriber terminal. In addition, the tool should allow the user to send a scenario of low speed data and send and receive plain text messages. This capability should enhance student abilities to understand the operational messaging system through simulation training and develop efficient and accurate instant message capabilities for information dispersion to an individual with specific need or for all participants within a space network. An ultimate proof-of-concept simulation technology capability will be developed based on demonstration assessment.

PHASE I: Demonstrate the feasibility to develop an application simulation training technology to support the instructor and student interaction and messaging required for an operation check list. Training technology demonstration and CONOPS assessment should be used to support the training capability.

PHASE II: Develop and demonstrate a prototype messaging simulation technology to support and assist the training of students using a subscriber terminal to increase the efficiency and effectiveness of operational performance. The training efficiency and effectiveness of this technology to the training environment will be documented to support ongoing USAF systems and potential commercial/dual-use platforms.

PHASE III DUAL USE APPLICATIONS: Successful Phase III Dual-Use Commercialization will result in transition of the messaging system simulation training technology to specific noted areas assessed by space as deficient in training and to assist current USAF space and satellite systems. At least one dual-use/commercial application of this technology will allow advancement in communication and simulation technology. This technology could also provide applications in the private sector and other government agencies to assist in maintaining operational effectiveness.

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KEYWORDS: Subscriber terminal, Instant messaging system, Student/Instructor interaction, Satellites systems, Satellite operations, Simulation modeling, Space Based Infrared System

AF02-080 TITLE: Imagery Manipulation for Simulator Databases

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop tools to automatically remove objectionable time-specific artifacts from overhead imagery and to automatically create 3D cultural features from overhead source imagery usable for simulator database development.

DESCRIPTION: This program will investigate technologies and develop a tool to, starting with overhead imagery usable as source data for simulator database development and modification, automatically recognize objectionable time-specific artifacts within the imagery, automatically remove these artifacts and replace them with appropriate nontime-specific data, and automatically generate accurate 3D cultural models based on the resulting modified imagery. Numerous numbers and types of image data covering simulated areas will be merged, ortho-rectified, and tone/color balanced. Objectionable time-specific imagery artifacts, such as aircraft parked on airport tarmacs, automobiles parked in parking lots, and all cast shadows will be automatically recognized, deleted from the image data, and replaced with appropriate and believable information. This tool should allow for programmable options for how many and what types of artifacts should be considered, allowing for cases when it will be desirable for certain artifacts to be retained as they were collected in the source image. Various 3D cultural items of potential value to later realtime simulations will be “tagged.” Once the image data is cleared, “treated,” of objectionable artifacts, 3D cultural models of previously identified and tagged items (such as buildings, clumps of trees, individual trees, etc.) will then be program-selectively automatically generated directly above their location on the treated image. Height of the 3D models will be accurate based on information attainable from the image(s). All vertical sides of the resulting 3D models will be filled in with realistic data and saved in OpenFlight (.flt) format. This technology will not be imagery format/media dependent or limited by camera/image collection hardware type, accounting for black-and white or natural color imagery, various bands of infrared, synthetic aperture radar, etc. Resulting treated imagery will be saved in Tagged Imagery File (.tif) format and in National Imagery Transmission Format, version 2.1 (NITF 2.1). Resulting 3D models will have accompanying information correctly positioned on the resulting merged, orthorectified and balanced, and treated imagery. Automation of this capability will be maximized.

PHASE I: Investigate the technical feasibility to design a tool to perform the following: merge and orthorectify various numbers and types of images, automatically recognize objectionable time-specific image attributes and items of potential value to later simulations, and remove program tool selectable attributes and replace them with realistic and believable non-time-specific data. Develop a preliminary capability to generate 3D OpenFlight models of selectable items identified in the imagery and position them properly. Document the results at the "draft" level. Deliver source code for the tools as developed at this level of completion.

PHASE II: Continue investigations and refine Phase I capabilities as necessary to develop an advanced capability automated tool and demonstrate the result using a variety of combinations of source imagery data. Document the results. Deliver a "draft" users' manual in both hard copy and soft copy (Word document). Deliver documented source code for the prototype tool.

PHASE III DUAL USE APPLICATIONS: This tool will benefit current and future military and civilian commercial programs that require extensive use imagery based simulator databases with a high degree of specific 3D cultural content. Results will provide a higher fidelity product with reduced resources.

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KEYWORDS: Data imagery, database models, databases, imagery-based simulator databases, realtime simulation, simulator databases, simulators

AF02-081 TITLE: Advanced 50 dB Hearing Protective/Voice Communication System for 150 dB Noise

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop innovative technology to protect hearing of personnel working in noise fields up to 150 dB sound pressure level by providing 50 dB of noise attenuation while providing communication capability.

DESCRIPTION: Combined passive and/or active attenuation technologies configured as insert, semi-insert, and/or circumaural devices. The hearing protection system should be capable of providing 50 dB of attenuation in a 150 dB noise field for a wide range of users at an affordable cost. In order to improve speech communication adaptive algorithms/digital signal processing of the incoming speech signal may be considered. Additionally miniature on-board power sources may be considered for complete in the ear function.

PHASE I: System design study including feasibility analysis, cost/performance trade-off analysis, and an transducer evaluation for operation in the defined noise fields.

PHASE II: Working advanced hearing protection/voice communication system for providing 50 dB attenuation in 150 dB noise environment including drawings, hardware, software, performance charts, manufacturing feasibility, projected reliability, estimated procurement costs, and estimated total life cycle costs.

PHASE III DUAL USE APPLICATIONS: Hearing loss and poor voice communication difficulties are generic to high noise activities worldwide. This technology has immediate commercial application to civilian industrial sectors including airline industry, firefighters, law enforcement, search and rescue, industrial high pressure paint removal, mining, and other high noise industrial settings.

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4. AFOSH Std 161-20, Hearing Conservation Program.

5. OSHA 29 CFR, Occupational Noise Exposure.

KEYWORDS: Hearing Protection, Voice Communication, Hazardous Noise, Active Noise Reduction, Hearing Conservation

AF02-082 TITLE: Viewer for Vision Research in Developing Agile Laser Eye Protection

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a viewer to enable research on effects of "agile" laser eye protection (LEP) devices on human vision.

DESCRIPTION: Concepts for military applications of lasers are increasing exponentially. Applications range from eye-safe, relatively lower power systems to be employed as non-lethal devices (NLD) in military operations other than war (MOOTW), to giant megawatt-class airborne/space borne systems capable of destroying ballistic missiles in flight. Protecting the vision of military personnel from lasers is essential to successfully accomplishing future missions. Because of the wide range of laser powers, emission wavelengths, emission durations (pulse widths) and repetition rates, coupled with the variable mechanisms of resulting biological effects, a "single" laser eye protection (LEP) solution remains elusive. Technologies providing "fixed" wavelength filter-type devices (dye, dielectric stack, rugate, and hologram) are effective at providing protection, but as one increases the number of blocked wavelengths in the visible spectrum there is a corresponding decrease in visual performance. This becomes a particular problem for night operations, creates color confusion, and eventually becomes unacceptable even for daytime use as the number of blocked wavelengths increases. At this time a potential solution to this problem is a look-through device capable of protecting against a large number of wavelengths, activating only when illuminated, and protecting only against the wavelength(s) of illumination with just enough optical density (OD) to produce the necessary protection (an "agile" device). Although we have some knowledge of visual penalties incurred with fixed filters, we have only some educated guesses regarding vision performance impacts associated with current technology candidates for "agile" devices, i.e., photochromic materials, liquid crystals (continuous laser emissions) and optical limiters (pulsed laser emissions). For example, what might we expect in terms of reduced resolution, contrast sensitivity, color discrimination and field of view? Is it possible to correct for color distortion in active devices while protecting vision? If necessary, how might one accommodate a requirement for correction of visual refractive errors in active devices? Other questions of interest include: how well will people adjust to wearing agile devices, and how often will these devices cause side effects like eye strain, headaches, nausea, and/or spatial disorientation? Research is needed to answer these questions but we currently have no way to simulate optical properties of an agile device in order to accomplish this research. Therefore, we require a "look-through viewer" that produces images of quality and content consistent with those of prospective photochromic-, liquid crystal- and/or optical limiter-based LEP, and is capable of generating the equivalent of 4 OD of protection at each of two wavelengths separated by at least 100nm in the visible spectrum (simultaneously) and each of two wavelengths separated by at least 100nm in the near infrared spectrum (simultaneously) alone or in combination with either or both of the protected visible lines.

PHASE I: Perform a technology feasibility assessment and deliver, if determined to be feasible, a description of the conceptual solution and a technology/technologies development proposal.

PHASE II: Execute the technology development plan proposed in Phase I and demonstrate the solution by delivering a prototype viewer.

PHASE III DUAL USE APPLICATIONS: This is likely to be a complex and expensive piece of equipment. Therefore, the overall market for the product is likely to be military, university, and commercial research laboratories interested in studying neurophysiological mechanisms of human visual perception and cognition. The number of these stand-alone products sold on the open market is likely to be in the "tens" rather than the "thousands." However, this work directly supports the "Joint Technology Office High Energy Laser Master Plan" initiative to cultivate directed energy-relevant technological capabilities in the private sector. The "universe" of companies with credible capabilities in the design and fabrication of these component technologies is very small. The knowledge and experience gained in performing this work (maturing and assembling the component technologies) will cultivate additional capabilities to address high priority, upcoming requirements for design, development, and fabrication of agile LEP. It is also well within the realm of possibility that these component technologies will find spin-off applications, such as miniature displays (for military aviators and ground troops), ultra-fast shutters for spectroscopy applications. If, 20 years from now, people are still flying airplanes we may be able to make aircraft canopies and windscreens, military and private/commercial, out of this "stuff."

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KEYWORDS: Laser eye protection, Agile devices, Liquid crystals, Photochromic materials, Optical limiters, Visual performance

AF02-083 TITLE: Fatigue Assessment through Voice Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a voice analysis system to assess a speaker's fatigue state.

DESCRIPTION: There continues to be a need for a non-obtrusive fatigue assessment system. One of the least intrusive methods, both in the laboratory and in the field, is voice analysis. Voice analysis has been used in accident investigations to examine whether a pilot may have been hypoxic(ref 1) or a ship captain intoxicated by alcohol prior(ref 2) to an incident. Voice measurement may also be useful in information operations, alerting observers to high-fatigue states in their opponents. Finally, such a Fatigue Assessment through Voice Analysis System would be useful in the laboratory to assess an individual's fatigue state without the need for obtrusive experimental equipment.

Voice has been shown to be sensitive to fatigue(ref 3). However, there are many issues concerning voice, which have received little or no scientific attention. Some of these are: comparing fatigue to alcohol, refining voice analysis techniques for fatigue, and packaging a voice system to be easily operated and understood. Producing a complete state assessment (i.e. fatigue, workload, intoxication) into a single system would produce a very useful tool. The system's utility would be further enhanced if it were constructed in Java such that the tool could be moved to whatever system contained or was to record the voice data.

PHASE I: Demonstrate the feasibility of using voice analysis as a fatigue assessment tool. Review extant algorithms and methods as potential candidates for voice analysis. Define the system architecture for Phase II development. Phase I efforts should be focused on English speakers.

PHASE II: Conduct research to refine and/or generate voice analysis methods and tools. If not already in the literature, conduct short studies using voice analysis to differentiate fatigue from other parameters that affect speech. Develop and test an operationally-relevant prototype Fatigue Assessment through Voice Analysis System. Evaluate system effectiveness in assessing fatigue state in non-English speaking populations and identify enhancements required for effective performance in these populations.

PHASE III DUAL USE APPLICATIONS: Should the system prove viable, multiple applications within and without the USAF are anticipated. The system would be useful to a range of human performance laboratories, as well as, accident investigation organizations (i.e. USAF/FSC, NTSB, FAA). The system may also have both defensive and offensive applications for information operations.

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KEYWORDS: Fatigue, Voice Analysis, Human Capability Assessment

AF02-084 TITLE: Robotic cRNA Processing System for Gene Microarray Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a robotics system to fully automate the process of preparing the cRNA target for hybridization with Affymetrix gene chips from total RNA samples obtained from biological material. The proposed system must include quality assurance activities at various steps in the process.

DESCRIPTION: The US Air Force is a high technology military force. To maintain leadership in military technology, the Air Force conducts research and development on a wide range of technologies and processes with the aim of fielding advanced weapons systems. These weapon systems utilize a diverse spectrum of exotic chemicals and materials to gain battlefield superiority. The health hazards of these materials must be evaluated to assure safe operations and to minimize life cycle costs for the weapon systems. The Air Force Research Laboratory has acquired the Affymetrix GeneChip oligonucliotide microarray system which allows for the detection of the expression of thousands of genes simultaneously. This new technology will improve our capability to identify the mechanism of action of chemicals of concern to the Air Force. Genomic studies of chemical toxicity will tremendously enhance available methodologies for risk assessment and improve capabilities for predicting the potential health risks to humans resulting from exposure to operational chemicals. However, extraction and processing of RNA samples into cRNA is a time-consuming, tedious, slow process and is the rate limiting step in generating gene expression profile data. The tools sought under this request should utilize the latest technologies to develop a robotics system to prepare cRNA targets. Such tools do not currently exist and successful development of the requested system will require research into compatibility of the sequence of biochemical reactions involved in sample processing. The system should be capable of extracting total RNA from biological materials and process the sample through various steps (cDNA synthesis, in vitro expression and cRNA labeling, and fragmentation of cRNA) required before the target is ready for hybridization with gene chips. The process involves numerous washings as well as quantitation of various physical parameters for quality assurance. The robotics system should allow large-scale sample processing (i.e., 96 well-plate platform) and should include quality control and process check points at each critical stage. Considerations should also be given to such factors as reliability, reproducibility and consistency. The robotics system should take advantage of currently available technologies and should be automatic or semi-automatic with minimal human attendance required. Cross contamination of samples must be avoided. This topic requires the development of a robotics system that must carry out specific chemical reactions, molecular biology reactions and quality control processes that are not currently available commercially. This system will be used to automate the preparation of field samples from DOD personnel to evaluate their responses to chemical exposure at the genomic level. The robotics system would also be employed in the integrated toxicity assessment system that will be used to evaluate toxicity of emerging dangerous substances to which the warfighters will be exposed.

PHASE I: Demonstrate feasibility of a robotics system that implements RNA extraction and cDNA synthesis to demonstrate feasibility of the methodology for automantion.

PHASE II: Develop a prototype robotics system that implements RNA extraction and cDNA synthesis to demonstrate feasibility of the methodology for automantion.

PHASE III DUAL USE APPLICATIONS: This phase will result in an final integrated reliable robotics system that allow large-scale sample processing (96-well plate platform) from RNA extraction to cRNA fragmentation. With the first draft of human genome sequence completed and rodent and other species genome sequencing under way, an unprecedented era of biomedical research has arrived. The post-genomic era demands more powerful high-throughput automatic robotics system to process large numbers of biological samples. The robotics system sought by this SBIR will be utilized by various entities across industrial, academia and government research institutes. The robotics system will be licensed to a vendor and marketed commercially when completed.

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KEYWORDS: Human Effectiveness, Toxicology, Health Risks, Chemical Hazards, DNA microarray, Gene chip, Genomics, Toxicogenomics, High throughput, Automation, Robotics

AF02-085 TITLE: Adaptive Training for Real-Time Intelligence Monitoring & Evaluation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop a high fidelity positional training and rehearsal exemplar for information warfighters.

DESCRIPTION: Recent advances in text and voice recognition and in the use of interactive information exchanges such as the Internet provide the means whereby large amounts of information can be made available for theater operations and for decision making. Given the proliferation of information, a number of concerns must be addressed. These are related to the following: (a) identifying and gathering primary information; (b) monitoring information sources and quality, (c) assimilating information in ways so that it can be used efficiently and effectively; and (d) determining when the information being used has been corrupted or compromised. In addition the current OPTEMPO severely limits opportunities to adequately train and rehearse needed competencies for such a complex and dynamic environment. This effort will conduct exploratory research to develop an adaptive training and rehearsal capability for operators who must monitor and evaluate incoming civilian and military information, identify key components of the information, identify inconsistencies in the information that would indicate data compromise, and provide near-real-time data to the human-in-the-loop for decisionmaking. It will also demonstrate the feasibility of subject-matter expert-based coaching to ensure that C4ISR personnel can use operational equipment at a mission ready level of performance in a much more timely fashion than is presently possible. A primary goal of this effort will be to explore the feasibility of using quantitative models found in voice and text recognition and latent semantic analysis to systematically evaluate and warehouse a variety of sources of information for use in strategic and tactical situations. It will incorporate an embedded adaptive coaching capability to identify shortfalls in current operator competencies and to tailor on-line training to ensure completion of mission-critical C4ISR tasks and activities.

PHASE I: Phase I activities will result in the development of preliminary adaptive interface and the quantitative intelligent information gathering, monitoring, and evaluation techniques. A proof-of-concept trainer will be developed and operator-tested.

PHASE II: Phase II will fully develop, apply, test, refine, and validate the technology. It will also complete development of the embedded adaptive coaching facility for both military and civilian applications. Proposals should assume that the technology will run in a platform independent environment.

PHASE III DUAL USE APPLICATIONS: This capability is of special interest to commercial companies that develop and manage large databases of information. For example, the proposed capability can be directly applied to literature data base search engines to increase their usability and accuracy. Applying this capability will not require wholesale rewrites of the existing databases or search capabilities, but would be used to augment existing search and retrieval capabilities and to add an information evaluation capacity that presently does not exist. There is also strong commercial potential for those companies that access such databases for their work. In this instance, the proposed capability will substantially enhance the utilization of information. Furthermore, there is considerable interest in the private sector for tools that enable managers to monitor the content and focus of discussion group and integrated product team conversations to identify when these groups have diverged from their main area of focus. It will be used to ensure that such teams are given feedback regarding their focus on the critical content areas and issues to be addressed. The developed technology will also provide an intelligent coach for new operators and information users to obtain and use more accurate information from a variety of sources.

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KEYWORDS: Adaptive training, Information operations, Intelligent information assessment, Latent semantic analysis,Voice recognition

AF02-089 TITLE: Enhanced Interoperability Through Common Translation Architecture

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop fully layered gateway translation architecture that ultimately provides seamless transfer of information across disparate data links

DESCRIPTION: The primary goal of this SBIR is to develop a new layered architectural approach for future translation gateways that enables data translation from one medium to another and/or among several mediums. With the mandated proliferation of Link-16 over the next 5 years, many aircraft System Program Offices (SPOs) are starting their Link-16 integration activities over the next 12-24 months, increasing the number of Link-16 systems in the inventory 10-fold. The System Integration Office (SIO) supports all of these SPOs by providing critical Link-16 system engineering/integration expertise. Every SPO must work together to ensure overall interoperability, not only among Link-16 participants but also among numerous other diverse systems and datalinks which are not Link-16 compatible. This non-interoperability with other diverse systems may be resolved by implementation of data forwarding rules, translation architecture(s), or other unique translation applications that act as a "Gateway" between non-communicative datalinks. These Gateways will provide communications connectivity for legacy and other disparate communications systems. Since legacy DoD systems will not be removed from the field at once, a translation requirement exists. This translation requirement will remain, regardless of the future implementation of a global seamless communications infrastructure, until all systems use the future common infrastructure and a common information representation format. Accordingly, this SBIR seeks established or developmental initiatives that may exist in DoD or commercial practices that deal with the translation of data from one medium to another. As this SBIR progresses through its phases, the end objective will be to minimize the duplication of effort at various AF agencies, establish a centralized translation protocol and provide a body of reusable tools that any future gateway might use.

PHASE I: Develop translation protocols with the intent of developing a layered, common, neutral data architecture that provides simple modification, certification, and reuse of the layered modules. The effort will compare the developed architecture and prototype to the Transmission Control Protocol/Internet Protocol layered model. Translation and forwarding rules will be documented and available to alternate developers for future refinement. The innovator will also clearly show that a gateway neutral data format approach provides economic maintenance and sustainment benefits.

PHASE II: Design, build, and optimize a Gateway system that provides a natural portal for simulation and training systems both for now and the future. Incorporate the translation protocol into a Gateway System. The Gateway system, with appropriate peripheral radios and other components, will be integrated on the Global Hawk Endurance or Predator Unmanned Aerial Vehicle (UAV) for evaluation during a future Expeditionary Force Exercise (EFX) demonstration.

PHASE III DUAL USE APPLICATIONS: The benefits of this common, neutral data format are evident in the number of locations that will acquire the battlespace picture. The modeling, simulation, and training communities will also be able to use this Gateway architecture as a direct conduit to the real Command, Control, Communications, Computers & Intelligence (C4I) systems. Research into the commercial sector has uncovered similar data translation issues. A "spin-on" approach to addressing the military's concerns is plausible. The Open Applications Group (OAG), a commercial organization, is tackling very similar translation and forwarding issues from the electronic commerce and business interoperability perspective. The OAG is a non-profit consortium focusing on best practices and process based Extensible Markup Language (XML) content for electronic business and application integration. Open Applications Group, Inc. is building an industry consensus based framework for business software application interoperability. They are using Object Oriented Design and metadata concepts to implement their architecture. We believe these technologies will enhance our future communications interoperability solutions as well.The Open Financial Exchange standard used by commercial markets provides another good example of one approach for data interoperability. The Open Financial Exchange standard, created by Microsoft, Intuit and CheckFree in early 1997, provides a unified specification for the electronic exchange of financial data between financial institutions, businesses and consumers via the Internet. Open Financial Exchange supports a wide range of financial activities including consumer and small business banking;

consumer and small business bill payment; bill presentment and investments, including stocks, bonds and mutual funds. It is evolving as a de facto standard for this industry. Aspects of these existing commercial technologies could be potentially altered for insertion into the proposed Gateway layered architecture. Data translation issues occur outside the military environment. It is hoped that this SBIR proposal may encourage innovative solutions from the commercial sector that are not readily obvious in the DoD arena.

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[2] Federal Standard – 1037C, Telecommunications: Glossary of Telecommunications Terms, dated 7 August 1996

[3] Joint Chiefs of Staff Publication 1-02

[4] Open Applications Group White Paper: Plug and Play Business Software Integration, The Compelling Value of the Open Applications Group

[5] Open Financial Exchange web site, http://www.ofx.net

KEYWORDS: Gateway, Data Link Infosphere, Communication Bottleneck, Translation, Forwarding, Fusing, Seamless Data Transfer, Communications Interoperability, Transparent, Extensible Markup Language, Metadata, Link-16

AF02-090 TITLE: Data Link Common Software for Multiple Link-16 Applications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop Low Cost Integration (LCI) common software for multiple Link-16 interfaces on a single platform.

DESCRIPTION: Link-16 has been mandated for implementation on several platforms and is currently in use on a number of platforms. Previous unique implementations of Link-16 have resulted in problems with interoperability and high software support costs. To achieve overall Link-16 software cost reductions, the LCI effort plans to develop a single common Link-16 software implementation to be shared among platforms. The Airborne Warning and Control System (AWACS) Data Link Infrastructure (DLI) has been selected as the initial Low Cost Integration solution for the Air Force. A number of changes will be needed to make this product suitable for all Air Force platforms, especially those command and control platforms with multiple data link interfaces. The present DLI provides transmit and receive processing of data exchanged on a single Link-16 communications link. A number of platforms that will be using the LCI require forwarding from one Link-16 network to another Link-16 network. These links are typically used in different geographic areas, between different organizations, or must be conveyed by different transmission media. It is necessary to establish an accurate, reliable, straightforward approach to provide data link forwarding for such platforms. The forwarding scheme must maintain data integrity and must not degrade the accuracy of the data communicated. Forwarded data delay times (latencies) must be minimized to ensure continuing utility of the forwarded data. Duplicate track identities and data looping must be avoided. Reporting responsibility rules must be followed to ensure use of only the best available data.

PHASE I: Develop a Link-16 architecture with multiple interfaces within a single platform all operating Link-16 that provides a data forwarding capability between links to interconnect various Link-16 capable command and control platforms such as the Combat Reporting Center (CRC), the AWACS, Joint Stars, the Airborne Laser (ABL), the Modular Control Element (MCE), the Tactical Air Control Party (TACP) and others. Data forwarding capability will be from Link 16 to Link 11.

PHASE II: Build and test a sample implementation of the forwarding architecture, implementing the management and forwarding of messages between multiple links, LINK 16 AND LINK 11, e.g. ABL, AWACS, Joint Stars, MCE. Evaluate the performance and data latency as the number of data links increases. Determine the maximum number of links involved in data forwarding that can provide data integrity, acceptable data latency, and accuracy. Develop documentation to meet the performance requirements and interface definitions suitable for the platform, e.g. ABL, AWACS, Joint Stars, MCE.

PHASE III DUAL USE APPLICATIONS: Develop documentation to meet the performance requirements and interface definitions suitable for the platform, e.g. ABL, AWACS, Joint Stars, MCE. Demonstrate how the forwarding architecture approach can be applied to data transfer between multiple commerical wireless local area networks with low latency.

REFERENCES:

[1] DLI documentation comprised of a System Performance Specification, System Requirements Document, System Design Document and Interface Design Document are to be delivered to the Government at the end of CY01

[2] DLI software – to be delivered to the Government at the end of CY01.

[3] LCI System Requirements Document– to be provided by ESC/DIVJ

[4] Link-16 MIL-STD-6016A and approved Interface Change Proposals. Documentation will be in draft format in October 2001 and final format in December 2001.

[5] Link 11 MIL-STD 6011 and approved Interface Change Proposals

KEYWORDS: Data Link Infrastructure, Data Link Forwarding, Common Data Link Software, Link-16, Low Cost Integration

AF02-091 TITLE: Innovative Method for Performance & Mission Worth Analysis of Integrated Command and Control Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop information technologies to compute measures of performance for command and control and advanced information systems architecture.

DESCRIPTION: The network revolution has just begun: our desktop computers, cell phones, and personal digital assistants are networked, and in the future every home and office device will have a digital presence on the network. In the defense sector, the joint vision is for a network-centric battlefield, where all battlefield command and control nodes are on a network that is highly mobile and adaptive. These future commercial and defense information system architectures will allow people to interact with their environment and other people in rich and robust ways. But current methodologies for development of information systems are not up to the challenge of a highly networked, dynamically changing environment. In both the defense and commercial sectors, new methodologies are needed for designing, analyzing, and developing future information system architectures and measuring the performance of systems based on these architectures. In this research effort the contractor shall develop and demonstrate innovative information technologies to simulate and compute measures of performance for command and control, and other advanced information and communications system architectures. The contractor should consider employing technologies such as colored petri nets, unified modeling language, or similar approaches for specifying system architectures. The methodology shall include the ability for the user to specify the integrated operational/system architecture as an input. The contractor shall develop methodologies to compute mission and military worth, measures of performance, identify bottlenecks, and perform sensitivity analysis. The contractor should consider measures such as reachability, reversibility, absence of deadlocks, liveness, boundedness and mutual exclusion, and information system metrics such as latency, queue lengths, precision, evolvability, scalability, testability, formality, executability, tolerance, clarity, and cost effectiveness. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Any graphical depiction and output should comply with industry or international standards such as HTML, VRML, and graphics metafile images. Methodologies implementing the information system architecture should be open and standards based to support interfaces to other engineering and network simulation and modeling tools.

PHASE I: Phase I activity shall include: 1) specification of an information systems architecture modeling methodology to determine the performance of integrated operational and system architectures, 2) developing a design concept to compute measures of performance for command and control and information systems, and 3) a proof of concept demonstration.

PHASE II: The contractor shall accomplish a detailed design, develop, and demonstrate the system for command and control and advanced information systems applications. The contractor shall also detail the plan for Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust, off-the-shelf modeling and analysis system for use in defense and commercial automated information system development applications and discrete manufacturing applications.

REFERENCES:
[1] Jensen, Kurt, "Introduction to Coloured Petri Nets," University of Aarhus, Denmark, http://www.daimi.au.dk/CPnets/intro/

[2] Jensen, Kurt, "Coloured Petri Nets. Basic Concepts, Analysis Methods and Practical Use" 3 Volume set, Monographs in Theoretical Computer Science, Springer-Verlag, 1997.

[3] Unified Modeling Language, http://www.rational.com/uml/index.jsp/

KEYWORDS: Performance Metrics, Command and Control, System Architecture, Integrated Architecture, Colored Petri Nets, Military Worth Analysis

AF02-092 TITLE: Portable Universal Ground Processing Unit

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a portable universal ground processing unit (PUGPU) to control satellites in any frequency bands through a ground antenna.

DESCRIPTION: The architecture of a typical ground station of today for satellite control consists of three major groups of equipment: radio-frequency (RF), intermediate frequency (IF) and baseband, and the ground communications interface. The RF group includes the antenna and high power amplifiers for communicating with satellites. The RF group is usually large in size, especially if it is built for controlling high altitude satellites in frequency bands such as L and S bands. For higher frequency bands (such as super high frequency (SHF)) and lower satellite altitudes the RF group can be smaller. The IF and baseband equipment is amenable to size and weight reduction because of its large digital electronics contents. The IF and baseband equipment also tends to be applicable to multiple RF bands through properly selected IFs. The ground communications interface relays the Tracking, Telemetry and Control (TT&C) data between the remote ground station and the satellite control center (SOC). The current and future trend of the ground communication interface is to plug into the global wide area network (WAN).This research topic is to develop a portable universal ground processing unit (PUGPU) to perform the functions of the IF, baseband, and ground communications interface groups. An ideal PUGPU can be plugged into any RF group for communicating with satellites and into any local WAN service point for interface with a SOC. This ideal PUGPU will accommodate satellites in a universal way to include supporting multiple RF bands, multiple bandwidth-efficient waveforms and error correction coding capabilities used for current and future satellite control functions. It will also be compatible with industry standards and protocols so it can be easily plugged into the global WAN to easily communicate with a SOC. The RF groups to be supported by the PUGPU shall be selectable from a set of multiple bands to include at least L, S, X, and SHF bands. The waveforms supported by the PUGPU include those used for ranging, modulation and demodulation. The PUGPU shall provide a set of user selectable bandwidth efficient waveforms. The PUGPU shall provide forward error correction coding capabilities and accommodate the highest data rates for current and future satellites. The PUGPU shall support current and future industry standards and protocols for satellite and global WAN communications. Standards and protocols shall include SGLS used by DoD satellites, and those recommended by Consultative Committee for Space Data Systems (CCSDS). TCP/IP, ATM, and other potential protocols shall also be considered for the global WAN communications. Selection of common IFs is a key to isolate the different RF bands from influencing the baseband design. This research topic shall develop a set of common IFs to maximize the range of applicable RF bands for the PUGPU. In summary, a PUGPU will possess the following desirable features: - Small in size, weight, and power to be portable - Frequency-selectable transmit and receive modules - Waveform-selectable formatter and de-formatter - Coding-selectable encoder and decoder - Common IF frequencies - Ability to handle the highest anticipated data rate and power level - Selectable communications interfaces to global WAN

PHASE I: Examining both commercial off-the-shelf and specially designed hardware to determine the minimum weight, size and power of a Portable Universal Ground Processing Unit (PUGPU). The analysis must also estimate the cost of developing a prototype PUGPU, an operational demonstration unit and a normal production run. All these estimates should include the cost of developing special hardware. Any high-risk items must be identified. The proposed PUGPU includes the features mentioned above.

PHASE II: Fabricate and test an engineering prototype of the Phase I hardware and software. Compare the results to the performance objectives and discuss how modifications will allow meeting any failed objectives. If the operational unit requires specially designed hardware that the prototype did not use prove that the prototype design verifies the special hardware and reduces risk. Repeat the cost estimate for an operational demonstration unit and a normal production run but also include a savings estimate comparing the cost of purchasing and operating the PUGPU with the cost of purchasing and operating a current system with the same functional capabilities.

PHASE III DUAL USE APPLICATIONS: Numerous Air Force, NASA, NOAA and commercial satellite programs benefit from developing a PUGPU. Its reduced size, weight and power plus the elimination of numerous electronics racks reduces operation costs. Whether purchasing costs are reduced depends on the Phase II cost analysis. The PUGPU also permits a site to communicate with any satellite if that site has the appropriate antenna and associated equipment. This increases site flexibility. With the Phase II test results and cost estimates both government and commercial satellite programs can be contacted and funding from either one or both obtained to develop an operational PUGPU.

REFERENCES:
[1] "Satellite Control Systems - Opportunity for DoD to Implement Space Policy and Integrate Capabilities," Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives, GAO/NSIAD-99-81 United States General Accounting Office (May 1999).

[2] "Air Force Space Command Concept of Operations for the Satellite Operations, Mission," (12 July 1997).

[3] C. A. Sunshine, "Air Force Satellite Control Network Evolution Study," Aerospace report No. TOR-2000(1570)-2, January 2000.

[4] Tien M. Nguyen, James Yoh, Hen-Geul Yeh, et al., "Performance Evaluation of the DVB and DSS Waveforms for Global Broadcast Services - Part I: Baseline Model with Perfect Components," Report No. TOR-98(1464)-1, The Aerospace Corporation, El Segundo, California (15 April 1998).

KEYWORDS: Multiple Frequency Bands, Multiple Waveforms, Bandwidth Efficient, Error Correction Codes, Standards and Protocols, Wide Area Network

AF02-093 TITLE: Lightweight, Highly Deployable, Jam-resistant Satellite Communications Modem

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and build an ultra-efficient, low cost modem for airborne and ground wideband satellite communications.

DESCRIPTION: Currently, Military Satellite Communications (MILSATCOM) typically uses large, heavy ground terminals to communicate while deployed. Even if the weight of the electronics could be reduced, the antenna must remain large enough so that it can selectively point at only one satellite in space and not illuminate two satellites with its transmitted energy. A terminal with a very small antenna will only be allowed to transmit if it spreads its energy out across a wide bandwidth so that the interfering signal on the adjacent satellite appears as nothing more than background noise. This process is called direct sequence spread spectrum (DSSS). Military receivers for wideband DSSS are expensive (over $200k) and heavy (100 lbs.). Another benefit of DSSS is that it provides our lightweight deployable forces with a modest level of resistance to an unauthorized user or a jammer. This resistance to interference would be present regardless of whether the communication used military satellites or commercial satellites. DSSS would provide the DoD with its only jam resistant communications over commercial satellites. At the same time, the commercial wireless world will be experiencing a veritable explosion in its use of DSSS for the 3rd generation of the wireless internet (3G technology). Commercial receivers for reception of DSSS signals up to 10 miles away will be commonplace in 5-10 years. To apply this wideband (5 to 20 MHz wide) technology to military satellite communications presents unique problems in the tremendous distances (23,000 miles) to geostationary transponder satellites. The efficiency of the receivers for DSSS must be improved substantially. The approach recommended for investigation in this research topic promises to decrease the power required to communicate by a factor of 50 times. The production cost for a DSSS receiver would drop below the $10k price barrier. In addition, the weight of the terminal's modem would reduce to below 10 lbs. Low cost, small, lightweight, efficient, easily deployable, and jam-resistant make this technology a sure winner for both the DoD and the commercial worlds.

PHASE I: Determine the technical feasibility of utilizing this advanced DSSS modem technology for satellite communications. Quantify the efficiency improvements possible in CDMA networks using the technology. Develop a preliminary design for a Phase II prototype modem development. Computer simulate and/or prototype highest risk areas of modem development for Phase II.

PHASE II: Perform a detailed design of the prototype modem and a preliminary architecture for a proposed system to employ the modem for CDMA DSSS communications using transponded satellites. Simulate design through computer simulation or by analysis. Constuct breadboard CDMA DSSS communications system and demonstrate contractor/Air Force mutually agreed basic concepts.

PHASE III DUAL USE APPLICATIONS: The commercial wireless world is moving to wideband DSSS using code division multiple access (CDMA) techniques for sharing the same frequency channel. This technique would allow a single link to pass 25 to 60 times the data rate of a conventional DSSS link today. The commercial world would seize this technology in a heartbeat.

REFERENCES:
[1] Nassar, Dr. Carl (with Zhiqiang Wu). High Performance Broadband DS-CDMA via Carrier Interferometry Chip Shaping. Colorado State University/ECE Dept. Fort Collins, CO 80523-1373.
[2] TIA/TR45.5 The CDMA2000 ITU-R RTT Candidate Submission, July 1998[3] http://www.engr.colostate.edu/college/ee/pages/Research/rawcom, (CIDS-CDMA)

KEYWORDS: SATCOM, Modem, DSSS, Commercial, SHF, Wideband

AF02-094 TITLE: Signal Diversity Combining for Improved Satellite Communications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Investigate signal diversity combining for reliable voice and data satellite communications to handheld and airborne terminals.

DESCRIPTION: Future UHF satellite communications systems are required to provide reliable high data rate communications to very small and disadvantaged terminals. The satellites will have very large antennas to be able to communicate with these terminals under various link-impaired conditions (interference, fading, multipath, ionospheric scintillation, etc.). However, because of power flux density limits imposed on satellite transmissions to Earth, satellite antennas and power amplifiers can not be built large enough to provide reliable communications under all link conditions. A way to improve communications performance is to use signal diversity combining techniques. This can be done if the same information signal is transmitted over multiple satellites and coherently combined at the receiving terminal. Depending on the order of diversity, the performance gains can be between a few decibels and tens of decibels in a fading environment. Orders of diversity of 2, 3 and 4 are generally enough to improve communications to high levels of availability for handheld and airborne terminals. In this task, the contractor is asked to develop, implement and test an optimum spatial signal diversity combining algorithm for satellite link environments that are degraded by noise, interference and fading using a single aperture receive antenna. Up to four separate satellite signal paths can be combined. The performance evaluation may be done for coherent and/or differentially coherent signal modulation schemes.

PHASE I: Develop a spatial signal diversity combining algorithm that has been optimized for a noise, interference and fading satellite link environment. Demonstrate its performance in simulated link conditions using bit-error-rate and combining gain as measures of improved performance. Develop a preliminary design for a hardware implementation of the algorithm, suitable for transition into Phase II.

PHASE II: (1) Finalize the design of the hardware implementation of the algorithm. (2) Implement the algorithm in hardware, integrate it into a satellite receiver and test it over real satellite links subjected to simultaneous noise, interference and fading conditions.

PHASE III DUAL USE APPLICATIONS: The signal diversity combining algorithm developed will provide more reliable communications to terminals in both military and commercial satellite systems. Terrestrial cellular mobile communications may also benefit from this algorithm.

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[1] Winters, J. H., "Optimum Combining in Digital Mobile Radio with Cochannel Interference," IEEE Journal on Selected Areas in Communications, Vol. SAC-2, No. 4, July 1984, pp. 528-539.

[2] Lee, W. C. Y., Mobile Cellular Telecommunications, 2nd Ed., McGraw-Hill, Inc., 1995, Chapter 10.

[3] Tseng, S. H., "Optimum Diversity Combining and Equalization over Interference-Limited Cellular Radio Channel," IEEE Trans. Veh. Technol., vol. 47, No. 1, Feb 1998, pp. 103-118.

KEYWORDS: Satellite Communications, Signal Diversity Combining, Interference, Multipath Fading, Algorithms, Ionospheric Scintillation

AF02-096 TITLE: JAVA-Based, Performance Oriented Visualization System

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of a Java-based, performance-oriented visualization system that meets the stringent requirements of a Dynamic Battle Management (DBM) environment for Command and Control (C2).

DESCRIPTION: The Airborne Warning and Control System (AWACS) requires a modern Graphical User Interface (GUI) visualization system for the on-board workstations. A JAVA-based GUI will meet the needs of AWACS and provide a flexible, modifiable interface. The requirement is for a sophisticarted and well documented JAVA Application Programming Interfaces (APIs) that allows others to customize the API(s) specifically to an AWACS block upgrade or to a new platform. Specific technology that needs to be explored for this development are; distributed objectsm dynamic plug-in applications, and object persistence. AWACS is looking to have state-of-the-art graphics capabilities on the aircraft.

Background: The term web-based Visualization has arisen from the changes in the way that the World Wide Web has been used. From the web's initial focus as an information repository, it has become a suitable environment for distributed computing. The use of the web for visualization purposes has evolved from descriptive methods, whereby images could be used to present findings, to analytical or exploratory visualization techniques. These methods exploit the potential of the distributed computing concept to allow the interactive investigation of visualization data. Visualization can also be defined as an approach in which a computer-generated visual representation is used to improve our understanding. This general definition encompasses diverse applications from data visualization - where numbers are turned into pictures - to virtual environments for training - where the subject is placed in visual reconstruction of a real environment. Recent advances in graphics workstations and virtual reality modeling languages (JAVA 3D)now allow the development of improved tools and processes supporting an improved visualization system environment.

For the warfighter, advanced visualization technology is necessary to help support an environment of shared information and provide a common operational picture of the battlespace for near-real time integration among the Joint C2 nodes. The visualization technology can improve dominant battlespace awareness at C2 nodes leading to superior situation awareness in providing the decision maker and warfighter crucial information in a timely manner. This battlespace awareness is a broad real-time knowledge of enemy activities, intentions, and capabilities; status and capabilities of Joint and Allied weapons and forces; and environmental factors, necessary for fully informed C2 decisions.

The(AWACS) is a C2 node that could greatly benefit from a JAVA-based performance-oriented GUI visualization system. AWACS is an airborne platform that performs surveillance, control, and battle management and communication functions. It provides air surveillance and control functions and may act as a Control and Reporting Center during theater operations. Data visualization technology applied to the AWACS will greatly help the processing of surveillance plot and track data, turning numbers into visual representations of the battlespace.

Development of a Java-based high level development tool suite and system is crucial in fulfilling the need for a GUI visualization environment. The visualization system must meet the stringent requirements of modern Command and Control and Weapons systems. The visualization software shall be designed in an object-oriented manner and have a robust Application Programming Interface (API) that permits extension and customization by third parties. It must be capable of processing plot and track data at sensor output rates and handle greater than 2000 tracks at a two-second update rate without performance degradation. It is critical that the software support a wide variety of data inputs via industry-standard mechanisms such as CORBA and TCP/IP. A completely flexible look-and-feel and dynamic plug-in architecture are also mandatory. The software must be as platform independent as possible and operate with the latest Java Virtual Machine (JVM) available from Sun Microsystems. At a minimum, the visualization software must support the following National Imagery and Mapping Agency (NIMA) map products: ADRG, CADRG, DTED, WVS, and CIB.

PHASE I: Develop a visualization system with the characteristics described above.

PHASE II: Develop the proposed visualization system and test the high level Java tools as they are developed against supplied representative data sets.

PHASE III DUAL USE APPLICATIONS: The contractor will integrate the tools into AWACS and verify that they meet or exceed the criteria of Phase I.

Dual Use Commercialization Potential: The visualization technology can be easily extended to the other Joint C2 nodes to provide a comprehensive and common operational picture of the battlespace. The technology can also support collaborative work environments so geographically separate military teams/organizations can work together at the same time. Visualization technology has already found wide acceptance in the commercial community. Colleges are using the technology to improve student training. The medical community is applying visualization technology to help radiologists improve their diagnosis, while geologists are using it for petroleum exploration and production. Much of the commercial visualization technology already developed could be applied to the military's C2 applications.

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[2] Military Specification, MIL-C-89038, 6 Oct 1994, Compressed ARC Digitized Raster Graphics, (CADRG)
[3] Military Performance Specification, MIL-PRF-890202A, 19 April 1996, Digital Terrain Elevatrion Data, (DTED)
[4] Military Specification, MIL-W-89012, 27 Jul 1990 and Amendment 2, 30 Nov 1992, World Vector Shoreline (WVS)
[5] Military Performance Specification, MIL-PRF-89041, 15 May 1995 and Amendment 1, 31 Jul 1995, Controlled Image Base (CIB)

KEYWORDS: Data Visualization, Interactive Systems, Real-Time Systems, Graphical User Interface, Java Programming Language, Computer Graphics, Computer Animation, Visual Databases, Distributed Programming, Object-Oriented Programming

AF02-099 TITLE: Data Mining of GMTI Databases

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop concepts and techniques for data mining of Ground Moving Target Indicator (GMTI) databases. Warfighter Impact: GMTI databases have been developed with the ability to store and retrieve vast amounts of data from multiple platforms over a long period. This SBIR would provide a data mining capability to extract and exploit more information from databases of GMTI information.

DESCRIPTION: Ground Moving Target Indicator (GMTI) radar provides continuous wide area surveillance coverage of ground moving vehicles. Vast amounts of data are produced with every sweep of the radar sensor like the one utilized on Joint STARS. For example, the Moving Target Indicator Exploitation (MTIX) GMTI database program has the ability to store and retrieve GMTI data from multiple platforms and includes published APIs with available standard GMTI formats. Other databases are then populated with processed GMTI in the form of track, SAR, and report data.Data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information. Both GMTI and GMTI Track databases contain historical records of ground entity movement, sensor noise, and sensor orbit patterns. The technical goal of this effort is the development of techniques to discover these patterns, perform statistical analysis to identify meaningful information, determine event detection possibilities, develop rules for event discovery, determine sensor management implications, and identify database deficiencies. Innovative research is required to utilize existing technologies (relational databases) and define new requirements (object-oriented databases) to perform data mining of the vast amount of data in the GMTI database(s). In order to fully exploit the information within those databases, new tools, techniques, and algorithms will need to be applied. The data can be from a particular day or over many days or months. The information to be mined can be used to perform the following sample tasks:-Vehicle (traffic) Flow Analysis -Behavioral Pattern Analysis-Vehicle Complex Movement Analysis-Sources and Sinks of Traffic-Track Patching/Continuity Improvement-Indications and Warnings (I&W) - find 9 to 5 traffic pattern-Display all Tracks Leaving Area (route history for selected AOI) Based on Filters-Display all Tracks Entering Area-Find Staging Areas

PHASE I: The Phase I effort will conduct the research required to define the technologies and algorithms needed to extract information from existing sample GMTI database(s). The focus of this effort will be on data stored in GMTI and GMTI track databases. The Phase I research will identify the critical technology challenges, investigate the likelihood of pattern existence, investigate utility, and define Phase II. Phase I risk reduction experiments/simulations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Develop algorithms and software algorithms to implement the approach developed in Phase I. The Phase II effort will implement and demonstrate the prototype data mining techniques and algorithms defined in Phase I within the GMTI database. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: Air Force MTIX, Army CGS/JSWS systems, Navy TES (LSS) and Army TES, Oil Production Output Prediction, DOT Traffic Analysis, and Drug Enforcement.

REFERENCES:

KEYWORDS: MTIX, GMTI, MTE, Exploitation, JSTARS, Data Mining, Database, Warehousing, Data Archive, Information Management

AF02-100 TITLE: Coordinating Multiple Airborne Platforms to Improve Targeting Accuracy

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Quickly re-plan flight strategies to attain high targeting accuracy using multiple platforms and human input.Warfighter Impact: As new ISR information becomes available during a mission, quick route replanning and sensor retasking becomes a necessity to achieve time critical targeting. This SBIR will investigate strategies for replanning quickly to attain high targeting accuracy using multiple plaforms and human interaction.

DESCRIPTION: Advances in cooperative Intelligence, Surveillance and Reconnaissance (ISR) collection have demonstrated opportunities to improve targeting accuracy, collection timeliness, and system throughput by adapting individual platform routings and sensor taskings in real-time. New information regarding the presence of "high priority" targets is available from a variety of intelligence sources. To quickly localize these high-priority targets, a small number of platforms from a larger set of integrated, cooperating collectors can be appropriated and re-tasked for a short time. In an operational setting, planning and tasking platforms require developing a unified plan, which may include: (1) choosing from among the available platform assets, (2) synchronizing assets, (3) determining sensing modes and scheduling each platform's sensors, (4) considering the likelihood of the target’s existence and threat, and (5) developing platform trajectories. Generating these unified plans can require extensive time and computing power, but as new information becomes available during a mission, quick route re-planning (and sensor re-tasking) exercises become inevitable. The re-planning phase may consist of an automated decision aid that quickly evaluates re-planning opportunities, suggests candidate solutions, and determines the performance impact, safety, and cost of these modifications. Because these re-planning activities are time-critical, the original unified plan should be as robust and as insensitive as possible to subsequent re-planning perturbations. One approach for the generation of an effective and quick re-plan is to identify original planners that deliver (or can be modified to deliver) a family of plans that can be down-selected using data obtained in real-time, allowing the re-planning activity to maintain the effectiveness of the original plan. The re-planning method does not need to use the same techniques as the unified planner. For example rule-based technologies may be well suited to quickly determine an optimal plan from a family of plans. The rule-based system could encapsulate application specific heuristics and include analytic and expert knowledge of factors affecting the solution space size and characteristics. To achieve full operational viability, methods for incorporating human-like decisions into the automated system may provide for faster adoption to the field. For example, a mechanism to "learn" common human operator practices may be included. This "learning" of common usage modes (such as vetoing portions a subset of the automatically generated routes and taskings) can be incorporated gradually into the algorithm search directors and periodically encapsulated and reported to system administrators. These learned modes could be fully integrated in future upgrades. Investigating generalized solution encodings that can be easily modified to address dissimilar routing and resource allocation opportunities will allow flexibility and general application to both commercial and military applications. Although coordinating the strengths of various sensing methods among multiple platforms currently exists in other mission planning tools, this scenario is distinguished by its reliance on human interaction (with the associated ambiguities), the need to react quickly, and the complexities introduced by the need to deal with novel information quickly.

PHASE I: Survey current dynamic re-planning and re-tasking tools/algorithms that are being developed within the ISR communities. Evaluate candidate collection systems and obtain collection performance prediction models to be used for algorithm scoring. Design a method for determining unified plan robustness and for generating re-plans. Design an architecture for Phase II implementation and develop a proof-of-concept demonstration application. Concentrate on a small number of collectors (e.g. two) accounting for uncertainties in the problem, including those associated with humans who may have reported or interpreted evidence from the battle.

PHASE II: Increase the number of potentially retaskable platforms to a large number. Assume potential platforms to be retasked are currently tasked, requiring the platform selection decision to include consideration of the overall mission success. Define a model of the human component to augment evidence accrual. Demonstrate a prototype of the retasking procedure that clearly shows useful information gained while attaining acceptable risk levels

PHASE III DUAL USE APPLICATIONS: Commercial applications include logistics routing and resource allocation problems such as transit bus routing and intra-modal truck/rail routing, and developing civilian evacuation plans for natural and manmade disasters.

REFERENCES:
[1] Advanced ISR Management (AIM) DARPA Program

KEYWORDS: Replan, Multi-Platform, Decision Support Systems, Dynamic Replanning, Rescheduling, Dynamic Sensor Tasking, Cognitive Psychology

AF02-101 TITLE: Feature Aided Tracking (FAT) to Augment Track Continuity

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop automated tools to utilize the radar features in Ground Moving Target Indicator (GMTI) trackers to improve moving vehicle track continuity.Warfighter Impact: This Feature Aided Tracking SBIR will develop the capability for GMTI trackers to maintain tracks of individual vehicles over long time periods, through dense environments, terrain obscuration, vehicles falling below MDV, and sensor platforms going into turns.

DESCRIPTION: Ground Moving Target Indicator (GMTI) radar provides continuous wide area surveillance coverage and precision tracking of ground moving vehicles. GMTI trackers provide direction and velocity of ground moving vehicles but have difficulty maintaining track of a vehicle over a long period of time (> 10 minutes) or distinguishing one vehicle from another. Current GMTI trackers default to group tracking in dense vehicle environments, or lose track during complex vehicle movements or over long periods of time. Dense vehicle environments, terrain obscuration, vehicles falling below the Minimum Detectable Velocity (MDV), and sensor platforms going into turns all lead to track breaks.Innovative algorithms and software automation techniques are required to increase the track duration of the vehicles through the exploitation of various radar features. The features include but not limited to: Doppler, Radar Cross Section (RCS), High Range Resolution (HRR), RF TAGS (for friendly forces), and Terrain.

PHASE I: Conduct the research needed to define the radar feature attributes that can be used to improve track maintenance. Feature Aided Tracking techniques will need to address dependencies like angle, range, and speed attributes. The Phase I research will identify the critical technology challenges, the algorithms, and automation tools that need to be developed. Phase I will also define a prototype implementation that can be accomplished in Phase II. Phase I risk reduction experiments/simulations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement the prototype identified in Phase I. All developed algorithms and automation tools will be demonstrated and documented as to their capabilities and limitations. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: This technology could be used in a broad range of military and civilian applications where automatic surveillance, tracking and identification are necessary. Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, transportation system, and security in industrial facilities.

REFERENCES:

KEYWORDS: Tracking, Multi-INT Fusion Algorithms, Correlation, Data Alignment (spatial and temporal) Algorithms

AF02-102 TITLE: Spectral Filtering

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop very low power FFT, DEF, and IFFT implementation on an ASIC chip.

DESCRIPTION: Frequency domain digital signal processing offers enhanced performance for navigation, radar, communications and computer systems with less complex hardware implementation. A major application of frequency domain processing is in the area of adaptive filters for the excision of narrow band jamming waveforms in spread spectrum systems, such as the Global Positioning System (GPS). As jamming power increases, the need exists for filters with jamming suppression capabilities approaching 60 dB. Simulations have shown that these suppressions can be obtained by processing in the frequency domain. The current Fast Fourier Transforms (FFTs) dissipate excessive amounts of power and are therefore not applicable for many GPS receivers such as handhelds. A need exists for the development/demonstration of a low power, low cost and small size FFT, DEF and IFFT (Inverse Fast Fourier Transform) prototype chip which can be integrated in a handheld GPS receiver.The chip will perform three functions:(a) a Fourier transform (b) a filtering function (including the possibility of an excision filter)(c) an inverse Fourier transform For real-time applications, the chip will need to continuously output the results of a 1024-point complex transform(the industry standard) using the above computations [(a)-(c)] every 10 microseconds. In addition, the chip will needto be low power (much less than 100mW) to permit its application in wireless applications.

PHASE I: 1) Investigate technologies applicable to the design of a low power, low cost, small size FFT/DEF/IFFT chip meeting the requirements above.2) Develop detailed models of candidate FFT/DEF/IFFT chip designs. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed specifications. The basic focus would be the integration by simulation with a GPS receiver in the loop.

PHASE II: 1) Produce final detailed design of the FFT/DEF/IFFT chip.2) Produce a production prototype FFT/DEF/IFFT chip capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify FFT/DEF/IFFT chip performance. Provide final FFT/DEF/IFFT chip cost/power analysis.

PHASE III DUAL USE APPLICATIONS: Development/integration of a FFT/DEF/IFFT chip has both DoD and Commercial application in the future for communication. Currently 1 Watt FFT is available as COTS (commercial off the shelf).

REFERENCES:
[1] “CMOS building blocks shrink and speed up FFT systems,” INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 02991081 INSPEC Abstract Number: B87066010, C87059668
[2] “A high-speed FFT processor,” INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 01233934 INSPEC Abstract Number: B78039301
[3] “Efficient hard-wired digital fast -Fourier -transform processor,” INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 01122020 INSPEC Abstract Number: B77043037, C77027026

KEYWORDS: Digital Excision Filter, Narrowband Interferers, GPS Receiver, Fast Fourier Transform, CMOS (Complimentary Metal-Oxide Semiconductor), ASIC (Application Specific Integrated Circuit)

AF02-103 TITLE: Innovative Information Technologies

TECHNOLOGY AREAS: Information Systems Technology

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

DESCRIPTION: Proposals may address any aspect of Information pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange. 1. Global Awareness -- Global Awareness entails the affordable operational capability, from local to global level, for all pertinent personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. Specific areas of interest include: - Information Exploitation -- Image/Video/Text -- Signals - Information Fusion -- Information Fusion comprises situation assessment, impact assessment and process refinement. Innovative solutions to accurately perform situation assessment, identify current and future threats to blue forces, the ability to adapt to new patterns/environmental situations, as well as provide feedback to the data collection process are all highly desired. - Global Information Base: This is defined as a distributed, heterogeneous data/information management system which stores Global Awareness information, and provides information services to Dynamic Planning and Execution operations. 2. Dynamic Planning and Execution -- This thrust concentrates on the aerospace commander's ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists. Specific areas of interest include: -- Configurable Aerospace Command Center -- Time Critical C2 -- Real-Time Sensor-to-Shooter Operations -- Targeting - Joint/Combined Coalition C2: There is a critical need for the capability and enabling decision-making infrastructure needed to achieve dynamic synchronization of large-scale missions and resources from components and coalition forces. This area will seek to develop new command and control technology enabling a future coalition planning staff to take into consideration the differing influences of all members of a coalition force; including differing military Rules Of Engagement (ROE), force structures, authority roles, capabilities, doctrine, and culture. - Collaboration/Simulation/Visualization: This technology will provide planners and decision makers with the ability to view, understand, and analyze the vast amounts of information available from C4ISR systems. Collaborating teams require a common, shared context data environment where the visualization of the data is tailored to the application domain and the user preference. Specific modeling and simulation capabilities will assist in both proactive and reactive assessment. 3. Global Information Exchange -- Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communication and information system, available anywhere, at any time, and for any task or mission. Specific areas of interest include: - Global Communications: The technical goals center on wireless information exchange systems and technologies that interconnect remotely separated command and control systems and users, providing high quality, timely, secure, and low probability of exploitation communications to air, land, and space. The required capabilities provide line-of-sight and beyond-line-of-sight connectivity spanning the frequency ranges "from DC to light," in point-to-point, broadcast, or networked modes. -- Multiband/Multifunction Communication Systems -- Robust Tactical/Mobile/Wireless Networks -- RF Communications Systems - Defensive Information Warfare (DIW): DIW is concerned with the defense of friendly information systems and signatures and ensuring the authorized use of the information spectrum. This technology seeks to protect against corruption, exploitation, and destruction of friendly information systems; ensure confidentiality, integrity, and availability of systems; integrate actions (offense, defense, and mitigation) to ensure an uninterrupted flow of information for weapons employment and sustainment. -- Information Systems Protection -- Attack Detection -- Computer Forensics -- Secure Computing

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.

PHASE III DUAL USE APPLICATIONS: Many Information 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.

REFERENCES:

KEYWORDS: Information Technology, Command and Control, Communications, Computers, Intelligence, Global Awareness, Dynamic Planning and Execution, Global Information Exchange

AF02-104 TITLE: Innovative Approaches for Information Fusion

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of mathematically rigorous techniques for situation assessment and impact assessment.

DESCRIPTION: The Joint Directors of Laboratories (JDL) Subpanel on Data Fusion originally defined Data Fusion as "a process dealing with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimates, and complete and timely assessments of situations and threats, and their significance. The process is characterized by continuous refinements of its estimates and assessments, and the evaluation of the need for additional sources, or modification of the process itself, to achieve improved results".Steinberg, et al [Reference 1] later defined data fusion as "the process of combining data to refine state estimates and predictions." A breakout of the functional levels [1] is:· Level 0 - Sub-Object Data Assessment: estimation and prediction of signal/object observable states on the basis of pixel/signal level data association and characterization;· Level 1 - Object Assessment: estimation and prediction of entity states on the basis of observation-to-track association, continuous state estimation (e.g. kinematics) and discrete state estimation (e.g. target type and ID); · Level 2 - Situation Assessment: estimation and prediction of relations among entities, to include force structure and cross force relations, communications and perceptual influences, physical context, etc.;· Level 3 - Impact Assessment: estimation and prediction of effects on situations of planned or estimated/predicted actions by the participants; to include interactions between action plans of multiple players (e.g. assessing susceptibilities and vulnerabilities to estimated/predicted threat actions given one's own planned actions);· Level 4 - Process Refinement (an element of Resource Management): adaptive data acquisition and processing to support mission objectives.Information Fusion is the subset of data fusion that primarily focuses on situation assessment and impact (threat) assessment activities.Browsing through the various conference proceedings, journals, and books pertaining to data fusion, it becomes clear that the majority of research and research applications to date have focused primarily on Level 1 fusion. The main reason for the abundance of Level 1 activities is that the research community understands well how to extract relevant data about physical objects. For example, if your goal is to identify an object such as a fruit, the physical properties that would be used to describe it would be it's shape, color, texture, etc. These are physical properties that one can easily measure and comprehend. Similarly, if your goal is to identify an automobile or a tank, then again the physical attributes might include length, width, number of wheels, number of tracks, etc. However, when one addresses the higher levels of data fusion, the emphasis is no longer on physical objects, but the relationships amongst the various objects. And those relationships, particularly for impact assessment, are poorly understood.Specific areas of research within Information Fusion are:1. Development of a rigorous mathematical basis for information fusion;2. Novel approaches for inferring relationships amongst battlesphere entities and events;3. Strategies for information gathering and planning dealing with uncertain, incomplete and ambiguous data/information;4. Determining the current (and future) threats/impacts.

PHASE I: Develop a mathematically sound approach to a subset of the situation assessment or impact assessment function areas within Information Fusion.

PHASE II: Develop a prototype Information Fusion system based on the Phase I design. Demonstrate the developed Information Fusion capability in a realistic environment.

PHASE III DUAL USE APPLICATIONS: There are many dual use applications of Situation Assessment and Impact Assessment techniques. For example in the automotive industry, research is being performed for the use of Infrared Imaging, to detect animals and pedestrians near the roadways. By combining this information with a laser ranging capability, this fused information could then be used to perform situation assessment and perhaps initiate an operator alert or a breaking sequence. A broad range of military applications exist for this topic area.

REFERENCES:
[1] A. Steinberg, C. Bowman, F. White, "Revisions to the JDL Data Fusion Model", Proc. Of the SPIE Sensor Fusion: Architectures, Algorithms, and Applications III, pp 430-441, 1999.

[2] E. Waltz and J. Llinas, "Multisensor Data Fusion", Artech House, 1990. [3] R. Antony, "Principles of Data Fusion Automation", Artech House, 1995.

KEYWORDS: Information Fusion, Data Fusion, Situation Assessment, Threat Assessment, Impact Assessment, Correlation

AF02-106 TITLE: Quantum Information Science

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To exploit quantum phenomena and develop quantum information sciences technology.

DESCRIPTION: The quantum information sciences are a broad category of technology that can enable such things as the efficient solution of non-polynomial complete problems in polynomial-time, information assurance, protected transmission and the fast training of neural networks and intelligent agents. Research topics should concentrate on, but are not limited to, the development of algorithms, secure information handling, neural networks, artificial intelligence, quantum photon transmission of data, and data compression via entangled states. Specific hardware devices are not within the scope for this call.

PHASE I: Phase I activity shall include as a minimum: 1) A thorough review of classical solutions to selected issues compared with proposed quantum solutions, 2) Design and/or model of large scale solutions, and 3) Limited demonstration of technique on an applicable/scalable problem.

PHASE II: Phase II activity shall include as a minimum: 1) final development of selected method as it applies to a scalable demonstration problem or system, 2) a prototype demonstration of solution or system with forecasted improvements, and 3) a comparative cost/effective analysis of developed approach compared with classical solutions.

PHASE III DUAL USE APPLICATIONS: QuIS technology will be applicable well beyond DoD and Government applications, they will also be applicable to the commercial world in areas of massive-speed up calculations. QuIS endeavors will benefit areas where classical means have failed.

REFERENCES:
[1] P.Beinoff, "Quantum mechanical Hamiltonian models of Turing machines" J.Stat. Phys Vol. 29, pp. 515-546 (1982).

[2] D Deutsch "Quantum theory, the Chucrch-Turing principle and the universal quantum computer" Proc. Roy. Soc. Lond. Ser. A, Vol. 400, pp. 96-117(1985).

[3] D. Deutsch, A. Ekert, R. Lupacchini "Machines, Logic and Quantum Physics", quant-ph/math.HO/9911150, 19 Nov 1999

[4] M. I. Dykman, P. M. Platzman "Quantum computing using electrons floating on liquid helium", quant-ph/0007113 from LANL paper server.

[5] R. Feynman, "Simulating physics with computers" Interaction Journal of Theoretical Physics, Vol. 21 No. 6/7, pp. 467-488 (1982).

KEYWORDS: Quantum Algorithms, QKD, Quantum Transmissions, Entangled Pairs, Unconditionally Secure Information Transmission

AF02-107 TITLE: HPC for C2 Decision Support

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop HPC Real-time command and control decision support technology.

DESCRIPTION: Simulate and analyze Course Of Actions (COAs), in real-time, based on executable scenarios established utilizing Effects Based Operation (EBO) planning techniques. The major advantage of EBO, using the enemy-as-a-system concept, is that it explicitly seeks to understand, trace and anticipate the direct and indirect effects that planned actions have on an enemy’s center of gravity. Every planning operation evaluates alternative before the final plan selection. EBO based plans provide a unique view on which alternative plans are generated. Dynamic force structure simulations based on these plans will simulate the resulting COAs in real-time for immediate selection and execution. By simulation the EBO interactions, simulation tools can effective predict the effects a directed course of action will cause. Each battlefield scenario produces unique process graphs to simulate, the ability to parallelize the simulation in an adaptive manner addressing real-time constraints should lead to great improvements in both throughput and latency. This speedup will allow more alternate courses of action to be evaluated within a restricted timeframe, resulting in higher quality battlefield execution plans that can be adapted within the enemy's decision cycle

PHASE I: Develop parallel force structure analysis techniques that support:

1) Multi-faceted force structure behavioral models that can simulate the interactions necessary to achieve indirect effects based upon direct actions.
2) Dynamic rules of engagement and rapid course of action analysis techniques of force structure simulation.
3) Automated scenario generation based on extracting the battlespace knowledge from intelligence, reconnaissance and surveillance data.
4) Dynamic models that morph as real-time constraints are introduced.

PHASE II: An analysis system will be designed, developed and demonstrated based on the analysis technique or techniques evaluated or established in phase I. The demonstration should be based on a realistic sized scenario. A detailed phase III plan will be developed.

PHASE III DUAL USE APPLICATIONS: Real-time decision support and predictive analysis tools are necessary for any industrial organization providing time critical services subject to uncontrolled events. For example, travel services, delivery services, production and manufacturing, entertainment services all plan and establish contingency alternatives.

REFERENCES:
[1] J. Steinman, "Scalable Parallel and Distributed Military Simulations Using the SPEEDES Framework," Elecsim 95, 1995.
[2] Headquarters Air Force Doctrine Center, “Doctrine Watch #13: Effects-Based Operations (EBO)”, Article Date: 30 Nov 2000
[3] Dr. Maris McCrabb, "Concept of Operations for Effects-based Operations", Version 2, AFRL/IFTB, July 11, 2000

KEYWORDS: Automated Scenario Generation, Force Structure Simulation, Dynamic Model Behavior, Real Time Decision Support, Parallel Event Simulation, Effects Based Operation, Course of Action Analysis, Command and Control

AF02-108 TITLE: Configurable Enterprise Test Harness for Publish and Subscribe Architectures

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a configurable test harness that facilitates enterprise performance assessment of publish and subscribe (P&S) architectures.

DESCRIPTION: A Publish and Subscribe (P&S) architecture is composed of protocols, processes, and common core functions that permit participating applications and organizations to share and exchange critical data in a timely manner. In [1], the Air Force Scientific Advisory Board defined its vision of a Joint Battlespace Infosphere (JBI) which will enable military users to seamlessly integrate the information systems and data needed to conduct a single mission. In addition, numerous commercial firms are developing P&S standards and products that may form the basis for a comprehensive JBI platform. Given this critical mass of effort, the Air Force needs a test harness to assess and compare different P&S architectures. This capability would allow evaluators to design, simulate, execute, monitor, and report on scenarios that stress P&S system performance for a given enterprise. These scenarios are characterized by a representative set of information producers and consumers (clients) that populate a given infosphere. While a predefined library of such components is required, the scenario designer must be able to tailor them in terms of type, system load profile, and pedigree characteristics (e.g., priority, reliability, security level). Once execution of the scenario begins, the harness must simulate these components according to the selected parameters. More generalized scenario attributes might include operational tempo, enemy interference levels, and specification of mission events. A key design goal is that the harness be architecture and platform neutral; it must be easily reconfigured for the protocols and characteristics of the particular P&S system under evaluation. During a given scenario run, the harness must monitor, collect, and archive critical performance data at the system level and for selected client entities. The harness must include post-processing tools that visualize/summarize the performance at the appropriate level after a given scenario run. In addition, automated report generation tools will be provided to compare performance across scenarios for the same or different systems. As a design goal, the harness should (to the greatest extent possible) conform to industry benchmarking standards and practices.

PHASE I: At the end of the initial phase, we expect a prototype scenario generation tool. The contractor will demonstrate the utility of this tool in generating simulated clients for a sample operational scenario. In addition, the contractor will produce a design for a full enterprise test harness. As part of this effort, the contractor will demonstrate how the design leverages industry standard benchmarks and supports evaluation of multiple P&S architectures.

PHASE II: At the conclusion of this phase, the contractor will deliver a fully functional enterprise test harness. This package must include a set of evaluation/reporting tools (as outlined in the above description) and be compatible with accepted industry benchmarking standards. As part of the effort, the contractor will demonstrate the harness on at least three (3) different P&S systems operating on at least two (2) types of platforms. Heavy emphasis will be put on the versatility of the scenario generator and the ease with which the harness can be reconfigured to evaluate new systems. In addition, the contractor must validate the accuracy, fidelity, and integrity of the scenario simulation and the performance evaluation/reporting tools.

PHASE III DUAL USE APPLICATIONS: The proliferation of e-commerce standards such as the Extensible Markup Language (XML) and Simple Object Access Protocol (SOAP) is serving to fuel development of distributed P&S architectures. As with other types of enterprise critical systems (such as e-mail servers), there will be a tremendous need for both industry and the DOD to evaluate and compare competing P&S architectures and products. Because P&S is a relatively new paradigm, the to-date focus has been on standards development rather than implementation assessment. As P&S products supporting these standards are deployed over the next few years, we expect that emphasis to slowly change. By the conclusion of this effort, we anticipate significant demand in both the commercial and DOD markets for a test harness that simulates activity for a given enterprise and measures the associated P&S architecture performance. The contractor could market this system as a stand-alone product or as part of a comprehensive evaluation service.

REFERENCES:
[1] United States Air Force Scientific Advisory Board, Report on Building the Joint Battlespace Infosphere, SAB-TR-99-02, http://www.sab.hq.af.mil/archives/index.htm, December 17, 1999.

KEYWORDS: Publish and Subscribe, Enterprise Architecture, Test Harness, Benchmarking, Test Scenario, Simulated Client, Performance Evaluation

AF02-109 TITLE: Multisensory Assimilation of Complex C2 Information

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Explore multi-sensory assimilation systems for the purpose of providing decision-quality Command and Control information for both ground-based and airborne applications.

DESCRIPTION: In order to wage a successful campaign, next generation mission/battle commanders and air controllers will need to assimilate a tremendous glut of available information, from a wide variety of sources and types; ranging from hardcopy HUMINT to real-time sensor feeds. Armed with this data (some raw, some fused), they will be expected to see through the "fog of information" and make quick-response decisions - and to quantify the effects of those decisions - all in the face of uncertainty. It is a daunting task for which systems and tools available to current Command Centers and airborne control platforms offer no solution.That decision support systems for any domain are dramatically improved by the addition of some degree of visualization is inarguable. To date, however, even the most state-of-the-art visualization approaches concern themselves with visualization of data; e.g., terrain, maps, iconic depictions of threat laydowns and flight packages, etc. But data is not information, and it is information that the commander needs to wage his campaign or the airborne controller to control airspace. The proposed topic will explore multi-sensory assimilation systems and techniques that will improve the decision-maker's understanding of the myriad of information sources and types presented to him; tailoring the information to best support his decision processes. Proposers to this topic are to explore one or more of the following major focus areas:Multi-sensory assimilation systems. This area concerns itself primarily with determining the best mix of visualization paradigms (e.g., 2D, 2 ½D, 3D, 3D+time, stereoscopy, animation, etc) and sensory input, presentation and interface techniques (for example, tactile, haptic, voice, gesture recognition, use of color, texture maps, 2- and 3-D Audio, etc.) Specific effort should be expended to address the scientific basis for, and the human/psychological factors behind, a design for a multi-sensory visualization component; that is, it should address questions of the sort "Does the use of 3-D in a command center facilitate better human understanding of, and interaction with, information/data being presented, or does it further exacerbate information fatigue?" or "Is there a "best" color or presentation technique - perhaps blinking or an audio alarm - to get a user's immediate attention?" Also covered in this area are new approaches for decision-makers to interact with data - raw or fused - and information being presented.Information Visualization Techniques. This area involves technology approaches for a) visualizing the "invisible" aspects of a situation (examples for the military might include portrayals of threat envelopes, multi-source state information of adversarial air assets, effects of jamming on the range of coverage of an air defense radar, etc. More general examples include weather patterns and effects, chemical cloud dispersion, safe air corridors for air traffic control, population density overlays, etc.), b) depiction of complex information from multiple disparate sensors and information sources to facilitate command decision processes, c) "filtered representation" of information (i.e., "decision-quality information"); such as a combatant's strength, will, intent, degree of uncertainty of perceived data, and d) modeling today's human fusion processes; i.e., fusion levels 2 and 3.

PHASE I: Develop an overall system design and concept of operations for an advanced multi-sensory C2 information visualization system/component.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove the feasibility over extended operating conditions. Of paramount importance is a quantified measure of the worth of such a system to the warfighter/decision-maker.

PHASE III DUAL USE APPLICATIONS: This capability could be used in a broad range of military and civilian applications to improve or supplement decision support systems that are, or will soon be, overrun by rafts of disparate uncorrelated information. Advanced Information Visualization techniques and systems show great promise for intelligently filtering superfluous data, fusing relevant data into meaningful information, and otherwise dissipating the "fog of information" faced by the decision-maker of tomorrow.

REFERENCES:

KEYWORDS: Information Visualization, Human Factors, multi-sensor input, multi-sensor fusion

AF02-110 TITLE: Secure Peer-to-Peer Object Repository

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and prototype a secure, distributed object repository based upon peer-to-peer file sharing technology/tools/protocols.

DESCRIPTION: New military enterprise information management concepts like the Global Information Grid (GIG) and the Joint Battlespace Infosphere (JBI) [1], envision a globally accessible, secure, distributed information "space" where personnel from all echelons can go to find relevant, tailored "decision-quality" information in support of critical decision-making efforts. While a wide variety of approaches may be envisioned to implement such a repository, the peer-to-peer (P2P) model is one that has not been explored systematically. The P2P information-sharing paradigm is one that holds significant potential utility for such large-scale repositories due to its inherent scalability, de facto standardization, decentralized architecture, and low cost of entry. The recent proliferation of P2P technologies, such as GNUtella, Infrasearch, Napster, and Filenet have provided tangible examples of the power of the P2P model to facilitate global information exchange and influence the evolution of e-business. These modern implementations, however, focus on specific files and file types rather than more generic information objects and do not address security to a large degree. This effort will address the applicability of P2P architectures to the concept of secure, large-scale, distributed object repositories and seek to develop a prototype implementation. A key question will be how to ensure and manage security effectively. Factors such as technical feasibility, economic affordability and operational utility must be weighed in as part of this investigation.

PHASE I: Evaluate current P2P technologies for potential as platforms to provide a secure, distributed, large-scale object repository for an enterprise environment. Develop an approach for ensuring the manageability and security of a large-scale distributed object repository based on the P2P model. Assess the feasibility of this approach. Develop a design for a secure P2P object repository for generic information objects.

PHASE II: Develop and demonstrate a prototype secure P2P object repository addressing the key questions and factors listed in the Description above and based on the design in phase I. This prototype should be implemented to demonstrate how secure P2P technology can satisfy the principles embodied in a publish- subscribe and query architecture as described in [1].

PHASE III DUAL USE APPLICATIONS: Secure P2P Object Repository technology could be ideal for supporting rapidly deployable, "come-as-you-are" distributed command and control systems in which mission data is often spread across the various component applications of the system. The inherent discovery-based nature of P2P technologies eliminates the need for extensive coordination and planning of information requirements. Likewise, with the increasingly shortening business cycle, the ability of corporations to rapidly form and disestablish alliances will require information systems that are capable of interoperating in a distributed and opportunistic fashion; while providing levels of information assurance and security comparable to those expected by the DoD.

REFERENCES:

[1] United States Air Force Scientific Advisory Board, Report on Building the Joint Battlespace Infosphere, SAB-TR-99-02, http://www.sab.hq.af.mil/Archives/index.htm, December 17, 1999.

[2] J. Evans, J. Niccolai, P-to-P Moves Beyond Napster, InfoWorld, Feb 13, 2001. http://www.infoworld.com/articles/hn/xml/01/02/13/010213hnp2ptime.xml

[3] Related topic: AF02-108 "Configurable Enterprise Test Harness for Publish and Subscribe Architectures"

KEYWORDS: Peer-to-Peer, Data Repository, Objects, Information Security, Protocol, Information Management, Architecture

AF02-111 TITLE: Casting Hard Alpha Inclusion Detection

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a novel approach to detect and characterize hard alpha inclusions in 6Al-4V beta annealed titanium castings.

DESCRIPTION: Hard alpha inclusions are defects that can occur in titanium castings from contamination in the casting process. This contamination typically results from metallic material, such as splatter from welding or torch cutting operations. As they are of similar density as surrounding material, they are undetectable via radiography. Phased array ultrasonic techniques have shown some success in finding these defects, especially as porosity and/or cracking is often associated with these defects. These defects are surrounded by a halo region enriched with oxygen and nitrogen, typically doubling the effective size of the defect. These halo areas have been undetectable by any method. This topic seeks proposals for innovative approaches to detect and characterize hard alpha inclusions in 6Al-4V beta annealed titanium castings, including the defect and its associated halo.

PHASE I: Develop and demonstrate the feasibility of a nondestructive inspection technique capable of detecting hard alpha inclusions buried in titanium. Demonstrate the technique on representative coupons or samples.

PHASE II: Optimize the inspection technique and develop a prototype inspection system. Demonstrate the prototype system capabilities on representative aircraft components in a production environment.

PHASE III DUAL USE APPLICATIONS: This technology would be directly applicable to military or commercial aircraft, using cast titanium as the primary load-carrying structure.

REFERENCES:
1. J.D. Cotton, L.P. Clark, T.R. Reinhart, W.S. Spear, S.J. Veeck and G.R. Strabel, "Inclusions in Ti-6Al-4V Investment Castings," Paper #AIAA-2000-1464, 41st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference and Exhibit, 3-6 April 2000, Atlanta, GA.

KEYWORDS: hard alpha inclusions, titanium, castings, nondestructive inspection

AF02-112 TITLE: Lightweight Titanium Heat Exchangers

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and characterize optimum joining techniques for high strength, high temperature, reliable plate-fin titanium heat exchangers for liquids in advanced aircraft engine and airframe applications.

DESCRIPTION: To date, high temperature heat removal in advanced military aircraft has been accomplished with heat exchangers fabricated out of stainless steel or inconel materials. Unfortunately, these metals are heavy and make it difficult to produce weight-efficient designs. For this reason, there is a need to utilize lighter weight materials which can offer similar or better performance at lower weight and cost. As an example, the next generation of weapon systems, Joint Strike Fighter (JSF), requires a lightweight heat exchanger system in order for the weapons system to meet weight and cooling requirements. Titanium (Ti) is one material that can fulfill this requirement. However, before Ti can be fabricated into lightweight heat exchangers, work is needed to further develop thin sheet forming and joining processes such as brazing of thin, 0 .004- to 0.020- inch thick Ti materials. This program will: 1) select materials for bars, parting sheets, fins and header details within a heat exchanger; 2) select braze alloy/s; 3) perform material characterization.

PHASE I: Survey the Ti community for candidate titanium materials and select one or more materials which would be suitable for the brazing of thin section details. Selection criteria should include consideration of material costs and scalability of fabrication technique, as well as performance and maintainability issues. Fabricate coupons and subject them to a battery of mechanical tests. Assess the test results, identify material process refinements, and identify the most promising brazing process and materials.

PHASE II: Optimize the processing and performance of the chosen Ti materials through fabrication and testing of: 1) lap-joint braze coupons, 2) three-layer core samples: and 3) full-size representative heat exchangers.

PHASE III DUAL USE APPLICATIONS: The resulting brazing process will be directly applicable to commercial aircraft and engines structures as well as heat exchangers. This process can also be used in marine applications as well.

REFERENCES:
1. Davis, Joseph R.; Kelly Ferjutz; Nikki D. Wheaton. ASM Handbook: Welding, Brazing, and Soldering. 10th Edition, Vol. 6, 1994.

KEYWORDS: titanium, welding, brazing, heat exchanger

AF02-113 TITLE: Component Surface Treatments for Engine Fatigue Enhancement

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop and demonstrate affordable component surface treatments for increased fatigue life and improved foreign object damage tolerance for rotating engine components.

DESCRIPTION: Due to the projected costs of future gas turbine engines, component durability has been gaining significant visibility over the past several years. Many approaches are being considered to improve the durability of both fielded and future engines. Chief amongst these concepts is that of applying compressive residual stresses to rotating engine components via surface treatments. Shot peening has long been used to impose such stresses to fatigue-critical components. This process produces compressive stresses only very near the component surface, and relatively high levels of cold work, the latter leading to thermal relaxation of these stresses should the component be exposed to elevated temperature. More recently a number of surface treatment processes have been developed which result in higher levels of compressive stresses at much greater depths than shot peening. In addition, these processes produce only very modest levels of cold work, yielding compressive stresses with much improved thermal stability. These processes include, but are limited to, laser shock peening (LSP), lasershot peening, and low plasticity burnishing (LPB). Although these processes are at various stages of development from a manufacturing standpoint, they all suffer from a lack of understanding of the resulting three-dimensional state of stress and how this stress state impacts fatigue life and foreign object damage resistance. This solicitation will address these fundamental issues and to develop a proven methodology for the application of component surface treatment technologies to improve engine durability.

PHASE I: Demonstrate mechanical performance benefits (high cycle fatigue, low cycle fatigue, and foreign object damage tolerance for example) of component surface treatment on coupon specimens if data does not already exist. Develop preliminary processing techniques for the application of component surface treatments to representative turbine engine hardware.

PHASE II: Optimize processing parameters and demonstrate performance enhancements through bench or subsystem testing of engine components. A detailed stress analysis, fatigue characterization, and destructive/nondestructive material damage assessment will be conducted to validate the approach.

PHASE III DUAL USE APPLICATIONS: Commercial aircraft engines are also limited by fatigue performance. Successful application of optimized and fundamentally understood component surface treatments will result in improved engine durability in the commercial sector. Any industry where components are limited by fatigue life or foreign object damage tolerance could potentially benefit from successful implementation of this program.

REFERENCES:
1. A.H. Clauer, J.H. Holbrook, and B.P. Fairand, "Shock Waves and High-Strain-Rate Phenomena in Metals," edited by M.A. Meyers and L.E. Murr, (Pub. Plenum Publishing Corp., New York, 1981) p. 675-702.

2. P. Peyre and R. Fabbro, Optical and Quantum Electronics, Vol. 27, 1995, p. 1213-1229.

3. A.H. Clauer, J.K. Lee, R.A. Brockman, W.R. Braisted, S.A. Noll, and A. Gilat, "Modeling Residual Stresses After Laser Shock Peening," Proceedings of the 5th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2000, Chandler, AZ.

4. J.R. Ruschau, R. John, S. Thompson, and T. Nicholas, Journal of Materials and Technology, Vol. 121, July 1999, p. 321-329.5. P.S. Prevey, D. Hornback, and P. Mason, "Thermal Residual Stress Relaxation and Distortion in Surface Enhanced Gas Turbine Components," ASM/TMS Materials Week, Indianapolis, IN, 1997.

5. P.S. PREVÉY, D. HORNBACH, and P. MASON, "Thermal Residual Stress Relaxation and Distortion in Surface Enhanced Gas Turbine Components," ASM/TMS Materials Week, Indianapolis, IN, 1997.

KEYWORDS: laser shock peening (LSP), low plasticity burnishing (LPB), high cycle fatigue (HCF), component surface treatments

AF02-114 TITLE: Corrosion Preventative Coatings

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop tunable adhesion coatings (release-on-command) for corrosion prevention.

DESCRIPTION: Corrosion of metal structures is estimated to cost many billions of dollars annually. The most common methods of corrosion inhibition or prevention involve the application of heavy surface treatments (paints and primers) or conversion coatings using various metallics that use application and removal techniques that are strictly controlled and regulated due to toxicity and possible carcinogenic properties. Hybrid polymers, such as ionic self-assembled monolayers (ISAMs), show promise as protective coating materials that offer opportunities for environmentally-friendly release-on-command" coating systems.The Air Force is seeking new coating systems that reduce the use of volatile organic compounds and hazardous material, such as hexavalent chromium, and offer unique release on command properties. The focus of this research is to meet the Air Force's top priority of corrosion protection, and environmental compliance for aircraft protection systems. The ISAMs are a recently developed [1,2] revolutionary technique that allows detailed structural control of materials at the molecular level combined with ease of manufacturing and low cost. A broad range of layer functionality is possible through incorporation of a wide range of inorganic nanoparticles to control of the electronic, conductive, optical, magnetic, thermal and mechanical properties. High-performance polymers may allow excellent thermal stability, mechanical properties as well as processability. New coating processes based on ISAMs and nanoparticles that: 1) offer corrosion inhibition on metal alloys without the use of chromium, 2) neither contains nor generates hazardous materials, 3) offer the potential for release-on-command capabilities, and 4) have demonstrated practical application methods including spraying and non-electrolytic brushing are of interest. Development activity should focus on corrosion protection for advanced fighter aircraft to address corrosion concerns with use of aluminum (7XXX series and emerging Al-Li airframe alloys), high-strength steel landing gear, and hybrid metal /graphite reinforced composite joints (e.g., Al substructure in contact with Gr/Ep and Gr/BMI skins). Such material combinations can be susceptible to galvanic induced corrosion/degradation modes. Protection of aluminum structure and metal/composite joints which are buried in corrosive environments in hard to access and/or inspect areas of the aircraft are of significant concern and must be addressed as a part of this effort.

PHASE I: Address the requirements and goals described above, and demonstrate the feasibility of the technology developed as proof of concept. Viability of the technology will be quantified in terms of the breadth of needs addressed and demonstration of corrosion prevention. The Phase I product for a successful effort is the formulation of the coating system, and testing and evaluation of this coating system on aluminum structures.

PHASE II: The product from Phase I would be developed through optimization and scale-up efforts to establish large-scale application and removal techniques of the corrosion inhibitor coating system. The product of this phase of the effort will need to be compatible with Air Force's current methods of aircraft inspection and maintenance.

PHASE III DUAL USE APPLICATIONS: The technology that will be produced under this effort has application in the protection of composite and metal structures against environmental degradation. Managing the structural health of expensive assets is of prime concern to all government services and commercial entities.

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1. G. Decher and J.D. Hong, Makromol. Chem., Makromol. Symp. 46, 321 (1991).

2. O. Onitsuka, A.C. Fou, M. Ferreira, M.F. Rubner, and B.R. Hsieh, J. Appl. Phys.80, 4067

KEYWORDS: corrosion protection, suppression, environmental damage management, coatings

AF02-115 TITLE: Superlattice Materials for Very-Long Wavelength Infrared Detectors (VLWIR)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and development of innovative growth techniques and designs for semiconductor superlattices with narrow bandgaps

DESCRIPTION: The Air Force requires new very-long wavelength infrared (VLWIR) detectors with increased operating temperature, less than 40K in VLWIR, and improved detection for space-based applications. These detectors will be required to operate at wavelengths beyond 15 micrometers. The presently available detectors are based on extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. The principle alternatives to extrinsic silicon at present are compound semiconductor superlattices based on III-V elements, such as antimonides and arsenides, or II-IV elements, such as tellurides. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on novel semiconductor alloy combinations such as InGaSb/InAs, HgTe/CdTe or other promising materials. The key growth issues to be addressed are the interface purity, abruptness and repeated control of the individual superlattice layers, composition and thickness. Key design issues are optimized choices of superlattice layer compositions and thicknesses to achieve narrow band gaps with high IR absorption and low noise currents. Characterization of the superlattice electrical, optical or physical properties are also a major factor. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. Growth on novel substrates is encouraged.

PHASE I: Phase I will address growth and design of superlattices along with the minimum characterization to demonstrate that narrow bandgaps were achieved. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will optimize the growth process and design demonstrated in Phase I with more extensive characterization and modeling as appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III DUAL USE APPLICATIONS: Structures based on semiconductor superlattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room-temperature operating infrared detectors, infrared lasers and microwave transistors. The technical product from this effort is expected to be high-quality, heterostructure epitaxial materials. The commercial product can either be wafers of these materials designed to user needs, or devices fabricated from these materials.

REFERENCES:
1. J. L. Johnson, L. A. Samoska, A. C. Gossard, J. L. Merz, M. D. M. Jack, G. R. Chapman, B. A. Baumgratza, et al., Journal of Applied Physics Vol. 80, pg. 1116 (1996).

2. C.A. Hoffman, J. R. Meyer, R.J. Bartoli, X. Chu, J. P. Faurie, L. R. Ram-Mohan, H. Xie, Journal of Vacuum Science & Technology Vol. A8, pg. 1200 (1990).

KEYWORDS: Infrared Detector, Semiconductor Materials, Superlattice, Very-Long Wavelength Infrared (VLWIR), Hetero-interfaces

AF02-116 TITLE: Conductive Resin Systems for Aircraft Composite Structures

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a conductive polymeric resin matrix system that eliminates the requirement to secondarily apply conductive coatings to composite structures.

DESCRIPTION: Current advanced composites employ a structural fiber (fiberglass, carbon, kevlar, etc.) stabilized in a resin system. Current resin systems are very good dielectric materials i.e., they are non-conducting. This causes the manufacturers of composite aircraft concern. Electrical energy from sources such as a lightning strike can penetrate this dielectric film. In the case of fiberglass and kevlar, becasue they are nonconducting, electrical energy completely penetrates the fiber and enters the internal stucture creating structural damage. Airframe manufacturers can get around this by applying conducting coatings to these structures. However this is expensive, must be reapplied every time the paint is stripped from the aircraft, and causes EPA concerns from the standpoint of potentially releasing ozone depleting chemicals (ODCs) into the atmosphere and heavy metals into the waste stream.What is desired is a method to turn the dielectric film highly conductive to eliminate the use of these conductive coatings on the aircraft. The resulting product should minimize added weight and structural degradation while maximizing conductivity of the laminate into which it is introduced.

PHASE I: Demonstrate feasibility of an electrically conductive polymeric resin system in accordance with the requirements listed in the descriptive section. Material samples will be fabricated and analyzed. Electrical and mechanical property data will be provided from testing the samples.

PHASE II: Develop the conductive resin system and demonstrate the ability to manufacture panels employing the new resin system. Make panels, perform environmental testing to show stability of conductive materials and the amount of degradation to the mechanical properties of the laminates.

PHASE III DUAL USE APPLICATIONS: The Air Force has a variety of aircraft applications a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced lightning damage suppression for structures.

REFERENCES:
(1) O'Driscoll, D.; ,Hardwick, J.; Ryan, J. "Lighting Strike of Perforated Carbon Fiber Epoxy Laminar Flow Panels," J. Comp. Tech and Res, Vol 22 No. 2, April 01, 2000, pp 71-75

(2)Onera, "Studying Aircraft Lightning Strikes", Aerospace Eng., Vol 19 No. 9, Sept 01, 1999 pp 39-42

(3) Mazur, V.; Moreau, J.P.; "Aircraft-Triggered Lightning: Process Following Strike Initiation that Affect Aircraft," J. of Aircraft, Vol 29 No. 4, July 01, 1992 pp 575-580

KEYWORDS: conductive polymer, conductive resin, dielectric material, lightning strike, conductive coatings, EMI shielding, conductive composite, polymer resin, structural resin

AF02-117 TITLE: Tamper Resistant Coating Development

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Identify a new tamper resistant coating (TRC) to protect electronic circuit boards used in secure communications and electronic equipment.

DESCRIPTION: The next generation of Air Force communications and electronics equipment require a TRC be applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. The current tamper resistant coating technology is based upon an expensive, thermal-spray ceramic which results in lower than desired electrical yields of the delicate microelectronics being protected. There is an industry-wide need for a low-cost, high-reliability tamper-resistant coating that can be applied to multichip modules to protect not only the individual die, but also the interconnects. General requirements for a new TRC include:a. cannot degrade the performance of the cardb. cannot add cost or weight of more than 10 percentc. processing conditions cannot degrade the performance of the card (less than 175° C, no severe mechanical or vibratory stresses, no corrosive environments)d. can be used on existing circuit cards

PHASE I: 1) Identify alternate TRCs based upon lower temperature (less than 175° C) processing. The key requirements are a tough coating that, if removed, will catastrophically damage the underlying circuit board interconnects, traces, and or dies. 2) Evaluate these coatings for their affect on the underlying electronic reliability and demonstrate the material and process on a surrogate circuit board that demonstrates tamper resistance and operability of the underlying electronics.

PHASE II: 1) Develop a production-scalable process to implement the TRC technology identified in Phase I. 2) Evaluate this TRC for its ease of manufacture, affect upon circuit board materials/functional parameters (line widths, wire pitch, etc.). 3) Conduct long-term reliability testing of electronic circuit boards coated with the chosen TRC.

PHASE III DUAL USE APPLICATIONS: The TRCs developed for the Department of Defense are equally applicable for use on commercial microelectronics.

REFERENCES:
1. "Critical Infrastructure Protection: Presidential Decision Directive 63,", May 98, http://pccip.se-com.com.

2. "Cryptographic Hardware and Embedded Systems: 1st Internatinoal Workshop," CHES '99, Worchester, MA, Aug 12-13, 1999, G. Goos and Christof Paar (eds.)

KEYWORDS: Tamper, Resistant, Coating, Multichip Module, Microelectronics

AF02-118 TITLE: Secure Circuit Board Materials and Processes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop secure, tamper resistant (TR) circuit board designs that would eliminate (or significantly reduce the reliance upon) the need for TR coatings.

DESCRIPTION: The next generation of Air Force communications and electronics equipment require a tamper-resistant coating (TRC) be applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. Current TR technology utilizes a tough coating that is expensive and results in lower than desired electrical yields of the delicate microelectronics being protected. There is an industry-wide need to develop new materials and processes for low-cost, high-reliability tamper-resistant circuit board construction. Recent advancements in composite materials and ordered polymers could lead to the design and construction of circuit boards that are inherently tamper resistant. General requirements for a new TR circuit board include:a. cannot degrade the performance over current circuit board designsb. cannot add cost or weight of more than 10 percentc. processing conditions cannot degrade the performance of the card (i.e. less than 175° C, no severe mechanical or vibratory stresses, no corrosive environments)

PHASE I: 1) Explore circuit board construction materials to include imbedded trace and die design, improved interconnect design, and alternate packaging such as encapsulation. Encapsulation techniques could be used on existing boards but new construction approaches would have to be used on new board designs. 2) Evaluate a new circuit board construction design for its underlying electronic reliability and demonstrate the materials and processes on a surrogate circuit board that demonstrates tamper resistance and operability of the electronics.

PHASE II: 1) Develop a production-scalable process to implement the TR circuit board construction technology identified in Phase I. 2) Evaluate this construction approach for ease of manufacture, and its effect upon circuit board materials/functional parameters (line widths, wire pitch, etc.). 3) Conduct long-term reliability testing of electronic circuit boards.

PHASE III DUAL USE APPLICATIONS: Tamper-resistant/security-protected technology has both Department of Defense and commercial applications in the future for global positioning systems.

REFERENCES:
1. "Critical Infrastructure Protection: Presidential Decision Directive 63", May 98, http://pccip.se-com.com

2. Cryptographic Hardware and Embedded Systems: 1st Internatinoal Workshop, CHES '99, Worchester, MA, August 12-13, 1999, G. Goos and Christof Paar (eds.).

KEYWORDS: Tamper, Resistant, Circuit Board, Composite, Ordered Polymers, Multichip Module, Microelectronics

AF02-119 TITLE: Tailored Adhesives for Damage Tolerant Joints

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Improve the integrity and reliability of aerospace-grade adhesives in bonded joints increasing ballistic survivability and allowing reduction of fasteners with subsequent savings in cost and weight.

DESCRIPTION: Bonded joints have been shown to have adequate strength and integrity to eliminate fasteners in most joints, however, in wet wings there is still an issue with ballistic survivability because of hydrodynamic ram stresses. One technique that has been shown to alleviate this problem is z-pinning of the joints with a reinforcement of transverse carbon or titanium pins. This technique adds considerable expense to the manufacturing process and the diameters of the pins are such that they distort and break fibers locally during insertion, reducing their effectiveness.Aerospace-grade epoxy adhesives used in both original component fabrication and repair applications can have various forms of carrier materials, each of which can have a dramatic effect on adhesively-bonded joint strength and durability. The carrier cloths are available in either random mat, knit woven or square patterns in dacron, nylon or glass fabrics. Carrier cloths are placed in film adhesives during manufacture mainly for handling control during subsequent part fabrication; however, they also provide bondline thickness control of a cured bonded joint. The adhesive supported with the knit woven carrier gives the highest stiffness while the random mat provides superior handling characteristics. Several efforts have been conducted to demonstrate the impact of the scrim in an adhesive on the static, fatigue, and mechanical properties of a bonded joint. The additions of low fiber volume scrim materials (graphite, Kevlar and Boron) have shown dramatic improvement in fatigue properties. The problem with continuous fibers is the resistance to out-of-plane loading. A few efforts have investigated discontinuous reinforcement in an adhesive (graphite flakes and silicon carbide whiskers), which can offer z-axis reinforcement.

PHASE I: Address the goals and requirements discussed above and demonstrate the viability and potential to develop an inexpensive method for including translaminar reinforcement into adhesives and to apply it to joints in such a way as to make the reinforcement connect the adherends. The success of the Phase I effort will be determined by the ability to deliver small quantities of sample material, and the obtainment of corresponding mechanical property data as a proof of concept.

PHASE II: Develop the adhesive system and demonstrate the ability to manufacture subcoupons employing the new system. Make panels, perform environmental testing to show stability of mechanical joints and the amount of degradation to the mechanical properties of the laminates.

PHASE III DUAL USE APPLICATIONS: The Air Force has a variety of aircraft applications, a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced lightning suppression for structures.

REFERENCES:
1. Forte, M.S., "A Controlled Study of the Effects of Bondline Reinforcement On the Fracture Behavior of a Brittle Epoxy Adhesive," Ph.D. Dissertation, University of Dayton, May 1999

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3. Kuhbander, R.J., and Aponyi, T.J., "New Concepts in Fatigue Resistant Adhesives," Proceedings of the Twentieth National Symposium and Exhibition, San Diego, Ca, April 29 - May 1, 1975, San Diego, CA, pp 589-605.

4. "Exploratory Development of Improved Fatigue Strength Adhesives," The Dexter Corporation, AFML-TR-74-169, ADB009505, Air Force Materials Laboratory, November 1974.

5. "Improved Fatigue Strength Adhesive Part II - Adhesive Optimization," The Dexter Corporation, AFML-TR-74-169 Part 2, ADB009505, Air Force Materials Laboratory, December 1975.

KEYWORDS: adhesives, bonded joints, bondline reinforcement, scrim

AF02-120 TITLE: Qualifying Light, High-Performance Materials for Airborne Expeditionary Forces (AEF)

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a rapid materials-selection strategy and demonostrate efficiency on critical high-energy laser components and vehicle structures.

DESCRIPTION: The Airborne Laser (ABL) weapon system, based on the chemical-oxygen-iodine laser (COIL) concept, represents a major advancement in weapon system technology. The unique chemistry of a COIL presents new challenges in chemical processing, material handling, process material selection, logistics, and safety. Airborne laser and space-based chemical laser systems require lightweight, high-performance materials to achieve system performance objectives. The chemicals used in chemically-driven laser systems are incompatible with many materials used in aircraft, spacecraft and the chemical processing industry. In addition, materials that have been used for ground-based chemical laser systems pose extreme weight penalties for aircraft and space applications. Conventional material evaluation techniques require long test periods and are labor intensive. The objective of this project is to develop rapid, high-confidence, materials selection/evaluation techniques to predict material performance for critical aircraft/spacecraft laser systems, in a compressed amount of time.

PHASE I: Perform comprehensive materials testing/evaluation strategy studies, involving the use of subscale process elements, representative of full-scale operational equipment, intended for the use on high-energy chemical laser systems. Chemical exposure duration of as much as 3,000 hrs is required with intermittent material assessment. Phase I activity should include (among other activities): (1) material selection (to include coating systems), fabrication, and identification (government and contractor specified), (2) performance evaluation criteria, (3) material performance data correlated to system design (size, weight, process fluid interactions) and operation (reliability, availability, maintainability) and (4) material performance data correlated to equipment service decisions (mission capable, nonmission capable, mission capable with waiver).

PHASE II: Demonstrate rapid material qualification on selected process materials for COIL systems and weapon system vehicle structures. Provide equipment failure modes, assessment techniques for full-scale system evaluation, and mean-time-between-failure for system critical components. Phase II demonstrations should include: (1) identification and qualification of materials and material suppliers, (2) test configuration and chemical exposure, (3) subscale test component fabrication, and (4) post-exposure material inspection, analysis, and qualification. The strategy and demonstration should be an iterative process based on statistical experimental design that will result in the greatest amount of information in the shortest amount of time. Materials should be selected that will result in decision alternatives: i.e. plan B, C, etc., should any selected materials fail to meet performance criteria. Process materials must be suitable for use in systems exposed to basic hydrogen peroxide, chlorine gas, chlorine liquid, hydrogen peroxide (70-wt. %), and ammonia (anhydrous). Specific conditions can be provided upon request.

PHASE III DUAL USE APPLICATIONS: The procedures and methods developed in this effort will compress significantly the development time for advanced chemical-based weapon systems by reducing the time for selecting and qualifying new materials and new material applications. Air Force weapon systems of the future require new methods and tools for managing programmatic and technical risk such as the one specified herein. In addition, developments in this area will be of value in other process industries, such as production of polymeric materials and manufacturing that requires rapid prototyping. It is expected such applications will an abundance of applications in the commercial and defense sectors.

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1. Oxygen-Iodine Supersonic Technology Program, Area I Supersonic Laser, Subsystem Design Analysis Report, October 13, 1983, Unclassified, TRW Space and Technology Group, Redondo Beach, CA 90278, Contract Number F29601-82-C-0083.

KEYWORDS: Chemical-Oxygen-Iodine Laser (COIL), Material evaluation techniques, Basic hydrogen peroxide, Iterative process, Chemical decomposition, Statistical experimentalDesign, Airborne/Space-Based Chemical Laser

AF02-121 TITLE: Use of Alternate Materials for Infrared (IR) Missile Domes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop lower cost processing of missile domes and investigate alternate materials to sapphire which have already shown manufacturing potential, but require additional characterization to be acceptable for high speed missile applications.

DESCRIPTION: Sapphire, with its high strength and hardness, is the material selected for many infrared (IR) missiles domes due to the extreme environments encountered during flight. Although sapphire meets all the performance requirements, it is also one of the high-cost items in the total system. Sapphire is grown as boules from the melt and is expensive due to the waste following fabrication and the extensive polishing required due to its hardness. The current cost of a sapphire IR missile dome is $1800 to $2700 and generally is procured from one vendor. Thus, a different material is needed that has a flexible process resulting in lower cost missile domes. Additional process development would be expected to demonstrate a more affordable product than sapphire. Alternate materials to sapphire (in the 3-5 micron range) would include, but not be limited to, aluminum oxynitride (ALON), spinel, and MgF_2. These materials appear to have similar materials properties with sapphire; however, have not been proven in extreme environments that are encountered during flyout. Some of the more critical properties include compressive strength tests to simulate thermal shock and durability tests (rain and sand erosion). This effort will investigate alternate materials to sapphire that are easier to manufacture, thus will be less expensive to produce and fabricate into 3-inch IR missile domes.

PHASE I: Phase I will identify candidate midwave materials that are comparable to sapphire and can withstand the environments and performance requirements of IR missiles systems. Additionally, these candidates must possess flexibility in the manufacturing process and have qualities as described above. Currently, MgF_2 is the baseline, thus any candidate must meet, at a minimum, the performance properties of MgF_2 for thermal shock and durability to be considered. This phase may include modeling analysis on the candidate materials for screening purposes and to determine the thermal shock performance at elevated temperatures. A candidate material will be selected for testing. This testing would include, as a minimum, durability tests. Results from this testing will demonstrate the feasibility of at least one potential replacement for sapphire in IR missile dome applications.

PHASE II: Further development of the chosen material and processing methods will occur. The processing method will be analyzed to identify steps in the process that could be improved to result in a more affordable and efficient manufacturing process. Some trial runs are anticipated to test the potential improvements. The material will then be fabricated into prototype domes utilizing the improved process and tested to verify the overall performance and manufacturing efficiency. The critical test will be a compressive strength test that simulates thermal shock to the dome at a peak temperature of 450 degrees Centigrade. Based on the results, a performance comparison would be made to sapphire which would include manufacturability of the alternate material at the system level. A cost estimate will also be conducted to project actual production cost of 600 domes/year to a projected 10,000 overall. The desired outcome of this phase is twofold: a material that can be submitted for qualification as an alternate missile dome material and a new manufacturing process that could be licensed or patented

PHASE III DUAL USE APPLICATIONS: The alternate material identified would be a potential replacement in other sapphire applications beside missile domes. It is anticipated that a proprietary process will be developed that is improved and most cost-effective. A small business should be able to license or patent this new process. Military applications - Sapphire has excellent optical properties and provides great durability, thus it is used for IR windows. These windows tend to be flat, and the alternate material could be a utilized for IR window applications. Scale-up to larger (size) missile domes. Due to its rigidity, sapphire also provides good ballistic impact resistance, a very desirable property in transparent armor, which would be another military application. b. Commercial application - Sapphire is used in supermarket scanners, usually as a thin layer over glass, because of its hardness and scratch resistance. It is not formed into a solid scanner window due it being cost prohibitive, so it is applied as a thin layer over glass. The alternate material would be fabricated into a flat, solid piece and could replace the sapphire-glass laminate.

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KEYWORDS: sapphire, missile domes, aluminum oxynitride (ALON), spinel, magnesium fluoride, thermal shock, midwave materials

AF02-122 TITLE: Individual Plastic Component Water Sealing

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop material and process to prevent moisture absorption by plastic parts at the component level during storage prior to use in building next-level assembly, during storage as spares, storage of higher level assemblies, and while in operational use.

DESCRIPTION: Due to both cost and availability of traditional space and military-grade parts, modern missile systems are being forced to use commercial electronic components including plastic encapsulated microcircuits (PEM). Many types of commercial parts are not capable of performing in the harsh external environments required for military and space applications. One environmental problem when using PEM devices in space or high-altitude applications is moisture being absorbed into the encapsulant material prior to launch and changing to gas phase when taken to high altitude. The expansion that occurs when moisture changes to gas phase can crack the part case and cause electrical failure. Bursting PEM cases in this way has been dubbed popcorning. To prevent popcorning at altitude, the current design practice is to include an elaborate sealed chassis and/or desiccant, and conformal coating at the board level. There is considerable evidence that none of these measures prevents organic materials, including PEM packages, from becoming saturated when exposed over time to moisture. Traditional organic conformal coating materials, used at the board level, will obviously not work as a component-level moisture barrier. Therefore, a breakthrough is required in development of an effective moisture barrier for commercial-grade parts.In addition, an effective moisture-control measure must keep water content of device packages to acceptable levels during storage of flight hardware of both assembly and component-level spares. Effective measures must be taken in order to meet the demand for longer warrantees and requirements for a low maintenance burden. Stringent sealing, desiccation, and some conformal coating would not be required if a process was available that prevented moisture absorption at the component level. If enclosure-level moisture proofing was not necessary, electronic housings could be smaller, lighter, and less costly. Reliability would no longer depend on sealed chassis design and/or workmanship of hand-applied sealants.The situation is exacerbated by the need to use commercial parts as replacements for logistic repairs. Without adequate moisture control during storage of PEM devices prior to use as a repair part, there is a higher risk of popcorn failures following a repair. In addition, an acceptable PEM coating must be capable of withstanding the thermal and chemical stresses inherent in the board-level manufacturing and logistic repair environments, as well as, test environments at the part, board and box levels, and still provide a demonstrated effective moisture barrier.Today's military customer favors a solution that eliminates moisture sensitivity at the part and material level, and allows the use of lower weight, less-expensive enclosures for avionics assemblies.

PHASE I: Determine various materials and techniques that could be applied to the exterior of these components that would prevent moisture absorption.

PHASE II: Perform lab evaluations of the candidate materials and processes identified in Phase 1. This would include exposure to simulated external environments and pressures. Down select to a limited set of viable candidates.

PHASE III DUAL USE APPLICATIONS: Assemble a series of production electronic subassemblies using the candidate that is representative of various applications, such as power and signal processing. Perform qualification-level functional and performance tests under specified environments that include increases in levels that would demonstrate durability.

REFERENCES:

KEYWORDS: popcorning, plastic encapsulated microcircuits (PEM), integrated circuit, microcircuit, moisture barrier, coating, sealing

AF02-123 TITLE: Innovative Approaches in Secure Hardware

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Identify new materials and processing technologies for the fabrication of tamper-resistant circuit boards.

DESCRIPTION: The next generation of Air Force communications and electonics equipment require tamper-resistant coatings and other methods applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. Current tamper-resistant circuit board designs involve a variety of special coatings and treatments for both board and components. The utilization of emerging materials technologies to construct circuit boards that are inherently tamper resistant would improve the reliability and reduce cost and weight of electronic components. Self-assembled monolayers of conductive, semiconductive, and insulative molecules could be used to construct cards with no discernable construction. Advanced composite laminate construction techniques could produce multifunctional circuit boards with electronic packaging and tamper resistance functions. Other innovative materials and processing techniques that could be applied to secure circuit board design are also welcome. Secure materials and processing techniques should impart solvent, acid, and physical attack (drilling, sawing, etc.) resistance such that any attack damages the underlying circuit board components rendering the components useless.

PHASE I: 1) Define shortcomings in current circuit board construction and design that could be overcome with advanced materials and processing technologies 2) Identify promising materials technologies than could lead to improved circuit board designs. 3) Characterize promising constructions for processability and electrical performance. 4) Prepare specimens for the demonstration of key material attributes.

PHASE II: 1) Identify a baseline prototype circuit card design for demonstration of the materials technologies identified in Phase I. 2) Fabricate a demonstration circuit card for evaluation by the Air Force.

PHASE III DUAL USE APPLICATIONS: Tamper-resistant components developed for the Department of Defense are equally applicable for use on commercial microelectronics.

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KEYWORDS: Tamper, Resistant, Coating, Multichip Module, Microelectronics

AF02-124 TITLE: Demonstration of Compound Semiconductor Films on a Compliant Substrate

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Demonstrate the application of a compound semiconductor thin film on a silicon-based compliant substrate.

DESCRIPTION: Compound semiconductors offer a variety of material properties that enhance the performance of microelectronic devices, such as solar cells, infrared (IR) detectors, microwave devices, and optoelectronic integrated circuits, over that provided by the more common elemental semiconductors, silicon and germanium. It has been difficult to commercialize such compound semiconductor devices because of the high cost and relatively poor quality of the starting material. Recent success in transferring ultrathin compound semiconductor films to a silicon handle wafer offers the opportunity to significantly reduce the cost of these types of devices. Although it is anticipated that these new starting silicon wafers will also result in improvements in device performance, yield, and reliability, problems with achieving these benefits have yet to be identified and solved. Certainly, accommodating stress associated with the thermal mismatch between materials (silicon wafer/compound semiconductor), dealing with defects in the compound semiconductor device film, as well as at the interface between the device film and the wafer substrate are anticipated challenges. Therefore, the purpose of this project, therefore, is to demonstrate the application of a candidate compound semiconductor device to these new silicon starting wafers. The processing and inspection techniques that will be needed to put the resulting new materials into production should be identified and developed.

PHASE I: Phase I: Demonstrate the feasibility of a primary substrate material in terms of device performance, yield, and reliability. Identify any problems that may need to be addressed in a Phase II effort. Modeling and simulation may be useful in guiding the development of the chosen processing approach.

PHASE II: Phase II: Further develop the processing approach demonstrated during the Phase I effort. Prototype the proposed candidate (compound semiconductor wafer) device and substrate system. Quantify the advantages of the prototype device/substrate system with appropriate electrical, chemical, optical, and structural analyses. Develop a commercialization strategy to transition the prototype system to industry.

PHASE III DUAL USE APPLICATIONS: Any of the types of devices anticipated to be selected as prototypes in this program are expected to be of interest for both commercial and military applications. The potential advantages offered by the new starting wafers; (increased performance/lower cost microelectronic devices), would make the resulting devices attractive for dual use applications.

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KEYWORDS: Compound Semiconductors, Compliant Substrate, Thin Film Devices, Microelectronics, Solar Cells, Detectors

AF02-125 TITLE: Crack Growth Behavior of Hard Alpha Inclusions in Titanium Castings

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this research topic is to characterize the fatigue crack propagation characteristics of hard alpha inclusions in 6Al-4V titanium castings. Product will be an analytical tool to use for crack growth analysis of hard alpha defects in cast titanium airframe structure.This product is transitionable to military and commercial users of titanium castings.

DESCRIPTION: Hard alpha inclusions are defects that can occur in titanium castings from contamination in the casting process and are brittle in nature. To date, these defects have been analyzed as cracks, since little data has been developed on their behavior under loading. However, this approach may be overly conservative and result in designs being overweight or place an increased inspection burden on fielded aircraft. Data developed on fatigue crack propagation from within these defects can be used to more accurately assess impacts on structural life. This topic seeks proposals for innovative approaches to characterizing fatigue crack initiation at hard alpha inclusions within Ti 6Al-4V titanium castings.

PHASE I: Perform feasibility study to determine usefulness to major airframe designers of an analytical tool to account for hard alpha defects. Onsite visits with airframe vendors will be required to understand nature of hard alpha problem.

PHASE II: a. Prepare specimens of cast material with embedded hard alpha inclusions. An attempt shall be made to vary hard alpha size as well as associated interstitial diffusion zone ("halo").b. Perform constant amplitude fatigue testing, measuring small crack-growth during test.

PHASE III DUAL USE APPLICATIONS: a. Perform destructive analysis on specimens to measure actual hard alpha and halo sizes.b. Determine equivalent initial flaw size to be assumed for crack growth analyses.c. Transition analytical tool to users for design of cast titanium airframe structure.

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J.D. Cotton, L.P. Clark, T.R. Reinhart, W.S. Spear, S.J. Veeck and G.R. Strabel, "Inclusions in Ti-6Al-4V Investment Castings," Paper #AIAA-2000-1464, 41st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference & Exhibit, 3-6 April 2000, Atlanta, GA.

KEYWORDS: hard alpha inclusionfatiguecastingtitanium

AF02-126 TITLE: Verification of Composite Bonded Joint Integrity

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop an inspection technology to verify load-carrying capability of bonded joints.

DESCRIPTION: Standard nondestructive inspection techniques can identify, within limits, porosity and disbonds within bonded joints. Identification of bondline defects is a necessary but not sufficient condition for assurance of bond integrity. For instance, weak bonds may exist due to improper adhesive cure, inadequate surface preparation, contamination of the adherands, or insufficient pressure during the cure cycle. Additionally, environmental durability of bonded joints is strongly influenced by the prebond preparation of the mating surfaces. Some of the current research efforts in this area utilize embedded sensors to verify load-carrying capability. Depending upon their size and location, these sensors may be considered defects in the laminate or bondline and must be accounted for in the design process. This effort seeks to develop a technique to interrogate a bonded joint in completed composite structures to determine if the area in question is capable of carrying at least a minimum load. The technique may be utilized to determine initial bond load-carrying capability. If possible, it is desired that the developed technology be capable of providing data regarding a minimum load-carrying capability of the bonded joint throughout its service life. Attempts to estimate the strength of an adhesive bond via a number of nondestructive measurements have been completely unsuccessful. Because there is no reason to expect any breakthrough in this area from a fundamental scientific standpoint, this program is encouraging other novel approaches to the examination of the load-bearing capability of an adhesive bond. For review of previous work the reader is referred to the review articles listed below.

PHASE I: Efforts should focus on developing an NDI solution which does not create a bondline defect in and of itself. The proposed solution should be able to evaluate load-bearing capability at any stage of the bond's existence, i.e., initial or aged. The proposed solution should also consider unit cost to be paramount. The proposed approach must not take the route of previous failed attempts to provide the solution using ultrasonic methods.

PHASE II: Develop a prototype device and demonstrate its capability on both a repaired bondline (initial and aged) and an aged bond which has not been repaired but which has been aged an amount that simulates a field exposure of mutually agreed upon time.

PHASE III DUAL USE APPLICATIONS: Instrumentation will be produced that is applicable to both military and civilian bonding applications. For this phase of the program additional resources beyond that available from government funding must be acquired. The may be either angel or venture capital funds. These additional resources should provide sufficient resources to produce working devices that have wide applicability to both military and civilian marketplace.

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KEYWORDS: nondestructive investigation, embedded sensors, bondline defects.

AF02-128 TITLE: Logistic Fuel Sulfur Removal for Fuel Cell Use in Air Expeditionary Force (AEF) Operations

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate the feasibility of developing and optimizing an innovative, highly efficient, and miniaturized sulfur removal technology suitable for fuel cell use in AEF operations.

DESCRIPTION: The rapid evolution of fuel cell technology as a replacement for conventional electric power generators has provided a gateway to future efficient and reliable power generating systems using hydrogen as primary fuel. The major drawback to the use of fuel cells as electric generators for deployed forces is the inability to effectively use battlefield fuels (diesel and JP-8) as the primary energy source. The ability to use fuel cell requires the removal of sulfur to ultralow levels from logistic fuel before reforming the fuel to hydrogen. Sulfur content in fuel can reach 700 ppm. Conventional hydrotreating technologies require hydrogen feed as well as high-temperature and high-pressure reactors to produce low sulfur diesel, which results in higher capital requirements and excessive operating costs. Current state-of-the-art sulfur reduction technology developed by Phillips Petroleum, uses a regenerable sorbent that chemically attracts sulfur and removes it from hydrocarbon streams. The hydrogen feed requirement makes these technologies unattractive for military deployment missions. A new sulfur removal technology that operates at low pressure, is compact, efficient, requires no hydrogen feed with sorbent materia, andl that can be regenerated while the unit is operating is sought.

PHASE I: Demonstrate the feasibility of a sulfur removal technology using a laboratory scale reactor that reaches close to 100 percent removal efficiency.

PHASE II: Fabricate and demonstrate a 2 kilogram per hour fuel mass flow rate sulfur removal system.

PHASE III DUAL USE APPLICATIONS: A successful development of an efficient sulfur removal will have a multitude of commercial applications in addition to the bare-base fuel cell power generation. With the EPA requirement for super-low sulfur content in gasoline and diesel fuels, efficient and compact sulfur removal technology will have a great impact on the refinery industries.

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KEYWORDS: sulfur removal, logistic fuel reformer, fuel processor, fuel cell

AF02-129 TITLE: Advanced Materials for Lightweight Space-Based Mirrors

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative methods and materials (polymers, metals, ceramics, and their associated composites [e.g. fiberous, particulate, foams, etc.]) for manufacturing cost-effective, large, deployable, lightweight mirrors for airborne and space-based applications in the visible range.

DESCRIPTION: The Air Force (AF) is seeking new and highly innovative concepts for affordable space-based mirrors. Traditional mirrors are often very expensive and time consuming to produce. They are also generally quite heavy. These mirrors are generally machined to a rough figure from a relatively heavy blank of material, requiring extensive capital investment in machining capabilities and machining time. The mirrors are then finally figured using a variety of grinding and polishing techniques that can also be extremely expensive and time consuming. In addition to reducing the cost and time required to produce primary mirrors, reducing the areal density of a primary imaging or beam converging mirrors is critical to the deployment of future AF platforms, e.g., space-based laser. Desired material characteristics include low density, high stiffness, near-zero coefficient of thermal expansion (CTE) in the operational range, high thermal conductivity, and high fracture toughness for vibration, impact, and heat-load damage control. These properties, along with innovative processing methodologies, can be manipulated to allow a significant reduction in the mass and cost of primary mirror structures. Innovative methodologies and materials for the manufacture of lightweight, near net shaped, large, cost-effective primary mirror systems are sought.

PHASE I: Demonstrate feasibility of a material system, design approach, and associated manufacturing processes in order to optimize cost effectiveness and reduce areal density while maintaining performance. Develop performance estimates in terms of mass, cost, and appropriate mirror performance parameters. Fabricate proof-of-concept coupon/subelement components and develop/specify test methods necessary to aid in performance estimation. Suggest iterations to the design and manufacturing methodology to improve the manufacturing cost, scalability, and areal density without sacrificing performance.

PHASE II: Demonstrate the manufacturing and test methodologies suggested in Phase I on a subelement basis so that a down selection to an optimum design is possible. Demonstrate the capability of the material and process developed in Phase II by fabricating at least a 1-meter diameter primary mirror. Quantify the cost and performance of the mirror with respect to the estimated parameters from Phase I. Produce a plan for demonstrating reproducibility and reliability of the 1-meter mirror manufacturing process and for scaling to larger mirrors or mirror segments.

PHASE III DUAL USE APPLICATIONS: Primary imaging and beam converging mirrors have application on a variety of DoD and commercial spacecraft. Traditional mirror designs are heavy and costly. Demonstration of a lightweight, large, lower cost alternative would provide tremendous savings and capability enhancement for future spacecraft requiring these types of mirrors.

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KEYWORDS: adaptive optics, atmospheric compensation, micromachining, deformable mirror, space based laser wavefront control, cost effective, survivability, reliability, segmented mirrors

AF02-130 TITLE: Dynamic Filtering of MidWave InfraRed (MWIR) Radiation

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop materials and concepts for dynamic filtering of MWIR radiation.

DESCRIPTION: The continued growth of optical applications and devices outside visible and communication wavelengths has resulted in a need for optical control elements in these wavelength regions. One particular area of interest is the MWIR (2 to 5 mm) spectral region. The ability to dynamically filter information on millisecond or faster time scales and with high fidelity is the goal. The Air Force solicits new materials and devices for the controlled attenuation of light in this spectral region. Desired material characteristics include large contrast ratio, fast speed, and high transmission.

PHASE I: Demonstrate the feasibility of new materials and approaches for high fidelity filtering in this spectral band.

PHASE II: Develop the approach chosen and fully demonsrate its usefulness for commercial and military applications.

PHASE III DUAL USE APPLICATIONS: MWIR radiation is employed in a variety of industrial, medical and environmental applications for materials processing, inspection, diagnostics or chemical sensing. Agile and fast tunable filters developed in this program would have broad commercial applications in the MWIR systems as optical shutters, switches, filters and fiber-optic components. They would also have a wide variety of dual defense/commercial applications as solid-state components for multi/hyperspectral imagery in airborne and space-based sensing platforms.

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KEYWORDS: midwave infrared (MWIR), filters, switches

AF02-131 TITLE: Novel Materials for Spacecraft Thermal Control Coatings Technologies

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To identify and develop novel materials (e.g., nanoparticles, conductive particles) for very low solar absorptance and /or tunable emittance in spacecraft thermal control coatings. The new coating system will provide 15 to 20 years in-service thermal management in mid-earth to geosynchronous environment.

DESCRIPTION: Space assets inhabit a harsh thermal environment in which the high intensity of direct solar radiation can raise spacecraft temperatures to potentially dangerous levels. Thus, some method of thermal control is required for hardware to reduce the absorption of solar radiation, as well as dissipate internal heat to proper levels. Temperature control on current spacecraft is achieved using thermal control coatings on radiators.Current state-of-the-art thermal control coating technology uses a potassium silicate binder with a zinc oxide pigment. While there are several variants of this coating system presently in use, this technology has not changed much since the late 1960's when it was first developed. The resultant white coating has a typical beginning-of-life solar absorptance value between 0.15 and 0.20, and beginning-of-life emittance value greater than 0.80. However, after approximately 5-7 years in-service the typical solar absorptance value has degraded to greater than 0.40. As the sizing of spacecraft is done to the end-of-life properties, a much larger vehicle is needed to accommodate this deterioration. This is contrary to the Air Force's need to have smaller, lighter weight space vehicles in the 21st century that have in-service lifetimes of 15-20 years. Thus, revolutionary new materials that maintain their optical properties in service are essential to achieving these objectives.

PHASE I: Demonstrate the feasibility of a new thermal control coating for use in mid-earth to geosynchronous orbits that has the potential of improving the performance parameters mentioned in the description. Specifically, the thermal control coating(s) developed in Phase I will need to be shown to be capable of meeting an inital solar absorptance (as) value of less than 0.15 (threshold), and preferably be less than 0.10 (objective). For a passive coating (without tunable emittance), both the threshold and objective emittance values shall be greater than 0.80. The potential coating(s) will need to be shown not to exceed a 50% increase in solar absorptance after an exposure of 2000 equivalent sun hours to ultraviolet radiation. For an active system, it will need to be shown that the tunable emittance values can be varied between 0.20 - 0.80 after an exposure of 2000 equivalent sun hours of ultraviolet radiation. In addition, stability to electron, and proton environments will need to be demonstrated.

PHASE II: Further develop the proposed coating system. Simulated space flight experimental tests will be conducted on the coating to establish performance parameters, including durability. The new coating will also be flown/tested on an actual space flight experiment when there is an available mission.

PHASE III DUAL USE APPLICATIONS: The final coating system will have application that includes both commercial and military space satellites, vehicles, and platforms that are in mid-earth to geosynchronous orbits.

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KEYWORDS: geosynchronous environment, space environmental effects, ultraviolet radiation, proton radiation, electron radiation, degradation mechanisms, thermal vacuum, thermal control coating(s), spacecraft coating(s), thermal management

AF02-132 TITLE: Polymer Claddings for Space Photonics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop optimized cladding layers for polymer-based photonic devices.

DESCRIPTION: Photonics makes possible secure, high-bandwidth data links, and advanced data handling architectures for satellites while at the same time offering significantly reduced susceptibility to electromagnetic pulse interference, reduced radar cross-section, and reduced electromagnetic noise generation. Polymer-based photonics, in particular, provides additional advantages for space-based applications over devices based upon the state-of-the-art photonic material, lithium niobate. These are a higher tolerance against space radiation effects, reduced operating voltages, smaller device size, an ability to directly integrate with electronics, improved temporal and thermal stability, no piezoelectric ringing, higher frequency performance, and reduced operating power. However, one of the primary limitations to polymer-based photonics for optical modulators and routers has been a compatible cladding layer. Air Force patented technology has previously enabled the highest performance optical modulators by incorporating conducting cladding layers in the devices. However, cladding layers must be further developed for practical devices by optimizing their conductivity, dielectric constant, optical loss, chemical compatibility, and mechanical properties with respect to the electro-optic polymer core layer. Therefore, the objective of this effort is to develop compatible cladding layers for fabricating optical modulators with a high frequency cutoff (greater than 100GHz), an extremely low switching voltage (Vpi near 0.3 volt), low optical waveguide loss (less than 1dB/cm), high thermal stability (125 C operating temperature), temporal stability, and high radiation tolerance. The operating laser wavelength is 1550 nm. Optical waveguide devices may be fabricated only as an integral part of a materials development effort to evaluate and demonstrate the properties of the material(s).

PHASE I: Demonstrate a new material, the feasibility of a proposed new growth technique, improved functionality of a material through innovative processing techniques, or improved materials properties resulting from either growth or processing advancements.

PHASE II: Further develop the proposed material and/or the relevant processes to fully demonstrate the materials properties and usefulness for commercial and military applications. Establish all necessary manufacturing processes for commercialization of a product.

PHASE III DUAL USE APPLICATIONS: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications are optical switches for cable TV, optical phase shifters for phased-array radar, optical interconnects for electronic packages, and switching networks for optical communications.

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KEYWORDS: optical modulators, optical waveguides, photonics

AF02-133 TITLE: Multifunctional Thermally and Electrically Conductive Carbon Nanotube-Polymer Hybrid Material

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop multifunctional thermally and electrically conductive polymer-nanotube composites and adhesives.

DESCRIPTION: Polymer-nanotube composites offer the potential for great advantages over many of the materials used today for electrical and thermal management, on Air Force systems. These materials would result in as much as a 70 percent weight savings over metal-polymer composites, resulting in increased performance. Carbon nanotubes have previously been shown to possess high electrical and thermal conductivity by themselves. However, extremely limited work has been accomplished to determine the properties of truly uniformly dispersed tubes in a polymer matrix. The overriding difficulty in producing these systems occurs from an inability to disperse the carbon nanotubes completely uniform within a polymer matrix of interest.What is desired is a method to produce a uniformly dispersed carbon nanotube-polymer composite. The resulting technique should be applicable to a broad range of polymer systems. The composite should exhibit isotropic electrical conductivity greater than 25 S/cm and thermal conductivity greater than 50 W/m K. The finished product should be able to withstand traditional processing techniques such as extrusion or spray coatings with out loss of material properties.

PHASE I: Address the goals and requirements discussed above and demonstrate the viability of nanotube-polymer composites. Demonstrate feasibility of an electrically- and thermally-conductive polymer composite in accordance with the requirements listed in the descriptive section. Material samples will be fabricated and analyzed. Electrical, thermal and mechanical property data will be provided from testing the samples.

PHASE II: The product from Phase I would be further developed and optimized. Scale-up efforts will also be established.

PHASE III DUAL USE APPLICATIONS: During Phase III, the specific requirements of current Air Force platforms will be addressed. The Air Force has a variety of aircraft and satellite applications that a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced thermal management for electronics packages.

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KEYWORDS:

AF02-134 TITLE: Virtual Nondestructive Evaluation (NDE): Computational Methods for Virtual Prototyping

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Virtual designing and nondestructive evaluation (NDE) prototyping - that is modeling and simulation of designs and processes, simulating NDE from conceptual design through the service life phase of component knowledge chain - will provide the means to predict damage tolerance and service life, as one of the design criteria..

DESCRIPTION: The project efforts of this topic would work toward the creation of a virtual environment at a computer terminal: perform design process simulations, project appropriate manufacturing processes; evaluation of the NDE models to determine the necessary inspections for quality control, and provide predictive assessments to evaluate service life and damage tolerance of both structures and response configurations of different designs. This topic will focus on the modeling and simulation aspects of the NDE responses as part of the design cycle of new materials and components, with the current NDE information/knowledge chain providing future predictions for material design, manufacturing, and service life cycle. This area will be a necessity for developing modeling strategy for the Sensor Craft. A future system, currently in early design concepts, that would benefit from this type of effort would be the coherent conformal array technologies, focusing on the development of low profile, inexpensive conformal broadband active electronically scanned array (AESA) apertures. This system, and others still in design concept stage would represent particular application where virtual NDE can assist in design options for determining the optimum design for performance and manufacturing and life cycle processes. This conceptual modeling strategy is to include database construction for the purpose of predicting material property, understanding and visualizing the transition of micro to macro data and material development, predicting material performance, and capturing prototype life expectancies of components and manufacturing processes for the various design options.

PHASE I: Phase I is the development of conceptual design of the Virtual NDE process simulation. It is to map the direction of the modeling and prediction efforts. It should cover the approaches and the path of strategies of NDE knowledge utilization in virtual prototyping. The end product should be a feasibility strategy of inserting NDE models into a virtual design, manufacturing and maintenance environment. The strategy should also include some predictions on design components in the simulations of the component life cycle.

PHASE II: Phase II would further develop the model defined by Phase I. Visualization of NDE knowledge (that is: knowledge is obtained from experience and information and the information is extracted from the raw NDE data) are to be incorporated into the design cycle of defined examples of components. The value of designing for service life, the effectiveness of the models and simulations for the design, manufacturing, and service life options are to be analyzed and mapped with the cost/benefits of the computational approach performed.

PHASE III DUAL USE APPLICATIONS: Initial success, on a limited problem space, will spearhead the way for reliance on computational means to eliminate the expense of multiple first item design, manufacturing, and service life attempts. Here the final design will have examined many options, and determined the optimum approach, before any real (manufacturing) expense is incurred. In addition, the effects of aging will be incorporated into the design to find the optimum configuration for the entire service life of the part. This view has application to any business base that is creating (manufacturing) parts or components - aerospace, automotive, metals processing, and composite processing through a comprehensive view of predictive, virtual prototyping.

REFERENCES:

KEYWORDS: nondestructive evaluation (NDE), conformal antennas, modeling, simulation, design

AF02-138 TITLE: Distributive Processing Techniques For Interconnected Embedded Systems

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Investigate innovative distributive processing techniques for load sharing interconnected embedded processors.

DESCRIPTION: Operational Flight Programs (OFP) modifications continue to be the cost and risk drivers for munition and aircraft integration. Technology that would allow the automatic shifting of some processing tasks from the flight computer to the dispenser when necessary would result in an increase in system capability. As munitions decrease in size, the number of munitions that a bomber or fighter can carry increases. Current flight computers were not designed to handle the number of miniature munitions that a bomber or fighter can carry. Flight computers, especially in bombers, do not have the performance capability or the capacity to perform the required processing. Distributive computing technology maybe useful in distributing some of the flight computer processor load to the munitions dispenser. For example, tasks like power management, test diagnostics, target assignment, moment arm offset, and weapon status check, could be offloaded to dispenser's embedded processor. Current developmental smart dispensers are designed to be passive. They are smart only in the sense they carry smart weapons. With their limited processing capability, bombers and fighter aircraft cannot take advantage of their physical capacity to potentially carry several hundred munitions. Distributed processing techniques may help overcome this obstacle.

PHASE I: Investigate feasibility of using distributive processing techniques to increase the processing performance and capability of two or more embedded processing systems that are interfaced together. Innovative approaches are needed that would allow overburden processors to tap resources of other underutilized processors.

PHASE II: Develop and prototype a distributed processing architecture capable of automatically shifting the processing load between embedded processors. Develop an electronics/logical specification for the prototyped system.

PHASE III DUAL USE APPLICATIONS: Distributed computing has several useful military and commercial applications where embedded processors and or microprocessors base hardware are interconnected together – for example computer networks in a commercial or military command and control center, web servers, telephone switches, wireless weapons networks and local area networks (LANS).

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KEYWORDS: Operational Flight ProgramsDispenserMiniature MunitionsFlight ComputerDistributed ProcessingEmbedded ComputerReal-Time ProcessingLoad Balancing

AF02-141 TITLE: Micro Air Vehicles for Munition Bomb Damage Indication

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop technologies for integrating Micro Air Vehicles (MAV) with a munition to provide Bomb Damage Indication/Bomb Damage Assessment (BDI/BDA).

DESCRIPTION: Micro Air Vehicle sensors that can be attached and deployed from a munition can be an innovative concept for acquiring BDI/BDA information. Weapon impact location, inertial navigation system/global positioning system (INS/GPS) state at impact, fuze function, pre- and post- impact imagery are examples of information that could be gathered and relayed by a MAV. MAVs could have the ability to provide long duration imagery and/or sensing for BDA. Target characteristics and contents may be discernable for deeply buried targets. Additionally, counterproliferation concerns are driving requirements for target detection at low dosage levels. These munition deployed sensors could detect signatures of suspected agents. Miniature expendable air vehicles could be utilized for remote sensing and/or high-resolution imagery to fly through and/or track agent clouds without decontamination and reconditioning. To date only small investments have been made in fuze function recovery and munition deployed cameras. Further research is required for sensors, munition integration, assessments, and data links/data processing. The purpose of this topic is to investigate innovative concepts of a MAV for BDI/BDA, focusing on the design, deployment and stability of the MAV.One concept is to have the attacking munition deploy a MAV. The MAV will be attached to the munition upon launch from the host aircraft. At some point in the trajectory, this MAV will separate from the munition, stabilize, and fly to the target coordinates for post-impact BDA. The MAV needs to record the impact event and rebroadcast this data plus the BDA imagery back to an applicable platform. The packaging, separation, and stabilization of the MAV is technically challenging since the host munition may be traveling at near sonic velocities when the MAV is to separate. Technology investments that are necessary to utilize an MAV for BDI/BDA include the following: 1) Resolve issues involved with MAV separation/deployment – how is the MAV deployed from the munition so there is little or no effect on the host munition and allows the MAV to establish stable flight.2) Resolve issues involved with sensor selection (e.g., EO, IR, RF, etc.) – identify the most promising sensor for the widest range of munition operating conditions (e.g., day/night, weather, etc.).3) Resolve issues involved with data transmission (bit rate, power, antenna, range) and receiving platforms (UAV, satellite, etc.)

PHASE I: Identify and define the feasibility issues for an innovative overall MAV concept and design that is compatible with current weapons. Packaging, deployment, stabilization, and successful operation on the MAV are critical technology issues that need to be addressed in the feasibility effort. Low cost is an essential aspect for weapon implementation and should not exceed 20% of the munition cost.

PHASE II: Develop and perform a prototype demonstration. Conduct testing to prove feasibility over various operating conditions. Testing will consist of component test hardware fabrication, integration on a suitable test vehicle, and flight testing.

PHASE III DUAL USE APPLICATIONS: Remotely gathering information on fortification layout, criminal/ friendly disposition, etc. for use by law enforcement agencies in a terrorist or hostage situation.

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KEYWORDS: Sensors, video, surveillance, tracking, vision system, pattern analysis

AF02-142 TITLE: Bomb Impact Analysis and Damage Assessment via Remote Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Identify sensor technologies for gathering and assessing bomb damage indication/bomb damage assessment (BDI/BDA) from a munition deployed asset.

DESCRIPTION: Today’s autonomous munitions are proving to be an effective means for prosecuting an air war. Standoff cruise missiles are used for opening days of the war and short time duration contingencies. Inertial Navigation System/Global Positioning System (INS/GPS) guided bombs have the potential to be the general purpose workhorse for future air campaigns. As a result of these autonomous munitions, direct overflight of the target is not required and aircraft loss rates have dropped dramatically. However, BDI/BDA is becoming more difficult with autonomously guided munitions. "Gun camera" imagery is not available from the delivery platform. High overhead imagery is either not available or is unable to discern target damage, especially for buried targets. The recent Kosovo operations demonstrated increased need for BDI/BDA associated with INS/GPS munitions. The percentage of unknown results for INS/GPS munitions was three times that for traditional laser guided bombs. The prospects for the future could be even worse with the advent of miniature munitions that will provide even less visible damage to the target. Without improved BDI, targets will be reattacked unnecessarily, requiring more sorties, munitions, etc.Munition attached and deployed sensors can provide valuable data for BDI/BDA without overflight by valuable manned aircraft or unmanned aerial vehicles (UAV). Weapon impact location, weapon function (i.e., did it detonate), pre- and post-impact imagery are examples of information that could be made available. We seek innovative sensor applications and/or development that will provide BDA/BDI from a "pop-off" vehicle. The sensor must be able to work in high and low light conditions and may also need to work in areas of low cloud cover. In addition, technologies need to be developed or exploited that will allow for autonomous processing of the gathered BDA/BDI data to provide a "level of confidence" in target destruction.

PHASE I: Design, develop, or exploit appropriate sensor technologies to gather information about a munitions performance. It is highly desirable to develop/design a sensor that can determine weapon performance for a deeply buried target. The sensor can either be part of the weapon itself or be deployed prior to impact. Phase I shall address methods for distributing data gathered by the sensor. Additionally, Phase I shall investigate processes that provide automated confirmation of target destruction from the sensor data.

PHASE II: Devlop, demonstrate, and validate a prototype sensor and processing algorithm. This will consist of test hardware fabrication, bench testing of components, and prototype sensor testing.

PHASE III DUAL USE APPLICATIONS: Dual Use Commercialization Potential: Application, integration, and test and evaluation (T&E) for remotely gathering information on fortification layout, criminal/friendly disposition, etc., for use by law enforcement agencies in a terrorist or hostage situation.

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KEYWORDS: sensors, video, surveillance, tacking, vision systems, pattern analysis

AF02-143 TITLE: Effects of Internal Weapons Bays on Advanced Munitions

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Investigate and quantify the effect of internal bay flow fields on smart weapon operation.

DESCRIPTION: Effects of internal bay flow fields on advanced munitions is somewhat unknown. These effects include: acoustics and flow anomalies due to air flow over an open weapons bay. Acoustic effects have the potential to destroy sensitive electronics (seekers, sensors, receivers, etc.) and reduce fatigue life of surrounding structures (fins, outer casings, ejector racks, etc.). Flow anomalies can cause unpredictable separations of miniature weapons, which could lead to catastrophic effects on weapons and in extreme cases aircraft.Steinburg [Ref. 9] describes the effects of acoustic noise on electronic equipment, and distinguishes between two types. The first effect is outright failure due to physical breakage (fatigue failure). The second effect is called microphonic. This is when a component is sensitive to acoustic levels due to the change in size (volume) of a device, which in turn changes the electrical properties of the device. Offerors should be equipped to analyze the effects of both types of acoustic drivers on sensitive weapons components, and to describe the costs of alleviating both types of effects. Active flow control has been investigated in recent years as a means to achieve higher levels of acoustic suppression. Offerors should also be prepared to roughly evaluate the cost benefit of powered devices which could deliver higher suppression levels vs the cost of passive damping or hardening techniques applied to the weapons themselves.

PHASE I: Characterization of the flowfield environment (acoustics, flow anomalies, etc.) within an advanced munitions internal bay over a wide range of Mach numbers and flight conditions. Define areas of concern and solutions for a variety of advanced munitions. Areas of concern include, but are not limited to, structural fatigue in munition and aircraft, electronics failure, and safe separation. Determine the cost, risk and extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate under actual engineering conditions or demonstration under simulated flight conditions.

PHASE III DUAL USE APPLICATIONS: High-payoff military applications include massive delivery of small smart weapons to time critical targets anywhere in the world. Commercial applications include innovative techniques for delivering and recovering cargo to/from space, reducing acoustic noise in commercial aircraft landing gear bays, and cooling technologies for high-speed civil transport.

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KEYWORDS: Weapons Bay, Store Trajectory, Flow Control, and Acoustic Suppression, Weapons Separation, Cavity Acoustics

AF02-144 TITLE: Reconfigurable Computing Applications for Aircraft, Munitions and Dispensers

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Investigate and validate the feasibility of reconfigurable computing technology to increase processing capability, reduce parts obsolescence and integration cost.

DESCRIPTION: Current aircraft, dispensers and munitions interfaces requires costly hardware changes when upgrades are required. Innovative implementations of these interfaces are needed to reduce integration and upgrade costs. Recent advances in reconfigurable computing technology, offer opportunities to reduce cost and risk of munitions and aircraft integration. An additional benefit may also be gained in the area of parts obsolescence. Parts obsolescence in electronic components continues to be an issue in the military and commercial markets. Reconfigurable computing technology may solve this problem. The feasibility of implementing microprocessors and key electronic parts in gateware, to get significant increase in performance and capacity, needs to be investigated. Gateware is the merging of hardware and software. Gateware is not hardware specific, so if the hardware it resides on becomes obsolete, it is easily implemented on the new hardware. Since reconfigurable computing technology is reprogrammable, new or modified capabilities can be introduced to the war fighter in significantly less time and without having to re-certify electronics.

PHASE I: Perform creative analysis to determine effectiveness and technical feasibility of implementing reconfigurable computing technology (software upgradeable/reconfigurable hardware) to increase capability and compatibility and to minimize hardware obsolescence.

PHASE II: Develop and demonstrate an innovative prototype application using reconfigurable computing technology. Prototype hardware should be software reconfigurable and demonstrate a processing capability.

PHASE III DUAL USE APPLICATIONS: Reconfigurable computing technology has many commercial and military applications where hardware can be upgraded by software and real-time processing is required – for example Personal Computers, commercial/military avionics processors, weapon interface electronics and real-time image processing for x-ray equipment.

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KEYWORDS: Parts obsolescence, Operational Flight Program, reconfigurable computing, Aircraft integration, Field Programmable Gate Arrays (FPGA), adaptive computing.

AF02-145 TITLE: Liquid Payload Expulsion and Aerosolization

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop and demonstrate a computational approach for simulating the ejection of liquid payloads.

DESCRIPTION: In some cases, weapons may be used to rapidly inject neutralization chemicals into masses of chemical or biological agents. Conceptually, this idea is valid, but there are currently no computational codes that can simulate the release and aerosolization of a liquid neutralizer. Although some empirical techniques exist, a high-resolution computational code is needed in order for detailed design and analysis work to be performed. The relevant physics is very complicated and is not adequately captured by simpler models. If a liquid neutralizer is to be used against an aerosolized agent it follows that the neutralizer must be sprayed into droplets at the appropriate time in the detonation or expulsion event. If the droplets of neutralizer are too large, then the aerosolized agent may not be exposed to the neutralizer in a manner supporting neutralization. The same can be said for liquid agent stored in containers. Fragments may be used to open the containers, but it may be necessary to spray the neutralizer with a certain droplet size and within a certain time interval to promote neutralization. A high-resolution computational ability to predict droplet formation and aerosolization is needed to complement warhead experimental work in this area. Such a capability would also be important for couterproliferation analyses in addition to warhead design by being able to predict the release and aerosolization of agents from containers damaged by conventional munitions. Critical challenges in achieving this capability are the unsteady formation of droplets and the cascade from droplets to an aerosol. Specifically, an unsteady droplet formation/cascaded breakdown model would need to be developed based on the mechanics of turbulence and surface forces, and then cast in a framework consistent with subscale/LES (large eddy simulation) theory. Once integrated into a conventional LES turbulent flow CFD (computational fluid dynamics) code such a capability would prove extremely useful in warhead design efforts.

PHASE I: Develop an approach to deriving an unsteady liquid droplet formation and cascade breakdown model using the mechanics of turbulence and surface forces. Identify appropriate experimental data for validation efforts in phase II.

PHASE II: Develop an unsteady liquid droplet formation and cascade breakdown model and then formulate the model into a subscale/LES (large eddy simulation) framework. Test and demonstrate this model in a high-resolution Large Eddy Simulation (LES) CFD code. Validate the models and code against experimental data such as a turbulent jet or a turbulent free shear layer.

PHASE III DUAL USE APPLICATIONS: These new algorithms will be useful in commercial manufacturing applications, fuel injector design, and other industrial processes..

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KEYWORDS: Large Eddy Simulation, Computational fluid Dynamics, aerosol, droplet formation, turbulence, unsteady

AF02-146 TITLE: The use of synthetic aperture radar (SAR) imagery for targeting of Laser Radar terminal seekers

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an automated targeting concept to enable the use of synthetic aperture radar (SAR) data as a source of target information for active imaging seekers such as laser radar and SAR seekers.

DESCRIPTION: The Air Force is investigating technologies to support the next generation precision weapons and laser radar has emerged as one of the key technology candidates for application as a terminal seeker. Specifically, this task addresses the development of a technique to automatically extract required targeting information from both high quality SAR as well as aircraft quality SAR. The targets of interest are unplanned targets of opportunity, and include fixed (buildings, bunkers, etc), relocatable and moving targets. The effort must consider the weapon-borne 3-D seeker as well as the seeker algorithm used to support autonomous target acquisition and track.Background: Synthetic aperture radar imagery is one of the most prevalent sources of target imagery. SAR can produce high resolution imagery from aircraft standoff ranges and is the only source available in almost-all weather conditions. As such, it is important that precision weapons and specifically those with terminal seekers be able to take advantage of this data source for targeting purposes. Targets of opportunity are of particular interest and drive the need to rapidly develop requisite targeting information, typically from on-board a strike asset. The basic problem of interest here is a solution to the problem of transferring relevant information from one imaging active seeker (e.g., a SAR) to another imaging active seeker (a laser radar, or another SAR) with substantially different performance parameters, in real time, with minimal human intervention. Details: A great deal of work has been done in developing algorithms and mission planning concepts for laser radar for interdiction, suppression of enemy air defense, and other missions, both for fixed high value and ground mobile targets. Unfortunately, these algorithms and mission planning concepts rely on targeting information developed during ground based mission planning and the majority of the imagery products used are either visible or infrared. The purpose of this effort is to attempt to use readily available SAR imagery for both ground based mission planning as well as real time, airborne mission planning.

PHASE I: Develop and evaluate candidate concepts to support transferring relevant image information from one active sensor (an air-borne SAR in the example) to another active sensor (a weapon-borne laser radar or SAR in the example). Phase I will result in a recommended concept with supporting analysis and rationale.

PHASE II: Develop detailed design for the recommended concept resulting from Phase I. Demonstrate the recommended concept through detailed modeling and simulation, using sensor parameters provided by the sponsor. Evaluate performance and provide resulting software and additional recommendations to the sponsor.

PHASE III DUAL USE APPLICATIONS: Automated transfer of imagery or equivalent information from one active sensor to another with different performance parameters could potentially be used to cue sensors to track objects, useful in tracking object's progress in processes and providing a means of process control.

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KEYWORDS: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

AF02-147 TITLE: Improvement of Penetrator Performance by Increasing/Engineering Case Mechanical Properties

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative concepts, processes and materials for improving strength and fracture toughness of steels.

DESCRIPTION: New and innovative concepts, processes and materials are required in the area of air delivered non-nuclear munitions that will have a dual use and high commercialization potential. Current methods for improving strength and fracture toughness are generally limited to reduction of sulfur content and adding substantial concentrations of cobalt and nickel. As a result, significant improvements have been made for the required properties but they have driven the cost of steel up 6-10 times that of ordinary steel. Now that it is known that the higher performance can be obtained, concepts and processes must be developed that will drive the cost down while maintaining the desired characteristics. The desired cost range is $2 to $4 per pound. Areas of research include improvements in quality control, functionally gradient materials, heat treatment, mechanical forming processes, micro-structural gradient control, reduction of inclusions that cause embrittlement and development of inclusions that improve strength in concert with fracture toughness. Exit target properties are as follows: a) 325ksi (235ksi minimum) Yield Strength and b) 34 ft-lbs (30 ft-lbs minimum) Charpy Impact Strength. The necessity for improvements is apparent as targets are further hardened, requirements for terra-dynamic steering are added and production costs continue escalating. Military uses include bombs, penetrators, sub-munitions, warheads, projectiles, fuze assemblies, aircraft structures, etc. Commercialization uses include higher performance and lighter weight car and truck frames, commercial aircraft structural components, bridge structures, etc.

PHASE I: Investigate new and innovative concepts, processes and materials for improving strength and fracture toughness of steels. Develop methodology of the proposed processes and establish control parameters. Demonstrate procedures are generally applicable and yield expected results.

PHASE II: Develop and demonstrate that the proposed concepts, processes and materials are valid and that the results are approaching properties established for materials such as HP9-4-20 up to AF-1410. Develop mechanical properties data base for supporting hydrocode development and produce one-quarter scale prototype penetrators. These prototypes will be used to verify the strength and fracture toughness properties and demonstrate that the new composition developed is robust enough to justify further developmental testing.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has extremely high utility for both the military as well as the commercial sector. Military tactical program objectives of increased penetration, terra-dynamic steering and reduced costs will benefit from the improved mechanical properties. Military aircraft developers will have greater latitude in design of weapon bays and deployment options by utilizing smaller, more efficient weapons. Commercial steel users such as aircraft manufactures, automotive producers and bridge contractors will have new materials available for new designs that are more efficient and cost effective.

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KEYWORDS: High Strength Low Alloy (HSLA) steel, nickel, chromium, cobalt, precipitation hardening, tensile yield strength, ultimate tensile strength, fracture toughness

AF02-149 TITLE: Agent Defeat Short Time Neutralization Data Collection and Modeling

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: To determine short time (1-100 milliseconds [ms]) neutralization requirements of biological agents for counterforce weapon and model development.

DESCRIPTION: Knowledge of the neutralization rate of spores and other biological agents by heat, pressure and/or gaseous chemical neutralizers in the 1-100 ms time range is urgently needed to enable predictive modeling of weapon effectiveness and collateral damage resulting from attacks on targets containing biological agents. Current methods for determining the neutralization of biological agents (and simulants used in testing) by heat, pressure and/or gaseous chemicals are limited to times greater than 100 ms. In addition, the knowledge base in the 100 millisecond time frame is very limited and tends to be extrapolated down from the 1-5 second time frame where more extensive data has been taken. This requirement is for the development and application of methodology capable of determining neutralization for exposure times of 1-100 ms while being exposed to selected thermal, pressure and/or gas environments. It is anticipated that the methodology developed in this program will also be of use in the development of rapid sterilization techniques for biomedical and civilian biological agent defense/cleanup purposes.

PHASE I: Compile neutralization data from government and open literature sources. Develop a preliminary chemical reaction model and determine the types of input data required. Experimentally evaluate innovative techniques for the exposure of bioagent simulants to heat, pressure and selected gaseous chemical environments for defined periods of time in the 1-100 ms range. The design proposed must be capable of simulating the heat, pressure and chemical exposure provided by an actual weapon.

PHASE II: Construct and demonstrate the exposure testing system which looks most promising from the designs evaluated in Phase I. Determine the time dependence of neutralization of selected bioagent simulants under varying thermal, pressure and/or chemical environments over the time range of 1-100 ms. Modify the design as required to optimally simulate all of the significant environmental conditions occurring in an actual weapon employment. Refine the PHASE I model to fit the data generated. Verify the predictive capability of the model with an independent set of experiments.

PHASE III DUAL USE APPLICATIONS: Optimal conditions for thermally enhanced chemical flash sterilization, which offers the potential for rapid removal of microbial contamination from the surfaces of medical instruments and similar items, could be rapidly evaluated using the techniques to be developed here. Methods for neutralizing terrorist released biological agents could also be evaluated using these techniques.

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KEYWORDS: Heat, inactivation, neutralization, spore, bioagent, flash, sterilization

AF02-150 TITLE: Low Cost Universal Flight Termination System

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate an innovative solution for a Universal Flight Termination System (FTS) for use in conventional weapons flight testing.

DESCRIPTION: In order to test a munition on Eglin AFB land ranges, as well as many other test ranges throughout the country, a munition must be able to terminate flight at any point during a mission when safety becomes a concern. The Range Commanders Council has developed a common design and testing requirements standard, RCC 319-99, that details Flight Termination Systems for virtually all government test ranges. The development of these devices, however, remains individualized to each program. Since qualification and testing of the FTS can be a significant amount of a flight testing budget, testers are looking for a "cheaper" and easier way to include FTSs in their munitions. The technical challenge is to innovatively standardize separate FTS components (i.e., Safe & Arm, receiver, antenna, etc) without violating constraints of RCC 319-99. For example standardizing the Safe & Arm device means that all munitions could use a general device to ensure that certain safety and performance requirements are met before the main charge of the weapon can be detonated. The standardization of FTS components would increase affordability by reducing research and testing efforts required by RCC 319-99 for each individual program. Instead, each program could focus on the actual performance of their munition.

PHASE I: Investigate innovative FTS solutions that are applicable to the greatest number of munitions. Select preferred method for phase II developmen

PHASE II: Design and construct solution selected in Phase I. Perform ground testing on various munitions to demonstrate the capability. Conduct validation testing of the concept for risk reduction and transition maturity to future flight termination systems.

PHASE III DUAL USE APPLICATIONS: There are several uses for the technology that goes into developing an FTS device. Some include use in mining, blasting, and demolition. Police or demolition forces could use this technology as a safe, reliable method to destroy terrorist bombs. In addition, commercial space launches could benefit.

REFERENCES:
1. RCC 319-99 Flight Termination Systems Commonality Standards

2. Mil Std 1316

3. "Flight Termination Receiver/Decoders Design, Performance and Certification," RSG-313-80 (ADA089746)4. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Munition, Flight Termination System, Electronic Safe and Arm, Explosives, Fuzes, Miniaturization

AF02-151 TITLE: Use of Kalman Filter Residuals for Independent Fuze Safeing

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Analyze using weapon navigation filter's residuals for verification of safe weapon separation for fuze safeing.

DESCRIPTION: Current military aircraft-launched weapons use an FZU-48 air turbine as a signal that guarantees that the weapon is in the unique environment of flight after release from the aircraft. This power signal to the fuze allows the fuze to be "safe" in all other conditions (accidentally released on the ground, etc.). The Air Force is interested in using battery power in place of the air turbine to save space and lower the drag induced from the turbine to verify that the bomb is indeed in the unique environment of flight away from the aircraft.The GPS/INS guidance system in current Air Force weapons has two independent sources of information that may suffice. The fact that the GPS receiver has locked onto multiple satellites demonstrates that the bomb is not shadowed or masked by the wing of the aircraft, and the accelerometers in the INS should sense drag and lift accelerations associated with flight. These signals are measured and combined in the Kalman filter to determine current position and velocity. It is proposed that the residuals between the latest measurements from the GPS and/or INS and the filter's estimates could then be used to determine the condition of stable flight after release from the aircraft.

PHASE I: An analysis of a characteristic navigation filter of an aircraft-launched weapon should be performed in a digital computer simulation to determine the appropriate residuals to indicate state change associated with weapon release (i.e., from captive carriage to freefall). A decision-making process to safe or arm the fuze should be generated and integrated into the computer simulation. Various scenarios of weapon launches should include aircraft dynamics, GPS/INS signal measurement, GPS antenna shadowing, and air data simulation for characteristic weapon launch trajectories.

PHASE II: A current weapon system's navigation filter and fuze safeing mechanism should be integrated in hardware and software, tested rigorously in the laboratory to analyze the fuzing change from safe to arm states based on various measurement inputs (e.g., acceleration measured by accelerometers, GPS satellite signals locking, etc.), and flight-tested.

PHASE III DUAL USE APPLICATIONS: Filter residual monitoring could be useful in any remote monitoring implementation. Spacecraft operations, remote sensor operation, unmanned submersible operations could all use this technology for status verification.

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3. Dierolf, David A.; Richter, Karen J.; Christakis, Alexander N.; "Report on the Department of Defense Fuze Industry Workshop," Report Number: IDA-P-2386 (DTIC Accession No. ADA222637).

4. Fowler, Steven E.; "Safety and Arming Device Design Principles," Report Number: NAWCWD-TP-8431 (DTIC Accession No. ADA363924).

KEYWORDS: Fuze Safeing, Fuze Arming, Inertial Navigation, Kalman Filter, GPS/INS, Accelerometer, Covariance Analysis, Residual Monitoring

AF02-152 TITLE: Intraweapon Wireless Communication

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine feasibility/methodology of communications between two locations in a penetrating weapon without physical links.

DESCRIPTION: Communication between functional elements of weapon systems has been historically accomplished by physical wires carrying electrical signals. However, for hard target penetrating munitions this communication link cannot be expected to survive during and after target penetration. Advanced counter-proliferation weapons concepts require multiple functions at different locations within the warhead to maximize effectiveness. The Multiple Event Hard Target Fuze, now in advanced development, is being tailored to accomplish these functions. However, due to technology limitations, each functional location must operate autonomously after impact. Therefore, we are soliciting an R&D effort to investigate a communication technology that can survive impact and still transmit at least a fire or detonation signal between locations internal to the warhead without time of phase shift during high impact penetration events. It is highly desirable that no warhead case modification be required.

PHASE I: Phase I of this effort will include design and analysis of the proposed communication concept(s). This analysis must include frequency modeling to determine compatibility and transitivity through various media in a munition. In addition, this analysis needs to address critical component survivability during munition impact Methods of verifying feasibility in Phase II shall be proposed and documented in a Phase II test plan.

PHASE II: Phase II will involve the detailed design, fabrication of and demonstration of prototypes. The government will provide tests at no cost to the contractor in a 3.6 inch diameter by 24 inch length projectile at velocities up to 1500 ft/sec with contractor supplied hardware including instrumentation, to provide a shock survivability analysis. The contractor should demonstrate the validity of the design with a demonstration of the communication between various locations in a muntion.

PHASE III DUAL USE APPLICATIONS: The developed communication link may have industrial application in transmitting data in harsh environments including directly through stationary or moving bulk media. Certain concepts, i.e., communication through ferrous media, could have direct application to vehicles such as transmission of auto or aircraft crash information. In addition, wiredata transmission through various media is a commercial enterprise in itself and includes many technology areas.

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2. AFRL/MN Home Page: http://www.mn.afrl.af.mil

3. Andre, Nicholas, "Security Measures for Wireless Communications," TIB-93-8 (ADA319939).

KEYWORDS: Penetrators, explosives, signal transmission, warhead, fuzes, microwaves

AF02-153 TITLE: Innovative Sensor Precision Guided Munition Accuracy

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a method providing use of innovative sensors for precision guided munition accuracy enabling a 3 meter capability.

DESCRIPTION: Autonomous guided weapons concepts such as the Joint Air-to-Surface Standoff Missile (JASSM) currently use an infrared (IR) sensor and an automatic target correlation algorithm to remove errors induced in the coupled INS/GPS navigation system. Several IR pictures are taken prior to impact and used to update navigation errors induced either by GPS jamming or INS drift. Resultant guidance errors are reduced to less than 3 meters given greater than zero-zero weather conditions. However, this accuracy comes as a result of increased cost for the sensor and increased radar cross section due to the sensor aperture on the outer mold line on the front of the vehicle. Consequently, it is desired that a method be developed to provide 3 meter guidance. No gross impact in the mission planning aspects of the weapon system should be caused by the implementation of this guidance capability.

PHASE I: In Phase I of this effort, an innovative conceptual study on atypical sensor technologies, which will provide JASSM-like systems with a capability to precisely guide to ground fixed and mobile high value targets in day/night, adverse weather, and hostile environments without the use of a standard forward-looking sensor shall be investigated. Innovative sensors could include such technologies as magneto-resistive sensors, star trackers, passive optic flow sensors, etc. The candidate sensor shall be low cost and suitable to be integrated into the weapon airframe without major modifications. To test and evaluate the proposed sensor concepts, a preliminary simulation using JASSM parameters and requirements shall be conducted. A technical report, providing a detailed description of conceptual design of the candidate sensor processing approach and investigation result of the Phase I effort, shall be delivered to the sponsor. The conceptual study effort will be 9 months in duration.

PHASE II: In the Phase II effort, a prototype of candidate sensor will be developed, tested, and demonstrated based on the results of the Phase I conceptual study and design. The software/hardware development should be optimized for speed and performance and suitable for real time fight test demonstration. The researchers will have an option to conduct a captive flight test on slow speed platform (such as a helicopter) or a tower test based on technology offered. The researcher shall document the test and its result along with the software documentation, and deliver a final report to the sponsor at the end of Phase II effort. The development and demonstration of the system will be 24 months in duration.

PHASE III DUAL USE APPLICATIONS: The concepts developed and demonstrated during Phase II will be implemented, integrated, and demonstrated on a high-speed platform for JASSM applications. This technology also has potential for dual use applications in the following technology areas: Navigation, Surveillance, and Automatic Landing Guidance systems.

REFERENCES:
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3. K. Prazdny, "On the Information in Optical Flows," Computer Vision, Graphics, and Image Processing Vol. 22, pp 239-259, 1983.

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5. Kayton, Myron and Fried, Walter R., Avionics Navigation Systems. New York: John Wiley & Sons, Inc., 1997.

KEYWORDS: guidance, navigation, control, precision navigation, magnetometers, optic flow, star tracking

AF02-155 TITLE: Automatic 3-Dimensional Wire-Frame Model Generation Algorithm

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an algorithm to automatically build wire-frame models of targets from stereoscopic imagery.

DESCRIPTION: Automatic target correlation (ATC) algorithms for fixed ground targets often operate on significant edge features found in a scene, such as roof lines or corners of a building. The algorithms use these edge features to correlate with a target model that is generated in the "mission planning" phase of the effort. Because the algorithms operate on significant edge features, wire-frame models of the target's 3-dimensional structure are well suited for use in ATC algorithms. Unfortunately, the generation of the wire-frame models is a manual, labor-intensive, and time-consuming process that is prone to significant variation based on the skill and experience of the person generating the model. To alleviate these problems, it is desired that a computer algorithm be developed which will operate on stereoscopic imagery to automatically generate wire-frame models of a target and its scene. Systems such as the Joint Air-to-Surface Standoff Missile (JASSM), which currently requires the manual generation of models from stereoscopic imagery, will benefit greatly from such an algorithm.

PHASE I: In Phase I of this effort, a conceptual study will be conducted, which should address the issues involved in the generation of 3-D wire-frame models from stereoscopic imagery. The study should determine how to generate the models such that they accurately represent the significant structures of a scene while disregarding the insignificant ones. A design of a system that can meet these goals should be proposed.

PHASE II: In Phase II of this effort, an innovative prototype software system will be developed capable of generating 3-D wire-frame target models from stereoscopic imagery. The system should have a moderate run time and be able to generate a 3-D wire-frame model that accurately represents the significant structures of a scene. At the end of this phase, a prototype should be demonstrated which accomplishes this task. During this phase, the prototype developed should be integrated into the JASSM mission planning platform, and further developed such that the models generated by the prototype are compatible with the format of the JASSM models.

PHASE III DUAL USE APPLICATIONS: This system in its final form is applicable to many areas of non-military interest. These include but are not limited to: robotics, CAD generation, 3-D cartography, and law enforcement.

REFERENCES:
1. AGM-158 Joint Air to Surface Standoff Missile (JASSM) http://www.fas.org/man/dod-101/sys/smart/jassm.htm

2. Veron, H.; Southard, D. A.; Leger, J. R.; Conway, J., "3D Displays for Battle Management," MTR-10689 (ADA223142).

3. Gennery, Donald Bernard, "Modeling the Environment of an Exploring Vehicle by Means of Stereo Vision," STAN-CS-80-805, AIM-339 (ADA091081).

4. "Precision-Guided Munitions: Acquisition Plans for the Joint Air-to-Surface Standoff Missile," GAO/NSIAD-96-144 (ADA310864).

5. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: wireframe generation, stereoscopic imagery, image processing, feature extraction, Hough Transform, automatic target recognition, target model, automatic model generation, models, edge detection, scene analysis.

AF02-157 TITLE: Zero-Zero Target Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop algorithms and software to enhance air-to- ground accuracy in adverse weather and hostile environment.

DESCRIPTION: Systems using infrared (IR) sensors to perform automatic target recognition to remove errors induced in the coupled INS/GPS navigation system suffer reduced performance during zero visibility conditions (low level fog, rain conditions, etc.). To enhance the all-weather aspects of smart weapon systems a low-cost, adjunct sensor system is needed to allow all weather (zero ceiling – zero visibility) capability for targets requiring precision-guided munitions.

Such an adjunct sensor would have to be low cost to not adversely affect the current air-to-ground smart weapon unit production price.

PHASE I: In Phase I of this effort, an innovative conceptual study of sensor algorithms to provide air-to-ground smart weapons with a capability to precisely guide the current INS/GPS navigation system to ground fixed and mobile high value targets in day/night, adverse weather, and hostile environments shall be investigated. The candidate sensor shall be low cost and suitable for integration into comparatively low cost munitions. The candidate sensor is not constrained to operate only in the infrared region of the electromagnetic spectrum. For example, the sensor could be radar, synthetic aperture radar or passive millimeter wave. A technical report, providing a detailed description of the candidate sensor/ processing approach shall be delivered to the sponsor. The conceptual study effort will be 9 months in duration.

PHASE II: In the Phase II effort, innovative candidate algorithms and software will be developed, tested, and demonstrated based on the results of the Phase I conceptual study. The software development should be optimized for speed and performance and suitable for a real time demonstration. The offeror shall document the test and its result along with the software documentation, and deliver a final report to the sponsor at the end of Phase II effort. The development and demonstration of the software will be 24 months in duration.

PHASE III DUAL USE APPLICATIONS: The concepts developed and demonstrated during Phase II will be implemented, integrated, and demonstrated on a high-speed platform for air-to-ground smart weapon applications. This technology also has a great potential for dual use applications in the following technology areas: Navigation, Terrain Mapping, and Automatic Landing Guidance systems for commercial airline and NASA.

REFERENCES:
1. AGM-158 Joint Air to Surface Standoff Missile (JASSM) http://www.fas.org/man/dod-101/sys/smart/jassm.htm

2. "Precision-Guided Munitions: Acquisition Plans for the Joint Air-to-Surface Standoff Missile," GAO/NSIAD-96-144 (ADA310864)

3. AFRL/MN Home Page: http://www.mn.afrl.af.mil Keywords: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

KEYWORDS: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

AF02-159 TITLE: Munition Thermal Management

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Identify innovative methods and materials for the management of the internal thermal environment of small diameter munitions.

DESCRIPTION: The thermal management used in today's missiles, primarily insulation materials and component separation, may no longer be adequate for future munitions. Current reduction in munition diameter size has decreased the amount of space available for separation of heat generating components. This combined with the increased use of electronic components operating at higher temperatures has raised the internal temperature, especially for small diameter munitions. Additionally, as munitions are carried and operated at increasing speeds, the external heat transferred into the munition has increased. Innovative concepts and methods for internal thermal control are sought. Both active and passive processes are encouraged as potential approaches for this management.

PHASE I: Develop design concepts for internal weapon thermal management. Design concepts that can be used for small diameter munitions operating at high speeds.

PHASE II: Based upon the findings of Phase I, develop, test and demonstrate a thermal management concept. Demonstrate the capability of the concept to be packaged within a small diameter munition. The Phase II deliverables will include a working prototype of the developed concept.

PHASE III DUAL USE APPLICATIONS: Thermal management techniques that are useful for munitions should be beneficial to various commercial applications. The automotive, computer and aviation industry all have high temperature operating environments. With modifications to the packaging, thermal management concepts developed for munitions may be able to be employed to alleviate undesirable operating temperatures found in many commercial applications.

REFERENCES:
1. Tuckerman, Davic B., "Heat-Transfer Microstructures for Integrated Circuits," UCRL-53515 (ADA344846).

2. Ponnappan, Rengasamy, "Thermal Management Research Studies. Volume 1. Electronics Cooling," UES-225-TR-96-1-VOL-1 (ADA326973).

3. Bootle, John, "High Thermal Conductivity Composite Structures," TR-1000-0282 (ADA371758).

4. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Thermal Control, Insulation, Heat Exchangers,Cooling, Heat Sinks, High Velocity Friction, Thermal Management

AF02-160 TITLE: Low Cost Manufacturing of Range Extension Wing Kits

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Investigate and evaluate innovative materials/manufacturing processes for a low cost range extension wing kit.

DESCRIPTION: Recent flight tests of winged autonomous munitions have demonstrated the ability to significantly increase the range of non-powered weapons. Additionally, with smart electronics, range extension kits improve munition maneuverability and improve the impact accuracy of current munitions. Both aspects are desired by today's Air Force. The need to reduce the amount of time our pilots are within enemy defensive systems is met by increasing the standoff range of our munitions. The desire to improve target accuracy, enhance munition effectiveness and reduce collateral damage is also met. What still needs to be addressed is the wing kit cost effectiveness in meeting these goals. Current range extension wing kit designs utilizing standard manufacturing processes and materials are costly and require an extensive amount of time to procure. Research exploring innovative manufacturing techniques along with wing kit material selection is required. A solution is the design of a new wing kit with manufacturing cost as a primary driver. Having proven the value of range extension wing kits, it is now necessary to explore how wing kits can be produced at low cost (<$3,000). It can be assumed that the number of kits for procurement is approximately 12,000. Any new design must meet or exceed current performance capability specifically packaging constraints and munition effectiveness.

PHASE I: Design a new range extension wing kit supported by innovative material selection and manufacturing/joining processes to reduce cost; and/or evaluate current wing kit designs using cost effective manufacturing techniques and materials. Select preferred method for phase II development.

PHASE II: Demonstrate the capability to manufacture a more cost effective wing kit and meet current performance requirements as determined in phase I. Perform ground structural tests, deployment tests and aerodynamic tests under realistic operating conditions, to evaluate performance.

PHASE III DUAL USE APPLICATIONS: Utilization of a cost effective combination of manufacturing process and material selection can benefit the commercial sector in a variety of products. Specifically, low cost processes and materials for joined and moving parts can benefit. These products can range from spoilers on sport vehicles to external winglets on commercial aircraft. Military applications can extend to a broad spectrum of precision guided munitions.

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3. Bootle, John, "High Thermal Conductivity Composite Structures," TR-1000-0282 (ADA371758).

4. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Low Cost Manufacturing, Innovative Manufacturing Techniques, Cost Reduction, Hybrid material Structures, Range Extension Kit, Winged Autonomous Munitions

AF02-163 TITLE: Development of Structural Explosives for Low Collateral Damage (LCD) Warheads

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate a structural explosive material for a LCD case having penetration survivability and non-hazardous fragments.

DESCRIPTION: Considerable progress has been made over the last forty years in precision strike. It is possible to hit targets with pinpoint accuracy and destroy targeted structures – but there is still a high potential for unwanted injury and damage near the target area caused by blast and case fragments. It is highly desirable and even necessary in many situations to avoid the collateral damage typically associated with today's weapon options. To support new weapon concepts for urban warfare, a new development program has been initiated with the aim being to substantially reduce bomb blast lethal radius while actually increasing near-field blast effects. To compliment this, a second technology is needed which would provide structural materials for warheads that are rapidly consumed in an explosion – thus eliminating the case fragments that create a large lethal radius in today's weapons. One concept is to build weapons with structural explosives. Reduced blast radii from structural explosives, combined with precision strike, will provide war-planners access to weapons with a limited collateral damage footprint. This investigation will develop structural explosive materials and warhead designs that can meet "low collateral damage (LCD)" bomb requirements. It is conceivable, for example, that metal powders could be pressed into solid metal parts which, when sufficiently shocked, would disintegrate and burn or detonate. Goals for this effort are to formulate and demonstrate materials for this application. In a phase II effort, develop warhead concepts that would provide the required strength for weapon carriage and penetration survival into relatively soft targets.

PHASE I: Investigate new and innovative structural explosive materials. Develop formulations and fabrication methodology for the proposed composite materials and processes. Identify concepts for producing prototype fuze wells and warhead cases.

PHASE II: Demonstrate that parts can be scaled up and still yield anticipated results. Demonstrate that the structural explosive concepts and processes are valid and reproducible. Develop a mechanical properties database for development and production of full-scale warhead components. Produce and demonstrate full-scale warheads or warhead subsections.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has utility for both the military and commercial sector. Military tactical planners will have greater latitude for precision strikes in urban areas that will result in reduced civilian death and destruction. Commercially, this technology may be applied to nano-scale intermetallic composites for improved properties of mechanical strength and flexibility, commercial pyrotechnic materials for material cutting, and new ceramics for ballotechnic and pyrotechnic composites.

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2. Birkler, John; Hura, Myron; Shlapak, David; Frelinger, David; McLeod, Gary, "A Framework for Precision Conventional Strike in Post-Cold War Military Strategy," Report No.RAND/MR-743-CRMAF (DTIC Accession No. ADA317863).

KEYWORDS: Structural Explosive, Low Collateral Damage, Dense Metal Explosive, Non-Fragmenting Case, Reduced Lethal Radius, Intermetallic Composites

AF02-166 TITLE: Munitions Research

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative concepts in areas associated with air-deliverable munitions and armaments.

DESCRIPTION: The Air Force Research Laboratory Munitions Directorate's mission is to develop, integrate, and transition science and technology for air-launched munitions for defeating ground-fixed, mobile/re-locatable, air and space targets to assure the preeminence of US air and space forces.a. The Assessment and Demonstrations Division is seeking new and innovative ideas for future weapon integrating concepts, such as urban combat weapon, close air support weapon, low cost miniature cruise missile, counterproliferation weapon, time-critical target defeat, functional defeat of hard targets, and limited collateral damage weapons. Technologies under consideration include weapon design, innovative flight controls and range extension technologies, compressed carriage and ejecton technologies, micro technologies, processor, and transmitter technologies, and integrated subsystem techniques. Modeling and simulation tools of interest include high-fidelity physics-based codes for warhead design and penetration analysis, engineering-level tools for weapon/target interaction analysis, and system-level analysis for theater-level modeling. New concept and innovative tools are sought for system-level evaluations, the prediction of functional relationship of fire and/or blast effects on fixed structures, and dispersion of chemical/biological neutralization agents in a high-temperature environmentb. The Advanced Guidance Division seeks new concepts in areas associated with closed-loop guidance of autonomous munitions including inertial sensors, antijam (AJ) Global Positioning System (GPS), and terminal seekers, including electro-optical, millimeter-wave, and synthetic aperture radar seeker technology, and the components thereof, and the signal/image/data processing used in such areas. Concepts of interest include (1) guidance software, including guidance laws, estimators, autopilots, and AJGPS software, (2) innovative signal and image processing, and (3) operations/functions involving noise elimination, detection, segmentation, feature extraction, classification, and identification. Fundamentally new approaches to closed-loop autonomous guidance based on biomimetic principles are of particular interest. c. The Ordnance Division is seeking new and innovative ideas/concepts to support the development of advanced warheads, and explosives for use in air-delivered conventional munitions to defeat ground, mobile, air targets, as well as above-ground and buried structures. Technologies developed should ultimately result in new and innovative components which are needed to meet the complex future munitions requirements for general-purpose bombs, penetrating warheads, safe-arm-fire devices, explosive detonators, explosives and advanced energetic materials, and devices for collecting data to be used in warhead design and analysis. Technologies for defeating weapons of mass destruction, including biological and chemical agents, and/or access denial to stored weapons, are of interest.

PHASE I: Determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: Produce a well-defined prototype product or process.

PHASE III DUAL USE APPLICATIONS: a. Commercial dual-use applications for innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.b. Commercial dual use applications for these guidance technologies include sensors, processors algorithms applicable to medical imaging, commercial aviation (adverse weather penetration), remote sensing and surveillance. c. Commercial dual use application for these ordnance technologies include facility/plant security and monitoring, high speed wireless data transmission, micro-electrical mechanical devices for controls and collision avoidance, high powered energy storage devices (capacitors and batteries) and environmentally responsible recycling of energetics and other materials.

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KEYWORDS: (a) demonstration, assessment, airframe, munition, simulation, weapon (b) terminal guidance, autonomous guidance, automatic target recognition, precision guided munitions, sensor technology, seeker technology, autonomous target acquisition, signal and image processing, pattern recognition/classification, image understanding, artificial neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, data fusion, biomimetics (c) target detection; hard target defeat; warheads; explosives; fuzes; safe, arm, fire devices; nanoparticles; simulation; chemical neutralization.

AF02-167 TITLE: Miniature Initiation System Technology (MIST)

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop the key technologies to allow precise selectable initiation points within advanced miniature warheads.

DESCRIPTION: Recent advances in warheads that employ multiple Exploding Foil Initiators (EFI), coupled with EFI advances, offer the promise of very advanced kill mechanisms. In order to achieve the anticipated gains within ever shrinking warhead size, significant advances must be accomplished in the total EFI firing systems. Firing component (i.e., EFI, solid state firing switches, high energy density capacitors) improvements must be integrated into a system that will allow maximum flexibility of firing, both in selection and sequencing of initiation points, while minimizing size, especially within the active warhead functional area. The total system must eventually encompass safing and arming functions, voltage multiplication, high voltage storage, and switching as well as all necessary communication links. Significant trade off must be accomplished to assure maximization of firing flexibility and small size while maintaining adequate safety and reliability.

PHASE I: Investigate the feasibility of the proposed Miniature Initiation System Technology (MIST) concept. This investigation should include functional allocation, safety methodology utilized between modules and identification of high-risk components/modules. As a minimum, the function to be accomplished at each firing point shall be demonstrated at the breadboard level. These functions must be capable of being packaged in less than .1 cu. in. in the Phase II effort. It is highly desirable to minimize this volume.

PHASE II: The Firing Point Module (FPM) shall be packaged in its final volume of less than .1 cu. in. and demonstrate its capability to initiate PBXN-110. The complete MIST shall be breadboarded to the extent necessary to sequentially initiate four FPMs in a dynamic environment (PBXN-110) initiation phase.

PHASE III DUAL USE APPLICATIONS: Low voltage blasting cap technology (for mining and oil field use) has progressed to the point that electronic delays are now included within the blasting cap (detonator). In contrast, increasing commercial blasters are switching to Exploding Bridgewires (EBW) and EFIs because of their inherently greater safety. The successful completion of this SBIR effort could combine the flexibility of advanced blasting caps with the increased safety and EFIs.

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KEYWORDS: slapper detonators, high voltage switches, high voltage capacitors, miniaturization, exploding foil initiators, capacitive discharge unit,

AF02-168 TITLE: Enhanced Laser RADAR Through Augmenting Signal Information Content

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Augment 3-D ladar seeker concepts via optical multispectral/polarization/passive imaging information while minimizing additional hardware.

DESCRIPTION: The current approach to advanced laser radar seeker systems for munitions is to measure target shape and match that to a template of known targets. While this target signature is invariant with time of day, temperature and other environmental variables, the signature can be defeated by suitable modification of the object.The purpose of this topic is to maximize the information collected by the seeker using a single optical CCD sensor. Specifically, it is envisioned that additional target information could be collected within the spectral sensitivity of the sensor simultaneously with the shape information derived from laser radar. The advantage is that combinations of signatures, such as augmenting the shape signature with a spectral signature, provide more information content and therefore are significantly more difficult to defeat than a shape signature alone. The additional information could include spectral information, passive inband imagery, and the polarization state of the laser radar return.Temporally simultaneous approaches are preferred, but temporally multiplexed approaches are acceptable if the time to acquire all the necessary data is insignificant in terms of munition and battlefield dynamic time scales. Flash laser radar concepts are preferred, i.e., those where the entire field of view is imaged with a single laser pulse. Truly novel scanned laser radar approaches that are enhanced to provide multiple active or passive wavebands are sought as well.

PHASE I: During Phase I, the recipient would propose a complete design for a fused multispectral and/or polarimetric ladar system.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype system based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial and military applications exist for the technology addressed in this topic, including medical applications, weather forecasting, communications, manufacturing, and remote sensing. Commercial laser radar applications include geographic surveying, industrial monitoring, adaptive cruise control and collision avoidance, and automated aircraft landing and docking of space vehicles. Military laser radar applications include seekers for autonomous munitions guidance, surveillance and reconnaissance sensors and precision targeting systems. Additional optical information such as multispectral and polarimetric variants of laser radar can enhance the general performance of existing ladar systems.

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KEYWORDS: Laser radar, seeker, munition, polarization, multispectral sensing, polarimetry, spectrapolarimeter, flash ladar, data fusion.

AF02-169 TITLE: Navigation Solutions by Terrain Imaging

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Examine use of imaging sensor output to aid inertial measurement unit.

DESCRIPTION: Guided munition (or flying robot) stability and navigation functions require ownstate information. Conventionally this is provided by an inertial measurement unit (IMU). The IMU-based solution drifts due to the quality of the IMU, as reflected in the IMU error budget. Currently Global Position System (GPS) receiver output is used to bound the IMU error; the GPS provides position information (good for navigation) but not body attitude information. Past efforts have shown that position information can be updated by identifying “nav points” on the terrain and matching them to an onboard terrain map, but this is not the capability we seek. Rather, we wish to develop the capability to cleverly process information from an imaging sensor output to aid the inertial measurement unit for both the stability function and the navigation function. There are techniques within the field of optic flow which seem promising in this arena but any feasible concepts will be considered.

PHASE I: Analysis showing sensitivity of seeker-aided-navigation to seeker parameters such as instantaneous field of view, field of view, frame rate, etc., for both active and passive seekers; specific equations to enable calculation of egomotion (estimation of ownstate vector in 6 degrees of freedom) for both active and passive imaging seekers; preliminary designs for proof of principle (POP) concepts for passive seeker and for an active seeker.

PHASE II: Refine analysis accomplished in phase I; revise proof of principle (POP) designs; POP demonstrations: off the shelf imaging sensor output blended with IMU output to demonstrate that seeker output can aid stability and navigation solutions, quality and limitations of such an approach.

PHASE III DUAL USE APPLICATIONS: Replace IMU, GPS receiver on munitions through clever use of imaging seeker output. This technology could also be used for autonomous precision landing systems for commercial aircraft.Related

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KEYWORDS: Navigation, Stability, Optic Flow, Visual Flow, Image Flow, Terrain Mapping

AF02-170 TITLE: Positron Energy Conversion Based Weapons

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Conduct a Proof of Principle Experiment to show the Feasibility of an aspect of Positron Energy Conversion Based Weapons

DESCRIPTION: Positrons brought into contact with electrons produce energy according to the E=MC^2 equation. This is the highest energy density of which we are currently aware. This tremendous energy source offers a near unlimited opportunity for the weapons designer of the future. Recent developments in the production, containment and lethal effects assessment of positrons show that it may be feasible to build warheads for air launched weapons that will use the energy from positron - electron annihilation to provide a "dial-a-yield" capability. The possible lethal modes include gamma photons, electromagnetic pulse (EMP), heated plasma, and blast/fragments. Suitable targets for bursts of gamma photons are biological weapons of mass destruction. Electromagnetic pulse warheads are especially effective against targets containing electric circuitry. Heated plasma will be effective for penetrating armored targets. The kinetic effects of blast fragment warheads are effective against soft fixed and mobile targets. These weapons will have the added advantage of leaving no nuclear residue. This is because the gamma rays produced upon annihilation are only 0.511 million electron volts and are too weak to cause nuclear reactions. Positron annihilation energy can also be converted into propulsive energy to power turbojets and ramjets. Development effort is needed to establish the knowledge base for maturing the required technology for these weapons over the next 25 years. The key technical challenges are in the areas of positron production, confinement, and conversion. Production techniques include linear accelerators, high power lasers, and sodium 22 methods. Confinement concepts include electromagnetic Penning traps, magnetic mirrors, and spheromak techniques. Small scale laboratory conversion experiments for warhead (lethal effects) applications include gamma ray burst, metal plasma, metal vapor/liquid and kinetic energy demonstrations. Small-scale conversion experiments for propulsion applications include heat deposition and convective heating demonstrations. Innovative and creative approaches to laboratory level experiments at the proof of principle levels of positrons (10^12 to 10^15 positrons) are envisioned for the efforts proposed under this topic. This level of experiments is within the funding constraints of the SBIR program. The AFRL/MN will coordinate positron production experiments with current positron production facilities such as Lawrence Livermore National Lab. Proposals are expected to address a specific approach to production or confinement or conversion.

PHASE I: Select a promising approach to production or containment or conversion of positrons and conduct a feasibility study on performing a proof of principle experiment of a specific aspect of positron production or confinement or conversion.

PHASE II: Perform a prototype demonstration based on Phase 1 Feasibility results. Design, fabricate test hardware, and conduct a laboratory level experiment for a positron production or containment or conversion demonstration.

PHASE III DUAL USE APPLICATIONS: Positron energy storage devices may have significant commercial application in the future as a heat energy source for electric power generation using thermocouples. These "batteries" could power all types of hand held appliances or tools. This phase of the effort would tailor positron energy conversion for application to these commercial uses.

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KEYWORDS: Antimatter, Annihilation, Positron Production, Positronium, Positron Confinement, Penning Traps, Magnetic Mirror

AF02-171 TITLE: Biomimetic Concepts for Situational Awareness

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Demonstrate applications of insect biology inspired concepts for sensors and processing in autonomous air vehicles.

DESCRIPTION: The purpose of this project is to develop and demonstrate guidance, navigation, and control (GNC) sensors and sensor processing that will enable an autonomous air vehicle to achieve situational awareness in order to search for, detect, acquire, and track a target in a densely cluttered environment. Air vehicles of this kind may operate individually or cooperatively and, as such, each vehicle must possess situational awareness to avoid collision with other entities in its vicinity (e.g., objects, other similar vehicles, other targets) as well as be capable of extracting sufficient detail about the target to discriminate it from other targets, countermeasures, or non-targets. There are both military and non-military (e.g., search and rescue) applications for this capability. The relevant technologies include wide field-of-regard (e.g., 2 pi steradian) seekers, navigation sensors, optical flow guidance concepts, sensor fusion, and hybrid analog/digital processing. Because of the anticipated computational requirements to implement these capabilities in real systems, sensor configurations and hybrid analog/digital processing concepts inspired by the neurobiology of flying insects is encouraged. Insects integrate information from inertial sensors (e.g., halteres in Diptera), air flow sensors (e.g., Johnston's organ on antennae), internal strain sensors (e.g., campaniform sensilla at the base of wings and halteres), and position sensors between adjacent body parts (prosternal organ) with information from the compound eyes (e.g., imaging, optic flow) and ocelli (light intensity) for precision navigation and flight through complex environments. With inspiration from relevant research in these areas, a GNC sensory system design is to be developed for a suitable air vehicle prototype. Desirable characteristics of the system include: 1. Situational awareness capability for obstacle avoidance (e.g., buildings or trees, power lines, overhanging branches, or other air vehicles) 2. Detection, acquisition, tracking, and guidance to moving targets in background clutter, 3. Tolerance to transient sensor information distortion or obscuration, 4. Low cost, complexity, design overhead of implementing the GNC sensor concept (e.g., analog processing versus complex digital imaging algorithms).Rapid advances in micro component (e.g., sensor, actuator, and processing) technologies will soon make it possible to produce small air vehicles that are physically capable of precision flight. The design of GNC sensor systems to exploit the potential capabilities of this hardware is critical to realizing autonomous/cooperative precision flight. Although the knowledge base of insect neurobiology is quite large, insect biomimetics, especially as applied to aerospace operations, is a relatively immature field. GNC sensory system designs based on flying insect biology have yet to be demonstrated. Thus, a significant goal of the project is to conduct a demonstration of a candidate GNC sensory system in a prototype sensor hardware-in-the-loop test. For this reason, availability of prototype sensor and processing hardware, as well as appropriate test facilities, must be considered. In preparation for the hardware test, a preliminary evaluation of the candidate components or subsystems in bench tests, using hardware of appropriate fidelity to demonstrate the feasibility of the concept, should be conducted.

PHASE I: From suitable insect neurobiology candidate concepts, demonstrate that a GNC sensory system for autonomous/ cooperative precision flight is feasible. Demonstrate a limited prototype GNC sensory system (e.g., sensor and processing components or subsytems with prototype algorithms) in bench tests. Develop a test plan for conducting a Phase II sensor hardware-in-the-loop demonstration.

PHASE II: Refine the prototype GNC sensory system design tested in Phase I for more extensive sensor hardware-in-the-loop testing. Further demonstrate the feasibility of this approach under simulated flight scenarios. Prepare and conduct a demonstration using prototype sensor hardware in a suitable hardware-in-the-loop facility.

PHASE III DUAL USE APPLICATIONS: Commercial and military applications would include small surveillance and reconnaissance aircraft as well as AF unmanned air vehicles (UAV), and tactical autonomous/cooperative munitions.

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KEYWORDS: neuromorphic processingbiomimetic sensorsbiomimetic guidanceinsect vision3 dimensional egomotion computationarthropod vision systems

AF02-175 TITLE: Aero Propulsion and Power Technology

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies which provide major improvements in gas turbine engines, advanced propulsion systems, electrical power systems, and advanced fuels for manned and unmanned applications.

DESCRIPTION: The Propulsion Directorate aggressively pursues and solicits innovative ideas offering major performance advances in all areas of airbreathing propulsion including turbine engines, advanced and combined cycle engines, fuels, and electrical power. Payoffs include increased aircraft and weapon system effectiveness, survivability, reliability and affordability. Turbine engine technology development is focused on delivering higher thrust-to-weight ratios, reduced cost, improved efficiency, and increased reliability. Advanced and combined cycle engine efforts are focused on developing innovative and high Mach airbreathing engines for future manned and unmanned applications. Fuel technologies are currently focused on improving the performance (thermal stability, low temperature properties, etc) of JP-8 through the use of additives. Finally, electrical power efforts (non-propulsive) are focused on advanced techniques for power generation, storage, and distribution for aircraft, spacecraft, and weapons with a particular emphasis on directed energy weapons. Subsets of these technologies include innovative combustion measurement techniques, diagnostics, control techniques, microelectromechanical machines (MEMS), and engine related materials technologies. Offerors are strongly encouraged to establish relationships with suppliers of the aerospace systems relevant to their research in order to facilitate technology transition. Proposed efforts shall emphasize dual-use technologies that clearly offer commercial as well as military applications. Proposals emphasizing “spin-on” technology transfer from the commercial sector to military applications are also encouraged. Proposals also submitted for any other Air Force FY02 Small Business Innovative Research (SBIR) topic shall not be considered for this topic.

PHASE I: Develop the concept and perform analyses and subscale testing to demonstrate the feasibility of the proposed technology. Modeling and simulation is encouraged to guide the research.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: New and innovative propulsion and power technology is equally applicable to both military and commercial aircraft engines and power generation and distribution systems.

REFERENCES:
Air Force Research Laboratory Propulsion Directorate website address: http://www.pr.wpafb.af.mil

KEYWORDS: Turbine engines, high speed propulsion, scramjets, fuels, lubrication, power systems

AF02-176 TITLE: Improved Composite Duct Design for Increased Safety Margin or Weight Reduction

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Improve the accuracy of analysis predictions and testing methodology for buckling of polymeric matrix composite turbine engine ducts with large structural anomalies such as cutouts, reinforcements around cutouts, or flanges.

DESCRIPTION: Composite ducts are currently being used on various military gas turbine engines, specifically for the benefits of weight and cost reduction. However, certain studies have shown that the maximum weight reduction potential may not be realized due to current design practices and methodologies. Although an extensive amount of research has been conducted in the area of composite shell/cylinder buckling, the methods that provide accurate solutions are very difficult and costly to use, and therefore tend not to be used in typical day-to-day design practice. Simpler, approximate methods are used, however they fail to predict the actual buckling failure load, location, and buckling mode of the duct in a repeatable manner. Another concern is that, although composite ducts have proven capable of meeting the structural requirements of the engine and are flying in the field, it is not really known how good the ducts are in terms of safety margin. The current track record for composite ducts is good in terms of repairs and failures, which may indicate that the ducts are over designed. This is not a problem until performance and cost demands are stringent, and the reinforcements around cutouts and flanges are reinforced to the point of taking away any weight or cost benefit that could be realized if the duct was not over designed. Unique and innovative approaches are sought for improving current design methodologies used for designing large composite ducts with large cutouts and various flange configurations. Approaches are sought that could be incorporated into any company's design practice and analysis codes, but an independent software code is not sought.

PHASE I: Phase I should concentrate on the analysis portion of the objective, with fabrication and testing left for Phase II. Identify an approach that will provide a more accurate prediction methodology for buckling of composite ducts with large cutouts. Validate the feasibility of the approach, and identify a plan for applying to subscale and full-scale com-posite ducts.

PHASE II: The prediction methodology identified in Phase I shall be validated by fabricating and testing composite ducts with large cutouts. Improved, more accurate methods of performing buckling tests of large composite ducts shall be identified and applied during the testing portion of the program. The test results shall be correlated to the test predictions, and the methodologies shall be updated as appropriate.

PHASE III DUAL USE APPLICATIONS: This technology will benefit both the military and commercial engine businesses. The buckling methods used in this program can be used to design improved ducts for the land based turbine arena as well, although the use of composites through advanced manufacturing methods would provide a better impact on the cost side than the weight side for land based turbines. The information achieved in this program is also applicable to airframe structures, since composites are being used for large, curved panels with large cutouts as well.

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KEYWORDS: Turbine Engine Ducts, Polymeric Matrix Composites, Buckling, Cutouts, Buckling Analysis, Buckling Testing

AF02-177 TITLE: Innovative Onboard Power and Cooling Solutions

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an onboard capability that will generate 1000 KVA (1 Megawatt) electrical output and increase cooling capacity and thermal management for transport aircraft.

DESCRIPTION: The primary product is an on-board alternative power and cooling capability to be installed in a pressurized or unpressurized location of heavy aircraft requiring supplemental electrical power and cooling capacity for special applications including countermeasures and directed energy weapons. This capability would also permit aircraft systems to be operated without ground support equipment or generators driven by the main engines. Innovative research is desired to provide solutions for the supply of 1000 KVA continuous electrical output (110 V, 400 Hz, 3 phase ac) and operation with JP-8 fuel at altitudes up to 40,000 ft. The system should also simultaneously supply large quantities of pressurized air (approximately 800 lbm/min at approximately 50 psia) to drive an environmental control system or offer alternative high capacity cooling approaches. The very ambitious goal is to provide this added capability at a weight of less than 1400 lbs. Conventional auxiliary power units that offer this combination of power and compressed air are not available and scaled versions would exceed the weight goal. Solutions using several smaller conventional units are also too large and heavy. Unique turbomachinery architectures are one possible approach, though other less conventional or emerging technologies (e.g., solid oxide fuel cells coupled with electrically driven compressors) may satisfy the requirements. Should the research show that a solution using multiple units (e.g., 4 units of 250 KVA continuous rating) is preferred, this is acceptable. Solutions must be achievable in 5-7 years and consider realistic design constraints imposed by reliability, operational and maintenance safety, and ease of maintenance, installation, and removal. Volume should also be minimized. Potential offerors are strongly encouraged to establish relationships with larger contractors who may be more capable of transitioning any technology developments.

PHASE I: Efforts should focus on performing research on technology and systems options, establishing measures of merit for selecting that concept offering the best value, and selecting this best value concept. Hardware, software, and integration requirements of each potential solution should be considered.

PHASE II: Provide systems model and simulation of proposed system. Simulate the performance of the best value concept. Conduct in-depth analysis to verify overall system benefits. Design, develop, and demonstrate key elements of the selected power and cooling system; testing should be sufficient to completely validate performance.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of these technologies is future insertion into heavy aircraft with large power and cooling demands. The commercial market includes standby and mobile electrical power generation sources that could also supply cooling capacity.

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KEYWORDS: auxiliary power unit, electrical power, engine-driven generators, bleed air, thermal management, environmental control system

AF02-178 TITLE: Fuel Additives For Reduced Engine Emissions

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative fuel additive(s) for JP-8 and JP-5 fuels that will reduce both the mass Emissions Index (grams of PM2.5 emissions/kilogram of fuel) and the number density Emissions Index (particle number density/kilogram of fuel) of PM2.5 in the exhaust of military gas turbine engines by 70 percent.

DESCRIPTION: Gas turbine engines and ground support equipment are a major source of soot particulates. Soot particulate emissions lead to increased engine and fuel system components maintenance costs, and decreased engine life and aircraft/engine availability. They contribute to haze and impair visual range. They also form nucleation sites for condensation and sites for complex chemical reactions that can lead to ozone depletion at high altitudes. Efforts to legislate air standards on a global scale are largely the direct result of the rise in emissions of oxides of nitrogen (NOx), carbon monoxide (CO), and unburned hydrocarbons (UHC). The National Ambient Air Quality Standards have a health-based regulation for particulate matter with diameters less than 10 microns (PM10). The regulation limits exposure to air with PM10 concentrations greater than 150 micrograms per cubic meter (µg/m3) in a 24-hour time period and an annual 24-hour exposure of no greater than 50 µg/m3 (EPA Fact Sheet Dated November 29, 1996). There is growing evidence that this regulation is insufficient to eliminate serious health and environmental problems for particulate matter with diameters under 2.5 microns (PM2.5). Indeed, the EPA has adopted a revision of the regulation for PM2.5 particles (EPA Fact Sheet dated July 16, 1997). Studies have shown that turbine engine exhaust is comprised of particulates less than 2.5 microns. Recent epidemiological studies in the U.S. and Western Europe report strong correlations between airborne particulates and human health. Moreover, particulate matter has also been linked to the formation of contrails and subsequently cirrus clouds; and hence, it can also affect climate changes and from an operational point, survivability. Increased cloud formation has been identified as a contributor to global warming. National efforts to reduce emissions have focused on combustor design rather than on fuel chemistry/combustor interactions. However, recent experimental data has shown that additives can be used to reduce soot particulate formation. Particulate suppression via the use of additives may be effected via two paths: destruction of soot particulates once formed, or prevention of inception reactions. The latter offers a potential order for magnitude soot particulate reduction; hence it is desirable to develop and tailor jet fuel formulations to mitigate particulate formation. The goals for the additive are that it should: (1) be benign to the environment and safe to handle, (2) be low in cost (fractions of a cent per gallon of fuel); (3) be effective at low concentrations (ppm level); (4) not degrade the fuel performance specifications or combustion characteristics; (5) and not reduce engine performance and life. These goals seem reasonable when compared to the development of JP-8 +100 additive that currently costs $0.005 per gallon and is expected to decrease as volume increases. The +100 additive is present in the fuel at a concentration of 256 ppm by weight. It is desired to mitigate particulate formation without compromising performance. Reformulation of the fuel is not a viable option when one considers that it took 20 years for the military to transition from JP-4 to JP-8 fuel. Moreover, development of a reformulated fuel will be costly, and the resultant fuel (likely to be highly refined) may cost two to three times more than JP-8 or JP-5 (e.g., JP-7). We believe that the preferred approach is to use additives. The use of fuel additives is a pervasive and cost-effective approach that has the potential of reducing PM2.5 emissions in all engines in the fleet.

PHASE I: Demonstrate the feasibility of using fuel additives in JP-8 and JP-5 to reduce PM2.5 emissions from military turbine engines. Identify chemical compounds that potentially reduce PM2.5 based on chemical modeling and experimental assessments.

PHASE II: Continue development of fuel additives, and assess the performance of the most promising additives in a prototype combustor at conditions of interest to the Joint Strike Fighter (JSF) Program Office. Demonstrate additive effectiveness and optimize additive concentration. Conduct additive stability and material compatibility studies and perform modeling and simulation of additive and fuel chemistry to provide insight into the effects of the additive on soot formation and destruction.

PHASE III DUAL USE APPLICATIONS: Additives that mitigate the formation of particulate matter from military engines are very likely to be effective in commercial aircraft. Use of these additives in commercial aircraft could eliminate approximately 1.9 by 10^6 kg of particulate matter per year. This will provide cleaner air environments in airport surrounding areas, and will save airline companies millions of dollars in landing fees due to potential noncompliance of future local air quality standards. These additives (or others with similar chemistry) may also mitigate particulate matter from stationary and mobile diesel sources.

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KEYWORDS: Soot formation, jet fuel, fuel additives, aircraft emissions, particulate matter, pollutants

AF02-179 TITLE: Fuel Tank Compatible Oxygen Sensor

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: As military aircraft look for continually lighter and efficient methods of fuel tank protection from ballistic impact, the usage of OBIGGS (On Board Inert Gas Generation) is basically a ground-based operation. Regardless of the type of OBIGGS used, the final determination of performance is based upon the oxygen concentration of the output from the system into the fuel tanks. The key to determining this is a direct measurement of the oxygen content of the OBIGGS product, Nitrogen Enriched Air (NEA). The problem with this type of system is that current technology only allows for the measurement of the NEA prior to its entry into the fuel tanks. The presence of hydrocarbon vapors and fuel splashing on the sensor surface, e.g., a surface coated with a sol-gel fluorescent dye, tends to rule out currently "known" measurement concepts of the oxygen concentration once it is in the fuel tanks. The environmental effects can be very important for a self-calibrating oxygen sensor.This project will involve a thorough research, analysis and demonstration of near-term developmental technology that can meet the stated intended need. Oxygen sensing technology has many wide ranging applications in the commercial industry (automotive, medical, etc.) and it is possible that the technology already available can be adapted for aircraft fuel tank oxygen sensing applications with some appropriate physical/chemical modifications.

DESCRIPTION: The F-22 initially planned to utilize a sensor that could measure the "quality" of the ullage; however, the design was forced to change due to a lack of a mature technology, and the time pressures of First Flight. Currently, the F-22 sensor only informs the pilot/maintainer if the Air Separation Module (ASM) is working properly, with the assumption that validation testing accomplished on the F-22 Fuel System Simulator validated the performance of the OBIGGS. The fuel tank ullage is very dynamic, and frequent/rapid changes in altitude can result in relatively large changes in the oxygen levels in the fuel tanks, regardless of the quality of air being supplied by OBIGGS. The capability to sense in real time multiple locations inside the fuel tanks will allow for the development of a true inert ullage.New aircraft like the F-22 and JSF rely heavily on system monitoring for diagnosis of health and maintenance projections. The sensors will be able to alert the maintainers to potential problems with the fuel ventilation system based on in-flight monitoring of the quality of the ullage in certain locations. The sensor will also provide a Safety benefit. For example, the F-22 OBIGGS is considered to be Safety Critical because it provides lightning protection for the Fuel System. An enhanced sensor capability would provide a greatly improved assessment of tank inertness for both peacetime and combat service.Additionally, the sensor may have applications to commercial aircraft. The potential exists for the airline industry to begin incorporating OBIGGS on commercial jets in light of such mishaps as the crash of TWA Flight 800. This Oxygen Sensor concept would have a direct impact on airliner safety.

PHASE I: This task will involve proof of principle research on oxygen sensing technologies that can satisfy the requirement for safe and reliable operation in the presence of hydrocarbon fuels including wetting of the sensor. The measurement technique/ or techniques can be based on electrical, optical, or other measurable physical properties of the proposed sensor, which can be self-calibrated in-situ. In order to allow for a successful transition to a prototype system demonstration in Phase II, the choice of the sensor should be justified to meet the following requirements.1. Power requirements2. Hardware requirements3. Software requirements4. ROM costs for EMD type development5. System weight estimates6. Expected Reliability and Maintainability impact 7. Feasibility dates of availability for flight-worthy systemModeling and simulation of the sensor system is encouraged so that there is a defined process for the decisions on trade-offs.

PHASE II: Design and test the top ranking candidate system to demonstrate the dynamic range and sensitivity limit of molecular oxygen detection. The test matrix should be compatible with the intended application. Also, the hardware design should permit incorporation/retrofit into the existing OBIGGS designs.Provide results of the study and the tests to the following customers for potential incorporation/retrofit into OBIGGS designs: F-22 (USAF), JSF (USAF/USN) and C-17 (USAF). Commercial aircraft may also be able to utilize this technology based on recent flight mishaps, and the potential for fuel tank inerting implementation.

PHASE III DUAL USE APPLICATIONS: Evaluate the fuel tank oxygen sensor application for both new and retrofit of commercial aircrafts.

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4. Abstracts in the Bull. Am. Phys. Soc., March 2000, Session T2KEY WORDS: OBIGGS, Oxygen Monitoring, Fuel Tank, Joint Strike Fighter, C-17

KEYWORDS:

AF02-181 TITLE: Fuel Tank Ullage Oxygen Sensor for Live-Fire Ballistic Testing

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To design and develop innovative low cost oxygen sensor system for use in live-fire ballistic testing of aircraft fuel tanks.

DESCRIPTION: One of the cornerstones of assessing the survivability of current and future aircraft is live fire ballistic testing on actual aircraft hardware. A key area of concern is the ullage or head space of the aircraft fuel tanks. Fuel volatiles can mix with surrounding gasses to form potentially combustible mixtures. To ensure this does not occur, an inert gas is generated to fill the head space, thus reducing or eliminating the potential for ignition. A primary concern is the amount of oxygen present. Accurately measuring the oxygen content in actual aircraft fuel tanks, and in the test hardware, will ensure that realistic conditions are tested. The goals for this effort are to: (1) develop and demonstrate an accurate, low cost, long-life, nonflight weight prototype oxygen sensor for use in live fire destructive ballistic testing, (2) develop an innovative technique to determine the ullage oxygen content and assess the inerting capability of aircraft wing-tank systems, (3) incorporate the sensor and associated hardware within a C-5 aircraft wing-tank system, and (4) demonstrate the concept and assessment technique during live fire ballistic testing. Unique technical requirements are that the sensor: (i) size is limited to 8-inches length by 3-inches in diameter, (ii) maintain a minimum full-scale accuracy of 0.5 percent and a sensitivity of 0.1 percent over a range of 5-25 percent concentration oxygen, (iii) is immune to ambient temperature from -60 to 290 „aF, (iv) is capable of withstanding brief immersion within and repeated splashing by JP-8, JP-5 or Jet-A fuels and still maintain specified measurements after immersion, (v) stability is self-correcting using an onboard reference, (vi) system is capable of recording signals at a rate of two samples per second, with either automated signal processing, or postprocessing capability usable by a nonexpert and compatible with a PC computer. This effort is distinctly different from another topic that is focused on developing a long-life, flight-worthy oxygen sensor to be permanently installed in aircraft fuel tanks.

PHASE I: Design and demonstrate the feasibility of the low cost concept through subscale and/or full-scale component testing.

PHASE II: Fabricate and demonstrate a prototype of the proposed concept if not accomplished in Phase I.

PHASE III DUAL USE APPLICATIONS: This technology has application to both commercial and military aircraft markets. Lightning strikes and other mishaps, such as that which occurred with the crash of TWA flight 800, are growing concerns that can be addressed with this technology.

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KEYWORDS: Aircraft, ballistic testing, fuel tank, wing-tank, ullage, oxygen sensor

AF02-182 TITLE: Advanced Vibration Monitoring Diagnostics and Prognostics Techniques

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To advance the current state-of-the-art for turbine engine vibration monitoring and health assessment

DESCRIPTION: Vibration monitoring is key to providing accurate health assessment of rotating machinery and is used successfully in many turbine engines used by air forces in other countires. Also, sophisticated vibration analysis techniques are being employed in helicopter usasge monitoring. However, due to high procurement and life-cycle costs, high maintenance costs, flight safety issues (especially false alarms), it is used sparingly on a limited number of turbine engines in the USAF inventory. Innovative ideas and solutions are required to provide a comprehensive vibration system that shows significant improvement compared to systems used today. The primary focus of this SBIR topic should be to use vibration accelerometers (or other sensors), data acquisition technologies and analysis techniques, and computerized algorithms, and apply these to vibration spectrum frequency ranges well above the normal broadband and 1 per revolution (rotational frequency) ranges the engine manufacturers typically use. Advanced vibration motoring capabilities developed and demonstrated by this SBIR topic should involve analysis of vibration frequency spectrum ranges at least up to 6 per revolution engine rotational speed, up through 40khz (acoustic frequency range) and even up through 100khz (ultrasonic frequency range). These advanced vibration monitoring diagnostic and prognostic capabilities must be targeted for on-board, real-time, and in-flight applications, and would become part of a comprehensive Engine Health Management (EHM)or Prognostic Health Management (PHM) system. This new vibration analysis capability will be used to develop and demonstrate an accurate predictive (useful life remaining) part of prognostics. The vibration monitoring system has to record, store, and sort the vibration data to provide a comprehensive vibration trace and health map for better engine management and configuration control. To this end, the system must be able to provide accurate diagnostics to the component level, and trending out to at least 20 hours, with no false alarms. This system must have the ability to interface or linked with servicing records and maintenance publications. It must provide a flexible vibration-monitoring solution for several engines with easy modification and integration, to include the engines for the JSF and larger engines such as the P&W F117 for the C17. For the future, the vibration system needs to be adaptable to be integrated into future PHM and EHM systems and should be capable of plug-and-play operation without special software or the need for experienced or specially skilled operators. As the research work on the Versatile Affordable Advanced Turbine Engines (VAATE), and especially the Intelligent Engine, gathers pace, this SBIR work will ensure the current engine fleets are appropriately managed and maintained to reduce life-cycle costs and the logistic footprint. It will improve understanding and visibility of engine health, extend engine time on wing, help maintain engine performance, and provide a comprehensive database to cater for continuing work on advanced diagnostics and prognostics.

PHASE I: Develop a vibration monitoring system for the analysis of vibration frequency spectrum ranges at least up to 6 per revolution (engine rotational speed) and up to 100khz for use on a large fleet of military aircraft engines. The system must be capable of recording and storing vibration scans and provide accurate diagnostics, and trending to at least 20 hours, with no false alarms. Demonstrate the vibration sensor and system capabilities and list the benefits that these will provide over the best competition, such as those in helicopter usage monitoring systems. A modeling and simulation approach is encouraged to guide the design, experiments, and subsequent tests. Indications of system and sensor cost must be provided.

PHASE II: Develop and expand the system using an open architecture and, where appropriate, commonly available hardware and software. This sytem will be demonstrated in a real world engine environment either in an engine test cell or on-wing (not necessarily in-flight but the system should be flight-capable). If the testing is conducted on the engine of an AF prime contractor or in the prime contractor's facility, such testing should be conducted at no cost to the SBIR program. Base upon these test results, the USAF will select the most appropriate engine on which to perform a Field Service Evaluation. The SBIR contractor will provide a cost benefit analysis for installation to the chosen engine fleet and determine the best implementation path. The implementation would occur under Phase III.

PHASE III DUAL USE APPLICATIONS: The vibration analysis and health monitoring system could be used on other turbine engines in use in the airline or small-business-jet commercial aviation industry, power and oil, or on other rotating machinery as used by the automobile and power industries. It has the potential to increase availability and operational effectiveness, and reduce time to diagnose faults. The global market for advanced multi-capable vibration monitoring is massive. Moreover, as the cost of new, more complex, machinery increases, health monitoring and asset management will become essential to keep life-cycle costs in check, and at the same time provide maximum availability and readiness of the equipment.

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KEYWORDS: Maintenance, data, analysis, vibration analysis, readiness, turbine engines, engine health monitoring, prognostics, diagnostics, predictive diagnostics, gas turbine engine health monitoring and health management.

AF02-183 TITLE: Small, Low Cost, High Performance Engines for Miniature Munitions

TECHNOLOGY AREAS: Weapons

OBJECTIVE: The development of a prototype engine, suitable for a small munition offering improved performance over currently available engines.

DESCRIPTION: With the increasing interest in small smart munitions and the developments in automatic target recognition (ATR), the need arises for the development of fuel efficient engines to power them over the battlefield. Low cost, fuel efficiency, and small size are key. Ideally, engine weight and fuel efficiency could be improved using new materials, or even through the application of novel engine cycles. Also applying some of the lessons learned from the successes in miniature machine technology, size and weight could be reduced. In addition, with advanced manufacturing and design methods cost could be lowered. Sizes of interest would be less than 6" in diameter and capable of generating 50 to 100lbs of thrust across a wide operating range while still delivering thrust specific fuel consumption of less than 1 (fuel specific impulse greater than 3600 seconds).

PHASE I: Identify the basic engine operating cycle, estimated performance, system limitations, size and weight of the engine and required subsystems, as well as system cost. The definition should be of sufficient detail to lead to the design, fabrication, and testing of a prototype engine (flight type, not necessarily flight weight) in the following phase.

PHASE II: Construct and test (in a relevant environment) a prototype engine, or a representative system to fully determine the ability of the engine to be built and operated. This would prove the feasibility of the concept and design. In addition, identify any new materials or manufacturing processes that would have to be further developed and implemented for production of the engine concept.

PHASE III DUAL USE APPLICATIONS: Military applications of this technology would be for the powering of small munitions, and possibly decoys and remotely piloted vehicles. Further, this type of engine could have use as small, auxiliary power unit. Uses in the civilian world could be for small reconnaissance vehicles for pipeline inspection, or inspection of hazardous areas. In addition, this small engine could be used in recreational remote control aircraft.

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KEYWORDS: propulsion, missile, turbojet, ramjet, pulse detonation, pulse jet, ducted fan, air turbo rocket

AF02-184 TITLE: Global Reach High-Speed air Vehicles and Weapons

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Reduce high-speed propulsion drag during sustained hypersonic flight with either plasma gas dynamics or controlled burning. Design techniques for reducing drag of high-speed propulsion systems using gas dynamics or controlled burning.

DESCRIPTION: At high speed, base area drag in and around the engine can significantly reduce propulsion and vehicle performance. Propulsion systems operating over broad ranges of Mach numbers and altitudes are particularly vulnerable. At transonic speeds, controlling flow separation and pressurizing base areas with burning can minimize base drag. At hypersonic speeds, where the thrust minus drag margin is small, reductions in drag will lead to large gains in vehicle performance. Novel propellant injection systems and controlled combustion within the propulsion path have the potential to reduce friction and to increase pressure in base regions. Novel techniques for injecting fuel or spent coolants at selected regions have the potential of significantly reducing induced drag. "Smart" sensors and actuators will be required.

PHASE I: Design drag reduction devices for reducing base and friction drag using plasma gas dynamics or controlled combustion for high speed vehicles (Mach range >4). Develop computational tools to simulate the effects of the drag reduction technologies, and define the experimental efforts necessary to validate these tools.

PHASE II: Incorporate drag reduction methodology into high-speed propulsion system designs; evaluate the impact on achievable vehicle range. Experimentally validate the analytical models developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Computational tools and experimental efforts will result in more fuel efficient and long range high-speed aircraft as well as significant reductions in space-access costs for the next generation of launch vehicles.

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KEYWORDS: combined cycle engine, ramjet, scramjet, supersonic inlets, supersonic nozzles, increased range, drag reduction, fuel efficiency,

AF02-185 TITLE: Technologies for Air Breathing Propulsion

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Explore innovative approaches for air breathing propulsion systems for manned and unmanned applications.

DESCRIPTION: The Air Force Research Laboratory's Turbine Engine Division aggressively pursues major performance advances in all components for Department of Defense aerospace propulsion. Technologies are assured relevant demonstration and transition through coordination with the Integrated High Performance Turbine Engine Technology (IHPTET), High Cycle Fatigue (HCF) and Versatile Advance Affordable Turbine Engine (VAATE) initiatives. Technologies derived under these initiatives have resulted in higher thrust-to-weight ratios and improved efficiencies. The focus of this topic is to consider concepts that enhance the performance of gas turbine engines and other aerospace propulsion systems that could support manned and unmanned mission requirements. Concepts are desired to advance the current state of the art of technologies utilized for aerospace propulsion. Such applications include, but shall not be limited to, control technologies for increased performance and durability in gas turbine engines, composites for bearings, smart ceramic matrix composites (CMC) materials, advanced instrumentation, advanced turbine testing and analysis techniques (e.g. probabalistics). A strong need exists for high temperature sensing (up to 1300 degrees F for the compressor, 3000 degrees F for the turbine, and 4500 degrees F for the combustor). Sensor/actuation concepts may involve the use of microelectromechanical systems (MEMS). Such concepts should address packaging and durability issues. Other topics of interest include forced response, pulsed-detonation systems, combustion systems, turbine heat transfer and performance, component durability, and engine affordability.

PHASE I: Define the proposed concept and predict the performance of the proposed design. Explore the feasibility of the concept and demonstrate the merits of the design through analysis or small-scale testing.

PHASE II: Provide prototypical device, hardware demonstrations, or detailed analytical modeling.

PHASE III DUAL USE APPLICATIONS: Historically a large majority of the technology developed under the Integrated High Performance Turbine Engine Technology (IHPTET) Program has transitioned to military and civilian aviation systems. Technology that increases engine performance while enhancing durability and affordability will be enthusiastically considered for inclusion in upgrades or initial designs of engine systems.

REFERENCES:
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KEYWORDS: gas turbine engines, propulsion, durability, affordability, instrumentation, IHPTET.

AF02-186 TITLE: High Heat Flux Laser Diode and/or Solid State Laser Cooling for Airborne and/or Spaceborne Directed Energy Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop advanced cooling technology and thermal management techniques for airborne and/or spaceborne high power solid state and/or diode laser devices with high heat fluxes.

DESCRIPTION: Many of the state of the art laser diodes and solid-state lasers currently use cooling systems that are limited to less than 100W/cm2. Significant improvements in the heat flux capabilities of the thermal management system would allow these devices to be much more compact. Better cooling and load leveling during periods of peak usage will make these devices suitable for many more airborne and/or spaceborne applications. Through the use of advanced high-heat flux cooling techniques such as (but not limited to) spray cooling, jet impingement cooling, microchannel cooling, or porous metal cooling, the heat flux can be increased to 500-1000W/cm2 enabling significant improvements in the device output power, size and mass. Innovative cooling techniques are sought, scaleable to high power applications and suitable for airborne and/or spaceborne applications with the associated acceleration and vibration conditions.

PHASE I: This feasibility phase of the project should demonstrate the high-heat flux capability of the cooling technique proposed and establish a preliminary design for integrating the thermal management with the laser diode device. Modeling and simulation will be used to estimate the benefits of the improved cooling and the scalability.

PHASE II: This phase of the program should include the detailed design, fabrication and testing of proof-of-principle hardware integrated with the laser diode device.

PHASE III DUAL USE APPLICATIONS: The approaches developed to cool this very high flux power source may have commercial and industry applications in utilities and large-scale manufacturing facilities.

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KEYWORDS: directed energy weapons, laser diode cooling, thermal management, high-heat flux thermal management

AF02-187 TITLE: Ultra-wide bandwidth high-power solid state photoconductive power switch technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a high-voltage (10-20 kV) high-current (50-200 Amps) solid state photoconductive power switch with subnanosecond rise time.

DESCRIPTION: In many Air Force applications, such as radar drive circuits, directed energy weapons (DEW), plasma cloaking, and other electrical high peak-power systems for manned and unmanned aerospace vehicles, the availability of a compact and reliable ultra-wide bandwidth, high-voltage, high-power switch can become an enabling technology. Currently available high voltage switches for such applications, rely on thyratrons, krytrons, and spark gaps. The replacement of these vacuum devices with a low-jitter, high-speed photoconductive switch can significantly reduce cost, volume, the weight of pulse forming networks (PFNs), and also improve reliability. In order to achieve low-cost, highly reliable operation of a ultra-wide bandwidth high-power photoconductive switch, it will be required to develop a device which can operate near its bulk dielectric breakdown strength and also avoid current constrictions or filamentations. The high-speed low-jitter requirements can be satisfied by suitable choice of a direct band gap semiconductor material such as GaAs, or SiC. Research needs to be conducted to develop a heterostrucure or other metal-insulator-semiconductor structure device to alliviate near-surface dielectric breakdown caused by the onset of current filamentation well below the bulk dielectric breakdown strength of the material.

PHASE I: Assess device structure through modeling and a feasibility test of a high-voltage photoconductive switch to demonstrate improvement of the current filamentation formation threshold. Total system requirements should be defined for a packaged switch.

PHASE II: Design, develop, and demonstrate a prototype high-power, ultra-wide bandwidth solid state photoconductive power switch suited for radar drive circuits or plasma cloaking.

PHASE III DUAL USE APPLICATIONS: Aircraft and automotive ignition systems, chemical/biological agent or materials destruction using atmosphereic pressure plasmas.

REFERENCES:
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KEYWORDS: Photoconductors, direct bandgap semiconductor, high-power solid state switch, pulsed power, dielectric breakdown, space-charge,

AF02-188 TITLE: Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop techniques that enable the evaluation of electrical power system integrity and health monitoring for insulation systems, wiring, interconnections, and passive or dynamic loads for space and air (high altitude) vehicles.

DESCRIPTION: This topic addresses advanced and innovative concepts for monitoring the integrity of aerospace electrical power systems, including insulation systems and component or subassembly status, to detect incipient failures and, therefore, prevent subsequent breakdowns. The diagnostic techniques developed under this topic would enable the technologies necessary for monitoring the operational readiness of low-maintenance or unattended systems in manned and unmanned aerospace vehicles or orbiting platforms. In addition, the technologies developed under this topic would be important for compact electrical high power systems for critical technology areas such as directed energy applications, advanced surveillance systems, and electric propulsion applications. Power electronics in aerospace equipment may have to operate continuously at subatmospheric pressures. Operational integrity must be assessed with emphasis on discharge problems or high impedance faults due to a variety of factors, such as: high electric field stress with higher operating voltages, lower voltage breakdown characteristics due to the low pressure or space environment, derated breakdown thresholds at intermediate power switching frequencies (10 kHz to 1 MHz). The research should focus on offline methodology for component QC (quality control) and certification, as well as, for in-flight/in-space monitoring of system operation. During offline evaluations, sensors and detection systems must be capable of operation in a low pressure (less than 0.1 torr) environment of atmospheric and inert gases. Diagnostics may be tailored to specific, critical system components, to extend useful operational life via predictable, incipient failure indicators. To be non-invasive, sensors may need to be made a part of the device, without disturbing its electrical or mechanical characteristics. Regardless, the detection methodology must be capable of calibration via a standard technique, for potential incorporation into international test standards. Methodologies based on mature techniques such as continuity testing, hipot testing or conventional corona testing will not satisfy the innovative criteria. For the online, in-operation systems diagnostic case, progress has been made in the development of differential current monitors, ionization detectors, thermal sensors, miniaturized acoustic transducers, and small optical detectors. Hence, it is possible to consider the application of data fusion methods, correlation analyses, and adaptive algorithms to predictive health monitoring of electrical power systems or components. It is reasonable to assume that multisensing methodologies will lend themselves more readily to critical, isolated power components or enclosed subassemblies. The development of such schemes for subassemblies could eventually enable the development of a Built-In-Test (BIT) sensor system with appropriate signal conditioning and data analysis as an integral part of the power management system. However, the offline methodology must be demonstrated before the technique can be viably incorporated into an online, in-operation system diagnostic. Finally, the research should focus on providing diagnostic techniques for high reliability, high mean-time-between-failure (MTBF) systems for space and air (high altitude) vehicle electrical power where weight, volume, packaging and environmental constraints are major factors.

PHASE I: Develop a detailed technical definition of the problem, consider potential solutions, identify and justify a preferred proposed solution, and demonstrate the key technologies enabling the use of that solution. Techniques proven first for offline monitoring and qualification may prove effective for applications requiring on-line diagnostics. (It is presumed that systems requiring monitoring in-operation will likely go through offline QC as well.) The technique or method should be demonstrated in a working prototype, as a minimum. A physical-electrical model and simulation is encouraged to guide approaches and solutions, but is not sufficient to satisfy Phase I goals, by itself.

PHASE II: Iterate on research to resolve any remaining problems discovered from model and prototype and then concentrate on development of operational designs for components, subsystem demonstrations, hardware and software development.

PHASE III DUAL USE APPLICATIONS: The technologies developed under this topic can be transitioned to commercial aircraft, space satellites, reusable launch vehicles and terrestrial facilities that must operate in a sub-atmospheric environment.

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5. Proceedings, IEEE International Symposium on Electrical Insulation, Anaheim, CA, April 2000

KEYWORDS: Electrical Power Systems, Insulation, Sub-atmospheric Environment, Integrity, Reliability, Diagnostics, Interconnections, Components

AF02-190 TITLE: Improved Composite Front Frame for Weight and Cost Reduction

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To demonstrate that the front frame of a typical modern jet engine can be produced using techniques such as braiding and Solvent Assisted Resin Transfer Molding (SARTM).

DESCRIPTION: The Joint Strike Fighter (JSF) F120 engine faces the challenge of maintaining high performance while reducing weight and cost. Using a composite front frame would save about 30 pounds, compared to the titanium alternative. However, conventional composite manufacturing is very labor intensive, expensive and has varying quality. A potential solution is to use an automated processing technique such as braiding. Braiding is a traditional textile process that automatically places high performance fibers into the composite parts. In addition to the braiding, Solvent Assisted Resin Transfer Molding (SARTM) can be used to reduce the manual labor. SARTM is a proven process with proven materials with temperature capabilities up to 350 degrees F. There are several challenges for the JSF F120 engine front frame. It has a design requirement of 475 degrees F due to the anti-ice system. This frame must also remain structurally viable for impact loads and unbalanced loads due to blade out, while addressing the goal of

10% weight savings and 15% cost savings over conventional hand lay-up composite frames by using automated methods). Innovative approaches are sought to incorporate these types of techniques, so that issues related to a full-scale, functional, lightweight, high temperature, low cost design can be resolved.

PHASE I: Phase I will perform research on issues related to defining the manufacturing process, perform modeling and simulation for analysis of alternative designs and processes while Phase II will concentrate on developing and validating the selected manufacturing processes. During Phase I tasking, the manufacturing process will be defined using cost/process trade studies. A physical system model should guide the approach selected. Also, initial attachment features for a full-scale front frame structure will be researched and high risk/critical issues associated with the manufacturing process will be identified and solutions outlined.

PHASE II: Using the results of Phase I and initial design parameters (ref 4), the specific details of manufacturing a front frame will be researched and accomplished. These details include, determining material specifications, defining preform constructions, developing initial tooling, developing manufacturing automation methods, and developing nondestructive evaluation techniques. The manufacturing processes will be validated using structural analysis, material properties characterizations, subcomponent testing, and full-scale testing.

PHASE III DUAL USE APPLICATIONS: This technology will benefit both the military and commercial engine businesses. The materials and processes developed and verified in this program can be used in any design in which strong and lightweight material, operable up to 475 degrees F, is applicable, including land based turbines and airframe structures.

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3. “The Next Generation Attack Fighter: Affordability and Mission Needs”, Report Number RAND/MR-719-AF, ADA327531; Stevens, Donald; Davis, Bruce; Stanley, William; Norton, Daniel; Starr, Rae; 1997.

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KEYWORDS: Turbine Engine Frames, Polymeric Matrix Composites, Resin Transfer Molding, Fiber Braiding, Composite Processing, High Temperature Resins

AF02-191 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative components, manufacturing and processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a critical need for novel, innovative approaches to develop technologies that can double existing rocket propulsion capabilities by the year 2020, and for new, nonconventional aerospace propulsion-related technologies that will revolutionize aerospace propulsion in this century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either maintaining or decreasing existing life-cycle costs. The proposed solutions shall emphasize "dual use technologies" that clearly offer civilian/commercial as well as military applications. Proposals emphasizing "spin-on technology transfer" from the civilian/commercial sector to military applications will receive additional consideration. Our technological goals are intended to exceed the improvements expected to be realized by current programs, such as the Integrated High-Payoff Rocket Propulsion Technologies (IHPRPT) program. Examples of achievements at this level include: (1) Improve specific impulse and mass fraction for boost and orbit transfer, spacecraft, and tactical missile propulsion by more than 40% over current state of the art (SOA). (2) Reduce the stage failure rate by 2X. (3) Reduce hardware and support costs for boost and orbit transfer propulsion by more than 80% and 40% over SOA, respectively. (4) Improve the thrust-to-weight ratio for liquid rocket engines by more than 100% over SOA. (5) Improve the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems by 80%

and 1000% respectively. (6) Improve density impulse of monopropellants for satellite propulsion systems more than 80% over SOA. (7) Improve the delivered energy of tactical missile propulsion systems more than 20% over SOA. In the conduct of rocket propulsion research, we strive to reduce environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency. 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. An example of such a concept may include the design and development of a rocket-based combined cycle (RBCC) engine. 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 performance sensors, performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination. New advanced propulsion and related technological concepts and products for space activities are solicited for development. The topics include revolutionary concepts in advanced fuels and oxidizers, metastable high energy nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques applied to rocket propulsion, enigmatic energy devices, 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 technology applications for prospective investigators. Proposals also submitted for any other Department of Defense FY02 Small Business Innovative Research (SBIR) topic shall not be considered for this topic.

PHASE I: Further research and develop the concept and perform analyses required to select approaches and to establish the feasibility of the proposed approaches. Modeling and simulation are encouraged to track the analyses of alternatives.

PHASE II: Complete the Phase I design and develop technologies for a demonstrator or prototype. Provide predictive performance analyses. Define reliability and manufacturability of chosen approaches. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Advanced rocket propulsion technologies will transition to new, higher performing and/or lower cost U.S. military and commercial rocket engines and motors or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability to remanufacture components to maintain and monitor the health of the U.S. ballistic missile fleet.

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KEYWORDS: Rocket Plume, Rocket Engine, Rocket Propellants, Satellite Propulsion, Boost Transfer, Orbit Transfer

AF02-192 TITLE: Air-slew Package for Air-launched Missiles

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop solid propellant maneuverability packages for use on air-launched missiles and compact spacecraft systems

DESCRIPTION: Technology is required to develop a compact, self-contained thruster system for add-on use on air-launched missiles, satellite systems, and other high-maneuverability needs. This type of slew motor technology does not currently exist due to the unique combination of requirements, including small size and weight, short action time, compact packaging volume, and possible requirements for thrust vector control. These systems could be used to rapidly re-orient air-launched missiles, increasing rearward coverage by eliminating the need to use fuel from the main motor to execute a large radius turn to the rear or employed as long-life stable maneuverability thruster for satellite systems. Innovative solutions to the various technological issues are required to demonstrate the feasibility of this type of system. These issues include, but are not limited to, propellant formulations, mechanical properties, ballistic requirements, ignition properties, and slew motor grain geometry. In addition, the aerodynamic and structural loads imposed on the system under this type of maneuver are unknown and must be investigated for their effect on missile integrity and flight dynamics. Modeling and simulation efforts, as well as small scale propellant and structural testing, are encouraged to guide the development of these technologies.

PHASE I: Perform research to demonstrate the feasibility of development of a compact add-on maneuverability system. Analyze several candidate motor configurations and assess the capability, risk, and payoff for each candidate. An air-slew package for maneuverability of a seven-inch diameter air-launched missile system is recommended as a prototype development baseline. Performs modeling and simulation to determine operational parameters and performance sensitivities.

PHASE II: Based upon the technology and designs developed in Phase I, further develop and test prototype slew devices to assess their performance, advantages, and disadvantages. Demonstration of the prototype systems' ability to meet the large offboresight/high maneuverability requirements of an air-launched system through the use of inert missiles or other viable analogs is encouraged.

PHASE III DUAL USE APPLICATIONS: This technology has direct application not only to the military applications for air-launched missiles, but also to rapid maneuverability needs for military and civilian satellite systems, orbital injection motors, and high delta-V maneuvers for interplanetary probes. This type of technology could also apply (either spinning-off or spinning-on) to automotive air-bag systems and other related safety mechanisms.

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KEYWORDS: air-slew missile, missile slew, aircraft defense, maneuverability, tactical missile, air launched missile, air-to-air missile

AF02-193 TITLE: Significant Improvements in High Temperature Resins for Solid Rocket Motor (SRM) Boost and Orbit Transfer Composite Cases

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: The development of a new high temperature resin and demonstrated compatibility with a sustainable fiber for SRM Boost and Orbit Transfer casing.

DESCRIPTION: The successful completion of the Phase III IHPRPT (Integrated High Payoff Rocket Propulsion Technology) goals for Solid Rocket Motor Boost and Orbit Transfer will result in a doubling of the capabilities of benchmark systems. In order to succeed systematic improvements of every component area are required including a dramatic increase in the Tg of current resin systems that are used for composite cases. The resin system is only limited to demonstrated sustainability (e.g., various uses in industrial marketplace) and must have a glass transition temperature (Tg) greater than 750 degrees F with a fiber stress at failure of greater than 700 Ksi at the desired temperature. Complete resin characterization of the polymer system (thermal, mechanical, electrical, physical properties) should be followed by resin/fiber compatibility studies and small pressure bottle fabrication and testing. Although pressure bottle testing is strongly en-couraged, if cost constraints are an issue, less expensive means to demonstrate Phase I success will be considered. Preliminary cost and weight reduction analysis relative to Phase III goals, commercialization efforts, and tie-in to rocket component leads are critical and should be included in the proposal. Innova-tive programs will look at ways exceeding the minimal temperature and pressure requirements.

PHASE I: The development of a >750 degrees F resin, demonstrating high translational efficiency, and small pres-sure bottle testing at use temperature.

PHASE II: The modeling, optimization, scale-up, and sub-scale testing (by Rocket Community) of pressure bottles under various temperatures. A complete program will integrate the use of the new resin for a SRM demonstrator and show transition pathways prior to the end of the Phase II SBIR.

PHASE III DUAL USE APPLICATIONS: The end product will be a new resin that will not only have applications for Propulsion Technology, but also be used in a variety of commercial applications where high temperatures (>600 degrees F) and pressures usually prevents the use of composites.

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KEYWORDS: Materials, Resins, Rockets, Casing, Composites, Fibers, Polymers, Thermosets.

AF02-194 TITLE: Determination of Composite Motor Case Damage

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Design and verify a sensing method capable of accurately assessing damage to solid rocket motor composite cases.

DESCRIPTION: Composites are excellent materials for use in solid rocket motor cases due to their high strength and low weight. However, because they are fibrous, damage may occur during manufacture or transport that is not easily detectable and may significantly weaken the case. Breaking of the fibers, damage to the matrix, and delaminations of the plies are examples of the types of damage and defects that may occur. A sensing technique or device is needed for commercial and military solid rocket motors. It must be capable of detecting the location, extent, and type of damage that may have occurred in sufficient detail that an accurate assessment can be made of the motor's health and ability to perform the mission. Because there is a need to examine already fielded systems as well as those newly manufactured, sensors which would be embedded in the composite structure or require modification to the manufacturing process are not desired. An ideal system would require minimal (or no) physical contact between the sensor and the composite structure and would preferably be portable, although sensor networks which can be applied to the surface of the structure and remain with the system over its useful life will also be considered.

PHASE I: Develop and demonstrate a prototype system capable of assessing damage to composite materials. Demonstration articles should include typical aerospace composite materials (e.g. kevlar and graphite systems) and should be able to demonstrate the ability of the system to assess damage quantitatively (size and type of flaw, location and extent of damage, etc.).

PHASE II: Design and manufacture a subscale composite motor case design on which to demonstrate the prototype case damage system. Verification articles should be damaged or manufactured with known flaws similar to those in large motor cases. The accuracy of the damage detection system should be verified by comparison with current (e.g. destructive) means of testing. In order to show the technique is applicable to real systems, verification articles should include loaded (inert) subscale cases.

PHASE III DUAL USE APPLICATIONS: Composite materials are becoming prevalent in industry, particularly in various aerospace applications, due to their low weight, high strength, and good thermal properties. A system such as this would find many applications in the manufacture, maintenance, and repair of commercial and military aircraft, as well as spacecraft applications.

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KEYWORDS: Composite materials, composite damage, delamination, composite fiber, damage sensors, health monitoring

AF02-196 TITLE: Multi-Sensor Data Exploitation Capability

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a multisensor sensing, processing, fusion and exploitation capability to support detailed parametric electronic signature collection, mission planning and sensor tasking, onboard sensor management, and onboard and postmission data exploitation.

DESCRIPTION: The rapid collection and exploitation of complex electronic threat-emitter parametric information is critically important to supporting several Air Force operational missions. Currently, this type of data is independently collected by space, air, and ground-based systems within a stove-pipe architecture involving very little collaborative information sharing across systems. In today's high-tempo force deployment and employment scenarios, advanced strike and support platforms are attempting to use this type of data in real-time to support ongoing force employment missions. The need to optimize complex electronic threat-emitter parametric information collection, fusion, exploitation, and timely reporting is identified by the tactical air forces as a mission support shortfall. This shortfall is the result of a fundamental lack of understanding of the fusion phenomenologies at the sensor physics level for each of the candidate active and passive sensor modes being considered. The Air Force is seeking innovative solutions to this problem. Elements of the problem include a study of the fundamental sensor physics, intrinsic target signature characteristics (information theoretics), information requirements management; information-theoretics based sensor tasking and cueing; mission planning, data collection, processing, and fusion; and onboard as well as offboard data exploitation and reporting. Instead of a collection of stove-piped sensor systems collecting and processing information independently of other sensor systems, a system-of-sensor-systems architecture in which communications and information sharing within a network-based or centric collaborative infrastructure solution is needed to address this problem. Moreover, this capability should provide situation awareness with respect to over- and near-the-battlespace all-source sensor and force employment operations.

PHASE I: Phase I will create a concept of operations for the proposed capabilities, technical specifications, and some prototyping of key functional elements from a system-of-systems perspective. A fundamental analysis of the sensor physics and the resulting target signature information content (information theoretics) is needed for candidate active and passive sensor systems such as Ground Moving Target Indication (GMTI), Synthetic Aperture Radar (SAR), High Range Resolution (HRR), Inverse SAR (ISAR), and Electronic Signature Measurement (ESM). Assuming that these are stove-piped sensor architectures, the next stage of the feasibility study is to investigate at the information theoretics level, the fusion process leading up to exploitation. Specifically, each sensor system

PHASE II: Phase II will create a prototype which simulates a God's Eye situational awareness of the operational problem environment.

PHASE III DUAL USE APPLICATIONS: Phase III will involve the design, development, and testing of an advanced prototype with interfaces to existing or new sensors and sensor systems. Commercial Potential: The technologies developed will have multiple commercial applications including firefighting, natural resources management, and agricultural crop estimation and flight traffic control.

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KEYWORDS: Information fusion, data fusion, multiintelligence fusion, multisensor fusion

AF02-197 TITLE: Digital Beamforming Transmit Subarray With Waveform Agility

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design a digital beamforming transmit-only subarray antenna that can rapidly synthesize a variety of digital communication waveforms at different data rates.

DESCRIPTION: Commercial CDMA and military spread spectrum digital communication systems that employ phased array antennas can benefit significantly from the use of digital beamforming (DBF) in their transmit mode of operation. DBF enables simultaneous multiple beams without loss of signal–to-noise performance, and permits far greater spatial diversity than conventional analog multi-beam array antenna systems. On transmit, DBF arrays require rapid, highly agile generation and coding of the signature waveform shape, phase, and frequency, as well as up-conversion, filtering, and amplification circuitry. The goal of this project is to develop and demonstrate a prototype DBF transmit-only subarray antenna system using novel waveform synthesis techniques and commercial-off-the-shelf (COTS) components. As a design goal, the DBF transmit subarray should consist of at least 4 x 4 elements fed by a single digital channel. Techniques for rapid generation and encoding of digital waveforms should be demonstrated through a combination of waveform synthesis algorithms embedded in digital hardware, and other hardware including D/A converters or Direct Digital Synthesis (DDS) chips, and microwave mixers, filters and amplifier circuitry.

PHASE I: Phase I activity shall include the following key tasks: 1) Investigate and compare the performance of current COTS D/A converters versus DDS devices, with emphasis on maximizing waveform diversity and waveform switching speed. 2) Develop waveform synthesis algorithms and techniques that enable rapid generation and switching between a variety of orthogonal digital modulations. 3) Design a complete DBF subarray transmit channel implemented using either D/A or DDS chips, coupled with programmable digital circuit components such as FPGAs, buffers, and control logic. In the design, also include all RF and microwave hardware necessary for transmit mode radiation, including mixers, filters, amplifiers, and antenna elements. 4) Design and model the performance of an array antenna comprised of at least 16 such subarrays. Strong emphasis should be placed on computer-based validation of a single subarray digital channel, and then the complete 16-channel array, using measured performance data obtained experimentally from actual D/A or DDS hardware.

PHASE II: Develop an operational prototype of a single channel DBF transmit subarray system. Use the DBF transmit subarray prototype to experimentally demonstrate generation of at least three different orthogonal digital communication waveforms, demonstrate at least two different data rates above 10 kbits/s, and demonstrate rapid switching between all the waveforms and data rates. Emphasis should be placed on measuring and quantifying the fidelity of the generated waveforms including signal-to-noise ratio, bit-error-rate performance, and microwave dynamic range. As a design goal, subarray performance should meet the current state-of-the-art.

PHASE III DUAL USE APPLICATIONS: A digital beamforming transmit mode array with waveform agility will be extremely useful for satellite-to-satellite, satellite-to-airborne, and satellite-to-ground communications systems. Such a system would potentially lower the costs of transmit terminals for both military and civilian applications, and stimulate the use of waveform diversity with spatial diversity in communication systems. Military applications include communication systems at S-band, and certain Extremely High Frequency bands. Civilian applications that would benefit from this technology include mobile/stationary ground terminals for commercial ground-based CDMA systems and satellite-based global communication systems for business/home use.

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KEYWORDS: Digital Beamforming, DBF on Transmit, Waveform Agility, Phased Array Antenna, Direct Digital Synthesis, D/A converter

AF02-198 TITLE: Improved Inertial Reference Transfer Unit (IRTU) - Gyros, Mounts, Models

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Improve inertial reference unit (IRU) accuracy at the system or component level.

DESCRIPTION: Develop enhanced performance and superaccurate inertial measurement capability. The accuracy and stability of inertial references allow precise aiming and navigation of weapon systems. Most current state of the art inertial reference units use the highly accurate fiber optic gyroscope. Because of relatively longer path lengths (~1 kilometer), high degrees of accuracy (<0.001 deg/hr bias stability) may be achieved. Indeed, angular random walk error of a few thousandths of a degree per root-hour, are available in commercial designs. Reducing errors like these and those caused by temperature sensitivities offer potentially super accurate inertial measurements. Likewise, the mounting hardware and environmental sensitivities of the supporting electronics have an effect on the inertial reference unit's performance. They, along with the unit's control software, can either enhance or diminish performance. Reductions in size, power and cost and enhanced reliability are also goals for this IRU.

PHASE I: Define the proposed IRU system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory or simulation environment.

PHASE II: Develop and fabricate a breadboard system and perform a laboratory demonstration to mutually agreed performance parameters. Demonstration of the IRU must be capable to support ground demonstration in a government facility and an airborne experiment. The prime consideration is deliverable system hardware and a demonstration of integrated system that performs well over the expected environments and has the potential for a 20-year lifetime.

PHASE III DUAL USE APPLICATIONS: This development of enhanced performance and super accurate inertial measurements will be used by multiple DoD programs involved with the navigation of weapon systems. The accuracy and stability of inertial references allow precise aiming and/or navigation for commercial applications such as telescope systems and sea, land, air, and space vehicles.

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KEYWORDS: Fiber Optic Gyroscope, Inertial Reference Unit, Inertial Navigation System, Navigation of Weapon Systems, Degree Per Root-Hour, Degree per Hour, Accuracy and Stability, Environmental Sensitivities.

AF02-199 TITLE: Improved UHF Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The U.S. Air Force is seeking new ideas and technology for an effort to support the growing communications performance requirements for the reception/transmission of UHF radio signals with conformally mounted antennas mounted within the airframe of a modern evolving aircraft.

DESCRIPTION: This effort is directed toward the development of an UHF antenna for both receive and transmit functions,such as; voice, and satellite data communications. The antenna must operate in the band from 225 to 400MHz with a peak gain of better than -3dB conformally mounted on an evolving modern aircraft. Issues to be addressed are one or more of the following: (1) Communications abilities at ranges up to several hundred miles; (2) Gain of the antenna across the entire frequency band; (3) Performance of the antenna when integrated into the aircraft; (4) Low reflectivity out of band. In the past cavity backed spiral and slot antennas typically have been used for these functions but these approaches do not provide enough horizon gain to meet the range requirements of modern air vehicles.

PHASE I: Provide a report and possible supporting data to demonstrate the proposed approach describing the UHF antenna. Fabricate or prototype any portion of the antenna that would increase confidence in a Phase II effort.

PHASE II: Fabricate and demonstrate a protype in a test bed environment that adequately simulates the antenna mounted on and/or within the aircraft.

PHASE III DUAL USE APPLICATIONS: The proposed antenna has potential use on commercial aircraft or ground vehicles such as automobiles or buses primarily for improved aesthetic reasons. The primary use would be for the U.S. Air Force, Navy, and Army vehicles which require increased performance at high speeds and low refletivity out of the operating band.

REFERENCES:

KEYWORDS: UHF Antenna, UHF Communications, UHF Satellite Communications, 225 to 400 MHz, Conformal Antennas

AF02-200 TITLE: Continuous Track and ID Fusion (CTIF)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To continuously detect, track, and identify time-critical targets by fusing track and ID information in context of a robust, distributed tracking model, and database architecture.

DESCRIPTION: Achieving this capability in all-weather conditions and at standoff ranges cannot be accomplished reliably without fusion of sensor data from multiple sources using distributed robust tracking processies and database architectures. Current fusion approaches combine information at the decision level, which needlessly discards a tremendous amount of rich object/feature-level sensor information that could be otherwise fused for improved target detection, tracking and identification. Innovative detection, cueing, fusion algorithms, models, and architectures are needed for accumulating target identification evidence based on object-level target features from multiple sensors dispersed in time and space particularly when track and ID information is either fragmented or distributed. The result shall be cumulative, continuous combat identification of highly mobile surface targets through all phases of their movement history. An underlying objective of this continuous detection, tracking and ID effort is to develop novel concepts and techniques for sensing, processing, and accruing evidence from both distributed sensors, tracks, and databases using robust sensing, processing, tracking, ID, and database models to associate detection, track, and identification data on targets of interest originating from different collections. A key part of the research is to tie the solution to the sensor capabilities. This ensure that the solution is a complete one and fully exploits the sensing and processing capabilities within the context of the fusion solution.

PHASE I: Develop and implement optimal or near-optimal track detection, generation and estimation algorithms of surface moving targets that appropriately deals with target, sensor, and environment modeling uncertainties. Develop concepts and techniques for associating detections, track fragments, and identification information originating from different Intelligence, Surveillance and Reconnaissance (ISR) assets resident in multiple databases. Model and demonstrate these sensor-level continuous tracking and ID techniques via engineering analysis and simulation. The Air Force will help to identify and provide scenarios, descriptions, analytical models, and software tools that can be used to conduct the research. One goal of Phase I is to demonstrate the performance of the technique/s on simulated Ground Moving Target Indication (GMTI), High Range Resolution (HRR), and/or other sensor data.

PHASE II: The major goal of Phase II is the demonstration of the method on Air Force real data collections of Ground Moving Target Indication (GMTI), HRR, and/or other sensors. Efforts are likely to include further developments to meet operational requirements.

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, and transportation systems.

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KEYWORDS: Cognitive Reasoning, Data Association (spatial and temporal) Algorithms, Data Fusion, Tracking and Identification, Tracking Model, Target Identification, Targeting, Feature-Level Fusion.

AF02-201 TITLE: High-Efficiency Amplifiers with Discretely Variable Output Power

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a power amplifier for phased-array antennas to provide high efficiency at discrete power levels

DESCRIPTION: Electronic phased array antenna systems often require a power amplifier at each element or subarray. To form an agile beam while maintaining control over the radiated power, it may be necessary to vary the power delivered by each amplifier. Typically, amplifiers are optimized for high efficiency at a particular power level. When operating at other power levels, efficiency suffers, causing excessive use of costly prime power. The goal of this project is to develop innovative designs for microwave/millimeter-wave amplifiers to achieve efficient operation at a small number of discrete power levels.

PHASE I: Phase I activity will include the following key tasks: 1) Investigate the trade space of high efficiency transistor amplifiers with discretely variable output power. The output power should vary discretely between 0 and a few watts in a small number (two to eight) of steps. The investigation should address linear amplifiers with at least 10 percent bandwidth and 30 percent power-added efficiency at discrete frequencies between 1GHz and 100GHz. Consider parameters such as transistor type, semiconductor material, circuit topology, amplifier class, bias levels, and related properties. 2) Develop conceptual designs of high-efficiency amplifiers with discretely variable output power at one or more frequencies in the 1 GHz to 100 GHz range. The designs should achieve small size, lightweight, and low cost, and use an easily implemented method of controlling output power. Switching frequency between states should be at tens of KHz or greater. 3) Identify critical elements of the design for detailed development during Phase II.

PHASE II: Perform detailed design of the amplifiers developed in Phase I. Develop and test functional prototype amplifiers to demonstrate feasibility of critical elements of the design

PHASE III DUAL USE APPLICATIONS: Power amplifier efficiency is a critical factor in achieving long battery life in DoD and commercial mobile communications systems. The high-efficiency amplifiers with variable output power could be adaptively adjusted to maintain communications links while minimizing battery power consumption.

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KEYWORDS: Power amplifier, Power-added efficiency, Satellite communications, Transistor amplifiers, Monolithic microwave integrated circuit (MMIC), Phased array antenna

AF02-202 TITLE: Low Mass, Low Power, Digital Beamforming (DBF) Subarray for Satellite Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design a digital beamforming receive-only subarray antenna, with very low mass and very low power consumption, for satellite communication array antennas.

DESCRIPTION: Space-based digital communication systems that utilize a phased array antenna as either the main radiating aperture, or as a feed to a large reflector, can benefit from the high degree of pattern control and multiple simultaneous beams afforded by digital beamforming (DBF). In space-based systems, power and mass are at a premium, however, present day DBF channel hardware and DBF array designs do not meet satellite requirements. A/D converters with sufficient resolution typically consume about 5W, and signal processors consume significantly more. In addition, conventional microwave radiating elements and feed lines have high mass densities and exhibit unsatisfactorily high RF loss. The goal of this project is to develop one or more receive-only DBF subarray architectures that comprise a unit cell in a modular DBF array architecture suited for satellite communications. Appropriate subarray design approaches shall feature the exclusive use of ultra-low mass materials, very low power consumption high-efficiency electronics, and RF aperture design approaches that exhibit very low RF loss. As a further constraint, appropriate subarrays must be designed as a modular component of a DBF array architecture, and be shown to exhibit sufficient G/T performance in that array environment, in order to prove the usefulness of the design for high speed satellite data communication. The subarray shall be designed to operate in the receive-only mode, and be capable of wide scanning in both azimuth and elevation planes, in an appropriate microwave communications band. With the exception of power supplies and signal generators, the subarray design shall contain and physically support all microwave and digital electronic hardware required for live testing.

PHASE I: The Phase I activity shall include the following tasks: 1) Investigate the use of very low mass flexible membrane materials such as Kapton or Liquid Crystal Polymer (LCP), used in combination with low mass rigid materials such as hex-cell, composites, or other materials, as a substrate for the subarray back-plane. 2) Investigate the performance and availability of commercial-off-the-shelf (COTS) electronics that have both low mass and low power consumption. 3) Develop circuit designs and electronic modes of operation that require very low power consumption and exhibit very low RF loss. 4) Develop advanced digital signal processing approaches and hardware implementations that consume very little power, yet provide full DBF functionality on receive, including channel equalization and adaptive weighting. 5) Design a subarray using results from the tasks described above. The subarray shall include all A/D, digital buffering circuitry, and microwave receiver components necessary to use the subarray in live tests that shall include measurement of the far field subarray pattern on an antenna test range.

PHASE II: Develop an operational prototype of the DBF subarray designed in Phase I. Experimentally demonstrate the operation of the subarray in the receive-only mode, and demonstrate channel equalization and the application of digital weights. Strong emphasis should be placed on measuring and quantifying the microwave and digital performance of the subarray, including dynamic range, signal-to-noise ratio, resolution, as well as measure the power consumption and RF loss of the subarray, and its mass.

PHASE III DUAL USE APPLICATIONS: A digital beamforming subarray having very low mass, and power consumption is an extremely useful component for DBF phased array antennas and DBF array feeds to lens and reflector antennas, for both military and commercial use. Space-based communication/surveillance/reconnaissance systems would benefit greatly from the development of this technology. Military applications include satellite communications systems at S-band and Extremely High Frequency bands. Commercial applications that would benefit from this technology include satellite-based global communications systems.

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KEYWORDS: Digital Beamforming, Low mass, Low power consumption, Phased Array Antenna, Subarray, Space-based Digital Communications

AF02-204 TITLE: Simulator Technologies for Rapid Prototyping of Advanced Receiver/Processor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/evolve simulator technologies for rapid prototyping of advanced radio frequency (RF) receiver/processor capabilities.

DESCRIPTION: Current research methodologies for evolving advanced RF receiver/processor capabilities are time consuming and require extensive/costly open-air range testing. Open-air ranges cannot generate the dense RF signal environments that would be experienced in actual real-world situations such as military combat scenarios. Open-air range productivity is low due to the fact that there are so many uncontrolled variables and the inability to make changes during the actual flight test. Receiver/processor research facilities do not have the real-time simulation capabilities to evolve advanced RF receivers/processors in the laboratory. Currently available laboratory RF emission simulators cannot provide the required fidelity and real-time signal environment generation capability. These laboratory simulators are costly to build because they achieve high fidelity through specialized RF synthesizers/modulators/amplifiers/attenuators and specialized digital control electronics that utilize expensive, precision-matched components. The current simulator architectures force the use of these expensive, precision-matched components. Increasing the laboratory simulator's fidelity through higher fidelity components is cost prohibitive and involves performance tradeoffs that actually limit the simulator's capability. As an example, inserting additional amplifiers in the signal generation chain to make up for precision component losses, raises the noise floor, limiting dynamic range and preventing the generation of realistic emissions. Current laboratory simulators cannot be effectively linked/operated together because they do not utilize the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office (DMSO). This inability to effectively link simulators detrimentally limits the realism of the generated emitter environments. Research is being sought to create affordable dual-use simulator technology advancements that enable higher fidelity through innovative architectures and/or component technologies. This Small Business Innovation Research addresses simulator technology needs for the DoD HLA concepts/requirements being sponsored by the DMSO under the DMSO M&S Master Plan.

PHASE I: The Phase I effort will conduct the research required to define dual-use simulator component technologies and/or advanced simulator architectures that enable the affordable rapid prototyping of advanced RF receiver/processor capabilities in the laboratory. The research should envolve innovative solutions that do not require detrimental performance tradeoffs. The Phase I research will identify the implementation concepts and establish concept feasibility. The Phase I effort will define the Phase II approach for developing/demonstrating the improvements. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the performance/benefits of the selected simulator component technologies and/or advanced simulator architectures.

PHASE III DUAL USE APPLICATIONS: The simulator component technologies/advanced simulator architectures can be implemented in government laboratories and test ranges for the development and evaluation of advanced RF receiver/processor capabilities.Simulator component and advanced architecture technologies are dual use technologies that have extensive commercial applications for markets such as the telecommunications industry. These technologies can be utilized to improve the laboratory capabilities enabling telecommunications equipment to be developed faster and more cheaply. These technologies reduce development costs and accelerate product movement to the market place through rapid prototyping in a laboratory development environment that incorporates realistic real-world effects.

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KEYWORDS: Simulator, Radio Frequency (RF)Simulator, Architecture

AF02-205 TITLE: Efficient Luneberg Lens for Multi-frequency SATCOM Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Investigate materials and fabrication techniques for wideband Luneberg lenses.

DESCRIPTION: A Luneberg lens is a sphere of low-loss dielectric material the index of refraction or relative dielectric constant varying along any radius. In the ideal lens this variation is continuous; however, this variation is often approximated by concentric spherical shells. When a hemispherical lens is placed on a ground plane reflections at the ground result in an effective doubling of the aperture making a lens antenna ideal for aircraft installation. Luneberg lenses are inherently wideband and are a prime candidate for multi-frequency aircraft SATCOM antennas. Good performance has been achieved at 20 GHz; however, difficulty has been encountered in achieving maximum gain performance at 44 GHz. Close examination of shells indicates that fabrication difficulties result in non uniformities in the dielectric constant within a shell. Other fabrication difficulties such as air gaps between the shells decrease lens performance. In transmit systems the 165 deg F melting point of fabrication material can limit the RF power.

PHASE I: Investigate fabrication techniques and material which will result in a wideband lens with maximum gain efficiency and uniformity at 20 GHz, 30 GHz and 44 GHz. An 8" diameter hemisphere lens with a uniform gain of 40 dB at 44 GHz is the target goal. Explore fabrication techniques for lenses with continuously varying dielectric constant, multiple concentric shells, or other architectures and compare cost and performance results . Investigate the effects RF heating and the use of material with melting points above 165 F. Develop a design of a wideband lens to be fabricated in Phase II

PHASE II: Use the design selected in Phase I to fabricate at least 6 lenses. At 20, 30, and 44 GHz measure the gain and the uniformity of the gain over the hemisphere. Measure the radiation pattern, directivity and input VSWR. Final report should document performance capabilities, fabrication repeatability and temperature heating effects due to RF source power and maximum input power limitations.

PHASE III DUAL USE APPLICATIONS: DoD applications for Luneberg lenses include antennas for large aircraft in the AF Advanced Wideband Terminal (AWT) procurement. Commercial applications include use with emerging Ku and Ka band commercial satellite communications systems.

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KEYWORDS: Antenna, Luneberg Lens, Aircraft Antennas

AF02-206 TITLE: High Performance Atomic Clocks for Space

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Improve the performance of spaceborne atomic clocks for GPS.

DESCRIPTION: Interest in atomic clocks has grown in recent years, with developments in physics package design and supporting electronics. Lasers are being introduced for state selection and preparation that permit more efficient interrogation of atomic populations leading to improved discriminator signal-to-noise. Alternative modes of interrogation are being considered for new physics package designs. Microwave signal generation is benefiting from the new gallium arsenide technology and digital electronics is being used to provide more comprehensive management of clock operation. These innovations allow alternative and new opportunities for clock technology to achieve higher levels of performance. At the same time, GPS requirements continue to demand the very best clock technology that can be flown in space. Timing accuracy of better than a nanosecond per day demands an Allan deviation of less than 1E-12 per root tau, with a flicker floor below 5E-15 and negligible drift. This program will address new clock designs to support these performance goals.

PHASE I: Select a clock technology and perform an analysis to identify the critical parameters that establish its performance. Develop computer simulation of selected clock together with integration of improved technology. Through simulation, measure improvement to critical parameters. Fabricate /integrate the necessary breadboard components to improve precision. Demonstrate the viability of the technology and measure the improvement to critical parameters. Results should show promising performance and progress towards meeting the overall objectives of the program.

PHASE II: Build a prototype clock based upon Phase I results. Utilize prototype unit to demonstrate performance goals mutually agreed upon between the Air force and Contractor. SBIR contractor should endeavor to establish a partnership with an organization that can provide commercial resources to sustain product development and ensure a path to flight production and space qualification.

PHASE III DUAL USE APPLICATIONS: Atomic clocks are widely used in communication networks and avionics where timing requirements are critical. The development of space clocks for GPS extends capabilities in clock design and manufacturing, and provides new technology for these commercial applications.

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5. Andy Wu and Bill Feess, "Development and Evaluation of GPS Space Based Clocks for GPS III and Beyond," The Aerospace Corporation, 2001

KEYWORDS: GPS, Atomic clock, Laser, Microwave signal, Atomic Clock Physics Package, Commercial resources

AF02-208 TITLE: Global Positioning System/Inertial Measurement Unit Ultra-Tightly Coupled Integrity Monitoring

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a global positioning system (GPS) integrity monitoring method utilizing Ultra-tight GPS coupling with an inertial measurement unit (IMU).

DESCRIPTION: GPS applications involving safety-of-flight operations (e.g., precision and nonprecision instrument landings) require integrity monitoring. Integrity monitoring can involve either onboard resources such as receiver autonomous integrity monitoring (RAIM) or offboard resources such as wide-area or local-area augmentation. Since measurements to only four GPS satellites are required for a GPS navigation fix, and there are normally many more in simultaneous view, most RAIM approaches traditionally rely on algorithms that use redundant satellite measurements. That is, unless there is consistency within allowable tolerances between the measurements to all satellites, there may be a problem with one or more measurements and the user is alerted to the possible error. With six or more satellites in view, it is normally possible to isolate the bad satellite. Experimental GPS landing systems have used a combination of inertial and radar altimeter measurements to implement the RAIM function. Several researchers have recently been investigating novel GPS-inertial integration techniques (deep-integration or ultra-tight coupling) that may yield markedly improved performance in the presence of signal interference. These techniques may be incompatible with conventional RAIM algorithms, but conversely may allow the implementation of even more effective integrity monitoring techniques. The purpose of this project is to develop, formulate, implement, and characterize the most effective RAIM techniques that exploit these new GPS-inertial integration architectures to obtain more robustness and greater reliability under all practical types of GPS and IMU failure modes.

PHASE I: In Phase I, develop computer simulation of the proposed solution. The simulation shall include the necessary levels of fidelity to test the contractor's approach with realistic degraded GPS and IMU performance parameters. Provide a simulation demonstration together with documented results and a detailed description of the finalized approach. A proposed Phase II outline shall be included in the final report.

PHASE II: Develop (Air Force/Contractor) mutually agreed test plans and procedures. The test program shall simulate various failure modes of GPS and the IMU, including soft failures. Perform tests (per plans) utilizing the finalized Phase I approach incorporating a real GPS receiver that is ultra-tightly coupled with an IMU. The test plan, procedures, and test data/results shall be included in the Phase II final report.

PHASE III DUAL USE APPLICATIONS: This technology will be applicable in the military Joint Precision Approach and Landing System (JPALS) as well as being applicable to civil airlines that use GPS for landing.

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KEYWORDS:

AF02-209 TITLE: Innovative Sensors and Algorithms for Detection and Identification of time critical targets

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and evaluate innovative sensor and algorithm concepts for the detection and identification of advanced time critical targets.

DESCRIPTION: Combat missions must now be accomplished in the face of significant challenges such as: 1) enemy air defenders using enhanced surface-to-air missile defenses employing new engagement tactics such as frequent threat emitter shutdowns and shoot-and-scoot tactics; 2) targets under trees; and 3) moving targets. Innovative sensors and algorithms are required to improve detection range and identification of these time-critical targets. Enhanced detection range and positive hostile ID may be obtained through the use of systems onboard the targeting platform and/or from off board sources.

PHASE I: The development and evaluation of innovative sensor and algorithm concepts for detection and identification of advanced time-critical targets requires an understanding of what features unique to time-critical targets are present, and what sensor and algorithm processing capabilities are needed to reliably exploit them. Consequently, the Phase I effort will consist of a two-part feasibility study. The first will be to determine the existence and characteristics of candidate target features. Existng ground moving target identificatiion (GMTI) and synthetic aperture radar (SAR) target databases, assembled under recent DARPA research programs, could be used to support this initial feasibility study. The focus will be to assess the characteristics of time-critical target features that can be reliably exploited using advanced sensor concepts such as SAR/GMTI fusion, wideband space-time adaptive processing (STAP), and high range resolution (HRR.) The second part of the feasibility study would be to do an initial hypothesis test using existing target detection, cueing, and identification algorithms for continuous detection and ID of stationary and moving time-critical targets to assess the feasibility of fusing these features . This will be achieved by exploiting complementary components of GMTI, HRR, SAR, and Moving Target Imaging (MTIm) radar modes, sensor-level data mining, and clutter cancellation algorithms. This fusion of modes, data, and algorithms will be needed to rapidly align, correlate, and fuse sensor multimode data into an integrated, detect-and-ID capability in order to continuously pursue a ground target whether stopped or moving. The end result of this two part feasibility study will be to assess the presence and behavior of uniquely exploitable target signatures. As part of the feasibility study, key radar parameters and performance tradespace will also be identified for utilization in the prototype demonstration phase II.

PHASE II: This effort will be a prototype demonstration. Using the findings from the Phase I feasibility study, a prototype advanced sensing concept for time critical targets will be demonstrated. This will involve implementing and improving the fidelity of existing sensor detection and ID designs using target features identified in Phase I feasibility study. A key part of the prototyping demonstration is the integration of key radar sensor parameters such as pulse repetition frequency (PRF), bandwidth, dwell, transmitter power, squint geometry, platform speed, etc with the algorithm behavior. This will ensure that the demonstration will accurately illustrate the interdependence between algorithm and sensor design for optimum detection, tracking, and ID as a function of the time critical target.

PHASE III DUAL USE APPLICATIONS: Known application areas include commercial aviation, drug enforcement, and transportation system analysis.

REFERENCES:
1. R. Mitchell, "Robust High Range Resolution Radar Target Identification using a Statistical Feature Based Classifier with Feature Level Fusion," Ph.D. thesis, The University of Dayton, 1997.

2. J. Westerkamp, D. Gross, J. Greenewald, R. Williams, "Tracking and Identification of Surface Moving Vehicles From Space Using Advanced SAR/MTI Concepts," 36th Space Congress, April 1999.

KEYWORDS: SAR, GMTI, HRR, Sensor Modes, Time Critical Targets, Detection, Identification

AF02-211 TITLE: 3-D Reconstruction for Missile Recognition

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Establish approaches for robust, efficient automatic target recognition (ATR) and registration systems for missiles.

DESCRIPTION: Recent advanced in model-based target recognition techniques have greatly improved the capabilities for targets in the open (i.e. unobscured). While missiles are generally unobscured, their speed and size impose significant problems for the standard approaches. Thus, innovative ATR and registration approaches are requested for high-resolution sensor systems that roughly track a missile.Ballistic missile defense can include preventing a launch through successful theater interdiction, but more generally denotes disabling a ballistic missile in flight. The first step to defense is surveillance. Sensors are the eyes and ears for surveillance and the associated systems must provide the brain for interpreting the data. Obvious sensor (wavelength) choices include infrared and visible, but should not be considered as the only option. Applications include target detection, classification, tracking, and kill determination.Two important additional technical goals are to discriminate decoys and to improve trajectory estimates. Thus these goals necessitate a coherent framework for integrating multiple looks at potential targets and a trade-off between speed and accuracy. The natural framework is the 3-D geometry of the missile. The 3-D geometry of a missile can be determined by tracking it over an extended time period. In simple cases where the missile trajectory is known, tomographic reconstruction would be sufficient. However, in the general case where the trajectory with respect to the sensor is not known, a more general solution is required to reconstruct the 3-D object from the data. An added benefit of a more general approach is ability to simultaneously handle both platform and target motion (the more they move, the better the reconstruction). Ultimately, a general approach will easily lead into many military and commercial applications of ATR and registration.

PHASE I: Demonstrate a prototype approach for automatic missile recognition and registration. Clearly address the extended operating conditions, testing, and evaluation methodology for demonstrating the feasibility of the prototype approach. Suggest a modified approach based on evaluation of the prototype.

PHASE II: Implement modified approach suggested in Phase I. Evaluate results achieved on several nominal cases. Demonstrate robustness to obscuration, decoys, and chaff. Develop plans for database, index, and algorithm creation and updates. Deliver the algorithms for additional assessment and possible transition into user applications.

PHASE III DUAL USE APPLICATIONS: An efficient and robust system for acquiring and tracking small targets among other similar targets has a clear application to air traffic control and space monitoring. The technology developed will also have application to plume tracking for pollution and numerous other commercial, medical, and military applications requiring ATR algorithms.

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5. M. Stuff, "Three Dimensional Invariants of Moving Targets", Algorithms for Synthetic Aperture Radar Imagery VII, E. Zelnio, ed., SPIE Proceedings, Orlando, FL, April 2000.Some of these papers are available at http://www.mbvlab.wpafb.af.mil/paper.html and they contain other relevant references.

KEYWORDS: Automatic Target Recognition (ATR), Detection, Tracking, Reconstruction, Recognition, Identification.

AF02-212 TITLE: Dual-Use Visualization Tools For Aircraft System/Subsystem Performance Assessments

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop dual-use, real-time visualization technology/tools that reduce the cost/time for performance analyses/assessments.

DESCRIPTION: Modeling and simulation are being utilized extensively to predict/analyze the performance at both the system and subsystem levels for both military and commercial aircraft. The analysis of the simulation data requires considerable time and manpower/cost to translate the results into meaningful information/presentation formats that can be used for rapid system/subsystem design/performance assessments. Approaches leading to the creation of innovative, user friendly, dual-use visualization technologies/tools that automatically translate simulation results into high fidelity formats where the analyst can readily visualize the predicted performance are sought. The goal of this research is to evolve affordable dual-use visualization technologies/tools that increase the productivity of performance analyses/assessments and reduce analysis/assessment costs. This research should address the visualization needs of constructive (digital models), virtual (man-in-the-loop) and hardware-in-the-loop simulation. The dual-use visualization technology base established by this research will enable significant reductions in the time/cost for both commercial and military aircraft system/subsystem performance assessments. This SBIR visualization research addresses visualization technology/tool needs for the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office (DSMO)under the DMSO M&S Master Plan.

PHASE I: The Phase I effort will conduct the research required to define affordable dual-use visualization concepts/technologies/tools for aircraft system/subsystem performance analyses/assessments. The key objective of this research is to create innovative dual-use visualization concepts/technologies/tools that increase the productivity of aircraft system/subsystem performance analyses/assessments and reduce analysis/assessment costs. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing/demonstrating the required visualization concepts/technologies/tools. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the critical visualization concepts/technologies/tools.

PHASE III DUAL USE APPLICATIONS: Visualization concepts/technologies that increase the productivity of aircraft system/subsystem performance analyses/assessments and reduce analysis/assessment costs are dual-use technologies that have extensive commercial applications for markets such as commercial aircraft, automobile, and video game entertainment industries. These concepts/technologies/tools automate the translation of simulation results into visualization formats that enable the aircraft/automotive system design engineer/analyst to rapidly review/assess the information, which will allow the design teams to rapidly modify their designs to balance cost/performance trade-offs. These same concepts/technologies/tools can be utilized by the video game entertainment industry to enhance the visualization and interaction of video games. These same concepts/technologies/tools can be implemented in government laboratories and test ranges for rapid assessment of aircraft system/subsystem performance analyses/assessments.

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KEYWORDS: Visualization, Simulation, Assessment

AF02-213 TITLE: Material and Component Development for Millimeter(MM)-Wave Imaging Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a material, processing, or integration technology to advance the state-of-the-art in mm-wave components for 140-GHz imaging receivers.

DESCRIPTION: Millimeterwaves (MM-Wave) can effectively penetrate fog, dust, and clouds during bad weather situations. The mm-wave signals can be sensed in a passive mode, much like in a visible imaging system that uses collection optics and imaging arrays. Therefore, mm-wave can be used to enhance an operator's vision in critical situations. The further development of mm-wave imaging systems will rely on improvements in materials, processing, and active components that can operate above frequencies of 140-GHz. Indium gallium arsenide and antimonide-based devices are good candidates for operation above the 140-GHz (mm-wave) range. These materials have the added advantage that they are readily integrable with mm-wave antenna elements. Integration of these structures on a common substrate would reduce the necessity for coaxial interconnects, thereby advancing system performance through enhanced efficiency and smaller size.This program seeks innovative approaches to improve the performance and reduce the cost of components used in mm-wave imaging systems. Innovative mm-wave circuit design and imaging system architectures are needed that reduce component count by increasing the level of integration. Novel materials growth and processing techniques are sought that will improve yield and device performance. For example growth of high indium content compounds on large diameter wafers would greatly reduce component cost. Processes of interest are transfer integration techniques that result in greatly improved device performance and allow the fabrication of semiconductor devices with low cost printed circuit antennas.

PHASE I: Demonstrate feasibility of new material technology or processing technique. Emphasis will be given to improving yield, device performance, or level of integration for components needed for mm-wave imaging systems. Performance and cost improvements in relation to mm-wave imaging systems will be documented.

PHASE II: Further develop the material, processing, or device technology investigated in Phase I. Fabricate prototype mm-wave components to demonstrate the feasibility of a 140-GHz imaging system based on the technology developed during Phase II. Demonstrate and characterize the operation of the mm-wave components.

PHASE III DUAL USE APPLICATIONS: The Air Force deploys an ever-increasing number of optical communication networks, both terrestrially and on airborne and space-borne platforms that use mm-wave components. Weight and other requirements increasingly dictate higher frequencies and more compact system designs for microwave and millimeter subsystems. Nondefense markets also exist in the areas of telecommunication, data networks, cable TV, ground links for wireless networks, and automotive radar.

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KEYWORDS: 140-GHz Imaging Sensor, EVS, Imaging Array, Indium Phosphide, MM-Wave

AF02-214 TITLE: 140 GHz Imaging Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Innovative passive and active imaging systems for the 140-GHz atmospheric window.

DESCRIPTION: The need exists to develop an array of components in the 140-GHz frequency range for imaging. Advances in the III-V materials and devices, particularly in the indium phosphide-based material system, enable manufacturable, low-cost electronics for signal generation, control, and detection at frequencies through 140-GHz. With a wavelength of 2.1 millimeters, imaging at 140 GHz provides higher resolution and smaller components compared to imaging at lower frequencies. Arrays of transmitters or receivers, or both, could be made on a single monolithic millimeterwave integrated circuit. At 140 GHz, imaging systems can operate day and night in adverse atmospheric conditions. These features promise applications in landing guidance systems, navigation, targeting, weapons detection, and battle damage assessment by providing imagery through all weather conditions and in the day or night.

PHASE I: Activities in this phase shall include: 1) Develop a system concept for an active and/or passive 140-GHz imaging system. 2) Demonstrate the feasibility of components for receivers and transmitters for the imaging system. 3) Develop a plan for partitioning and integrating components in an imaging array.

PHASE II: Activities in this phase shall include: 1) Demonstrate integration of components for an imaging system according to the plan developed in Phase I. 2) Develop a system architecture for a complete sensor, including target/scene environmental issues.

PHASE III DUAL USE APPLICATIONS: Potential applications are in military transport, commercial airlines, and airfreight as an enhanced vision system (EVS) sensor.

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KEYWORDS: 140-GHz Imaging Sensor, Enhanced Vision Systems, Millimeter-Wave Components, Indium Phosphide-Based Materials

AF02-215 TITLE: Real Time Sensor Image Fusion

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design, evaluate and build a real-time image sensor fusion system capable of penetrating night and weather that aircraft pilots can use during instrument approach/departure procedures.

DESCRIPTION: New image fusion approaches based on neural networks are being developed which can provide a real-time sensor image fusion capability suitable for use with an enhanced vision system (EVS) for instrument approach and departure procedures. The image fusion/EVS architecture will provide a heads-up display (HUD) with a substantially enhanced image for the pilot while flying in adverse weather and at night. The architecture can utilize sensors ranging from different types of infrared (IR) (~300 THz) to W-band (84 to 94 GHz) to Ka-band (26-40 GHz), each having its unique resolution, weather penetration, and night vision capabilities. Images from two or more of these sensors shall be processed and fused for display as an EVS video image for a HUD, which may include aircraft information. The goal is for the assimilated image to provide more information than any one individual sensor while suppressing sensor artifacts such as noise, blooming, and dead pixels. The image fusion/EVS system will provide the pilot and copilot with an optimized visual image as the aircraft transitions from initial approach to the missed approach point. The color weather radar (35 GHz) has better weather-penetrating capabilities than an IR sensor, but it has lower resolution. The best application would be ground mapping or terrain-following and could be used for executing initial approaches or low altitude navigation. The W-band frequencies (84 - 94 GHz) provide sharper resolution than the 35 GHz. This resolution could enhance airfield and runway identification, obstacle detection, and runway incursions while executing the final approach. Since IR has the best resolution and night vision capabilities, this imagery is best used for taxi and departure procedures and final approach at night. This image fusion/EVS system will combine the best features of these sensors to improve pilot performance while flying at night or in Instrument Metrological Conditions (IMC).

PHASE I: Develop and evaluate one or more designs to process and fuse the images provided by two or more of the following sensors: 35 GHz radar, 84 - 94 GHz millimeter wave (radar or passive system); and IR. Contrast the feasibility and accuracy of two or more approaches, and provide a preliminary design for correlating the fused image with terrain and vertical obstruction databases. Provide a preliminary approach to certification of the image fusion for flight safety system and hazardous misleading information mitigation.

PHASE II: Perform preliminary demonstrations of initial image fusion applications using realistic sensor data. Determine what levels of performance are required for the image fusion/EVS system to be used during instrument approach/departure procedures. Develop the capability to correlate the fused sensor images with terrain and vertical obstruction databases. Select the best approach to demonstrate a prototype image fusion system, including preliminary tests at night, in reduced visibility and in IMC. Develop a initial design for implementing the EVS with a HUD in the cockpit. Initiate an approach to image fusion certification or authorization for use.

PHASE III DUAL USE APPLICATIONS: This image fusion system could be used in a variety of military and commercial applications requiring improved vision for navigation, surviellance, threat warning and ATR in adverse weather and night vision conditions. This information can be presented through projection displays, HUD and Heads Down Displays, and can also act as an integrity monitor for the primary navigation and landing system. More conventional EVS engineering developments based on single sensors are being independently pursued by commercial airlines and airfreight carriers. The US Air Force, HQ AMC, and HQ AFSOC are exploring the potential application of this technology under the JPALS Program. NASA Langley Research Center is also pursuing a Synthetic Vision Systems (SVS) program for use in the high-speed civil transport aircraft and in general aviation safety.

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KEYWORDS: Image fusion, sensors, surveillance, threat warning, vision systems, Enhanced Vision System, instrument approach and departure procedures, EVS, HUD.

AF02-218 TITLE: Network Multiple frame Data Association

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop and evaluate multi-hypothesis multi-frame tracking techniques for decentralized applications where multiple linked platforms exchange sensor-derived information to produce an improved operational picture.Warfighter impact: This effort will contribute to the development of a fusion algorithm that will help AWACS meet its key performance parameter of multi-source integration (MSI).

DESCRIPTION: Multiple platform tracking, herein called network-centric tracking, can significantly improve tracking performance over single platform tracking due to geometric diversity and sensor variety. In addition, the fusion of information from multiple platforms yields a more global surveillance picture for battlefield management. For example, OSD's Multi-Platform Tracking Exploitation (MPTE) demonstrated enhanced continuity of track using operational platforms connected with operational networks. In the network-centric tracking environment, the inter-platform issues of decentralized data association (sometimes called correlation) and estimation are central and inseparable parts of the same problem. While decentralized tracking has focused on decentralized fusion and estimation, the central problem of decentralized data association using multiple frame processing has received little attention. For platform-centric tracking (i.e., single platform with single or multiple sensors) or centralized tracking in which all measurements are sent to a central processing location with tracks being transmitted back to the different platforms, multiple frame data association methods such as multiple hypothesis tracking (MHT) or multiple frame assignments (MFA) offer the ability to handle difficult tracking issues such as closely spaced objects, false signals and clutter, radar multi-path, residual sensor registration biases, and counter-measures. Multiple frame data association methods also offer improved performance in accuracy of the target tracks, discriminants, and covariance consistency, which in turn reduces track switches, track breaks, and missed targets. For network-centric tracking, one architecture that achieves outstanding tracking accuracy is the aforementioned centralized architecture; however, this architecture is generally unacceptable for multiple platform tracking due to communication loading and the single-point failure problem. Thus, the primary objective of the program is to develop and demonstrate a decentralized, network-centric, multiple-frame association algorithm that approaches the performance of a near-optimal centralized architecture across a network of platforms while managing communication loading and achieving a consistent air picture. In addition to these objectives, one must also deal with a number of problems such as (1) the types of information (e.g., measurements, tracks, tracklets) sent across the network; (2) sensor location and registration errors (sometimes called gridlock); (3) design for the use of information pedigree; (4) out-of-order, latent, and missing data due to both sensor and communication problems; (5) network topology; and, (6) use of attribute data. This effort differs greatly from the majority of work sponsored previously in that it seeks to integrate concepts from a number of approaches into an overarching system. The question of centralized versus decentralized tracking is an ongoing debate. While we know that the right answer is to use centralized tracking, the reality is that not all communication link bandwidths support this and for significant platforms the bandwidth will likely never exist. To leverage the benefits of multiple-platform tracking we are seeing in large surveillance platforms into and with smaller platforms we need multi-frame trackers that can process both reports and tracklets.

PHASE I: Investigate, develop, and establish the feasibility of innovative algorithms that perform network-centric multiple frame data association. Identify issues related to network-centric multiple frame data association methods. Investigate the effects of the issues identified relative to tracking performance and propose solutions to the network-centric multiple frame data association problem that mitigates these effects.

PHASE II: Develop a prototype distributed architecture, algorithms, and software for robust network-centric multiple frame data association and demonstrate its effectiveness in achieving superior tracking performance while managing communication loading and achieving a consistent or single integrated air picture. Other activities may include testing and evaluating the effectiveness of such architecture.

PHASE III DUAL USE APPLICATIONS: Network-centric multiple frame data association that achieves a consistent air picture while managing communication loading can yield significant tracking performance and information fusion enhancements for multiple surveillance platforms operating in a dynamic, uncertain, and adversarial environment. In the commercial market, the development of real-time adaptive team decision making, distributed control architectures, and sensory processing are equally applicable to the field of robotics [7] as well as to both economic and corporate modeling [6] where one allocates assets to optimize some global objective over both global and decentralized (local) constraints. Law enforcement applications exist which are very similar to military applications. For example, border surveillance by the Drug Enforcement Agency and the Immigration and Naturalization Service.

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KEYWORDS: multiple hypothesis tracking, network-centric tracking, distributed data association, consistent single integrated air picture

AF02-219 TITLE: Environmentally Driven Signal Processing Technology for Overland Height Finding

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop innovative algorithms and processing schemes to provide critical overland, low target height-finding capability to airborne surveillance sensors.WARFIGHTER IMPACT: Accurately detecting, tracking and prosecuting low, slow flying airborne vehicles is a key operational requirement that must be, but currently is not, met by conventional ISR sensors due in part to conventional processing methods. Future ISR sensor systems will likely be implemented on unconventional air vehicle designs utilizing conformal apertures and distributed sparse arrays. Such implementations offer many advantages but may also negatively impact tracking accuracy, particularly the ability to accurately locate and track the elevation component of a targets motion. This underscores the requirement for innovative methods of obtaining accurate positional estimates of difficult targets. This SBIR topic will provide technology to aid the warfighter in precisely determining the altitude of low, slow flying objects with much greater accuracy using advanced signal processing technology for improved kill chain effectiveness and target prosecution.

DESCRIPTION: Significant progress has been made in demonstrating the potential benefits of knowledge-aided (KA) signal and data processing. The incorporation of auxiliary sources of knowledge such as DTED, DFAD, LULC and other sensor information to (1) adaptively adjust the processing algorithms and their parameters to more closely match the environment, (2) adaptively and dynamically manage the sensor-level resources to change modes, waveforms, dwell time, and illumination schedules to enhance difficult target detection in severe interference environments and non-ideal geometries where grazing angles, ranges, platform altitudes and terrain cover/topology combine to degrade detection performance and tracking (to include height-finding) and (3) management of the ISR constellation (whether it be spaceborne, airborne or a hybrid) to address flight/orbit management, constellation and platform tasking, and inter-platform synchronization to improve detection and tracking, including height estimation. Additionally, high fidelity modeling has progressed to the point where predictive knowledge of the environment can be used to substantially improve the performance of electromagnetic sensors, and further extract critical position data, which ordinarily would not be available using conventional processing methods. This topic focuses on the application of advanced KA signal processing techniques to enhance detectability of slow, low flying targets and provide precise estimates of target altitude by virtue of the external interactions of the target with the electromagnetic environment.

PHASE I: Investigate advanced KA signal processing algorithms for altitude estimation of low flying targets overland based upon predictive knowledge of the environment.

PHASE II: Develop algorithms and perform sensitivity analysis quantifying dependence of errors on the accuracy of environmental knowledge for a significant number of geo-specific environments. Provide hardware and software specification to implement a real-time system.

PHASE III DUAL USE APPLICATIONS: The innovative technology developed will have a direct benefit to significant sensor problem areas, including height finding, electronic support measures (ESM) tracking, sensor evaluation, hot clutter mitigation and automatic target recognition (ATR)/Foliage Penetration systems. This will enable future tactical implementations involving precision handover from surveillance systems to fire control assets such as forward pass, over the horizon (OTH) targeting and defensive ESM.It is anticipated that cartographic data derived directly from geo-specific remotely sensed imagery would be used to drive the advanced signal processing algorithms. With continued advances in computing hardware and software, remote sensing and its kindred information technologies, such as Geographic Information Systems (GIS), could be directly inserted into tactical systems as a result of this applied research.

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KEYWORDS: Height Finding, Altitude Estimation, 3D, Precision Location Estimation, Knowledge-Assisted Processing,Knowledge Base Processing, Artificial Intelligence, Expert Systems, Signal Processing, Algorithms.

AF02-221 TITLE: Improved Pose Estimation for Tracking and Identification Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: The objective of this effort is to develop an improved tracking and identification system by using a very accurate pose (the orientation of the target relative to the tracking platform) estimates to reduce the “search space” of the identification algorithm. Here the search space is defined to be the set of “training” signals (e.g. from a high range resolution radar) that the algorithm has to compare the observed radar signals to determine the target type.

DESCRIPTION: Ground moving target indicator (GMTI) radar is known to track position and velocity of ground moving targets. Pose can be derived from these kinematics estimates of position and velocity (e.g., pose equals the angle between position and velocity). This pose estimate is sometimes used to reduce the search space of an identification algorithm. Due to the resolution of some radar systems, the GMTI tracker estimated pose sometimes exhibits very large errors causing large search algorithms and sometimes-faulty identification of potential targets. This SBIR will contribute to the development of improved tracker pose estimates for better tracking and identification of targets. The goal of this SBIR task is to investigate ways to improve coupled tracker and identification systems. Some possibilities might include using road and terrain data or somehow tracking micro-motions (i.e., tracking roll, pitch, and yaw) of the target.

PHASE I: The first task that the offeror will perform is to determine and predict the performance (degradation or nondegradation) of both the tracker and the identification systems due to poor knowledge of pose. Since JSTARS is one major platform where coupled tracking and identification is being considered, analysis will focus on such systems. If there exist problems, the offeror will suggest new/novel techniques and investigate them until good performance is obtained. Further, the offeror will calculate the sensitivity of changes in various parameters to probability of miss-association

PHASE II: The major goal of Phase II is the demonstration of the method on Air Force GMTI simulations and/or on real data from GMTI collections. Efforts likely include further developments to meet operational requirements

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, and transportation systems. Military applications include surveillance of the battle space with an improved and integrated picture of the battlespace among platforms.

REFERENCES:
J. Layne and D. Simon, " A Multiple Model Estimator for a Tightly Coupled HRR Automatic Target Recognition and MTI Tracking System," SPIE Conference on Algorithms for Synthetic Aperture Radar Imagery VI, Orlando, Florida, April 1999.

KEYWORDS: Tracking, Target, Identification, Pose, JSTARS, and Feature Aided Tracking (FAT)

AF02-222 TITLE: Fusion-Aided Continuous ID for Targeting (FACIT)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Only a limited amount of target classification has been done using the feature-level fusion of advanced radar modes. This Fusion-Aided Continuous ID for Targeting (FACIT) topic will be used to develop algorithms for the identification and targeting of time-critical targets through all stages of the move-stop-move cycle.

DESCRIPTION: The DARPA Moving Target Exploitation (MTE) program developed advanced tracking technologies while demonstrating proof-of-concept for limited target classification using advanced radar modes. The objective of FACIT is to extend the baseline MTE target classification technologies by developing and demonstrating advanced MTE target classification capabilities. This includes innovative feature-level fusion of advanced sensor modes and their algorithms for the ID of ground moving targets at extended standoff ranges in all-weather and all day, whether moving or stationary. This capability will support the reconnaissance, surveillance, and strike-support missions of air and space-based platforms; specifically, ground order of battle (GOB) reconnaissance and surveillance of ground moving targets, and the targeting of time-critical targets (TCT) through all phases of a move-stop-move cycle.

PHASE I: To achieve this advanced MTE capability, comprehensive target detection, cueing, and identification algorithms need to be developed for continuously identifying stationary and moving targets by exploiting complementary components of ground moving target indication (GMTI), high range resolution (HRR), synthetic aperture radar (SAR), and Moving Target Imaging (MTIm) radar modes, sensor-level data mining, and algorithms. This fusion of modes, data and algorithms will be needed to rapidly align, correlate and fuse sensor multimode data into an integrated tracking and automatic target recognition (ATR) capability in order to continuously prosecute a ground target whether stopped or moving. Major advancements will come from work developing advanced object-level sensor exploitation as well as tracker-assisted classification technologies to include but not necessarily restricted to, feature-aided tracking and range-doppler ATR. Multiplatform GMTI continuous ID will be demonstrated using appropriate object-level resource management and target information accural.

PHASE II: Further refine the continuous target ID architecture and software algorithms to implement the approach developed in Phase I. The Phase II effort will implement and demonstrate the fusion aided continuous ID/targeting capability defined in Phase I. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: This technology could be used in a broad range of military and civilian applications where continuous tracking and identification of objects in motion is needed. Known civilian application areas include commercial aviation, drug enforcement, mass transportation system, industrial security, and Intelligent Vehicle Highway Systems (IVHS).FACIT technology is particularly suited to long range all weather surveillance applications. In the drug war, there is a need to monitor US coastal waters for suspicious water traffic possibly indicative of incoming shipments of illegal drugs by fast speed boats. Current practice is to then vector airborne surveillance followed by the interdiction by boat. Given the need for wide area surveillance and accurate tagging of complex surface moving traffic patterns for cost effective and efficient vectoring of drug enforcement personnel, the FACIT technology could be tested by installing a wideband XBAND radar on GulfStream jet and then install and adapt the FACIT software in an onboard computer to cue and differentiate drug carrying speedboats by their unique doppler behavior and radar hull signature.

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1. Edward Waltz, James Llinas, "Multisensor Data Fusion," Artech House, 1990;

2. Yaakov Bar-Shalom, "Mutlitarget-Multisensor Tracking: Applications and Advances," Artech House, 1992.

KEYWORDS: Target Identification, Targeting, Feature-level Fusion, MTE, Sensor Exploitation

AF02-223 TITLE: Coupled Tracker and Identification Algorithms

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an advanced avionics system, which can perform joint target tracking and target identification. Target tracking and target identification (ID) are typically treated as independent systems. This SBIR will investigate ways to exploit couplings in these systems to improve performance.

DESCRIPTION: In recent years researchers have attempted to couple tracking and ID systems by investigating methods of using radar signal features to aid the tracker association problem. Such approaches are often referred to as feature-aided tracking (FAT). However, little attention has been given to the problem of combining information at the tracker kinematics estimation level to improve the tracker estimates. Other researchers [1-3] have shown that there exists a coupling (namely, the pose angles) between these systems. Other couplings might exist. By tightly integrating these systems, significant improvement in the overall performance might be obtained.

PHASE I: The first task that the offeror will perform is to determine all possible couplings between track and identification systems. The second step is to find ways to exploit these coupling in joint tracking and ID systems. Since JSTARS is one major platform where coupled tracking and identification is being considered analysis will focus on such systems. The offeror will suggest new/novel techniques and investigate them until good performance is obtained.

PHASE II: The major goal of Phase II is a demonstration of the methods on Air Force ground moving target indication (GMTI) and high range resolution radar (HRR) simulations and/or on real data from GMTI and HRR collections. Efforts likely include further developments to meet operational requirements

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS) drug enforcement, and transportation systems. Military applications include surveillance of the battle space with an improved and integrated picture of the battle space among platforms.

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KEYWORDS: Tracker, Identification, Joint Systems, Pose

AF02-224   TITLE: Multiple Database Evidence Accrual Techniques

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop concepts and techniques for accruing evidence to associate detections, track fragments, and reports resident in multiple databases.

DESCRIPTION: Situations occur in Intelligence, Surveillance and Reconnaissance (ISR) where large data gaps may exist between reports from individual assets. These assets have different sensing capabilities and the information is reported to various databases. Delays in information handling and processing may cause older data from various assets to lag availability of newer data in the databases.   For example, identification may not become available until a target has left its' original location and been tracked by other assets. Because of data gaps and data latencies, traditional techniques for real time data fusion and tracking may be inadequate. The objective of this effort is to develop novel concepts and techniques for accruing evidence to associate detection, track and identification information on targets originating from different assets in ISR databases in order to form a common tactical picture. Part of this effort will include identification of limiting parameters for these techniques. Parameters of interest may include, but are not limited to target densities, length of data gaps, data latencies, location errors, and type of data. This effort will include development a model for the above evidence accrual problem and determination of the sensitivity of correct associations to these parameters. Specific sensors of interest onboard these assets could include; foliage-penetrating (FOPEN) radars, Ground Moving Target Indicator (GMTI) radar, Synthetic Aperture Radar (SAR), high-range resolution (HRR) radar, electro-optic/infrared (EO/IR) sensors, communication intelligence (COMINT), and signal intelligence (SIGINT). Each of these sensors provides different information. FOPEN can provide detection of fixed concealed targets, but not direct identification. GMTI can provide track histories on moving targets, but track fragmentations are likely to occur due to obscurations or the target stopping. If the target is in the open, identification and location data can be obtained from other assets, such as SAR, HRR radars and EO/IR sensors. COMINT, and SIGINT can provide good identification information, but poor location data. A subset of these types of sensor reports should be considered for Phase I demonstration purposes.

PHASE I: Develop concepts and techniques for associating detections, track fragments, and identification information originating from various ISR assets resident in multiple databases. Model and demonstrate these concepts and techniques via engineering analysis and simulation. Identify limitations and sensitivity of these techniques. The Government will help to identify and provide scenarios, descriptions, analytical models, and software tools that can be used to conduct the research.

PHASE II: The major goal of Phase II is prototype development and demonstration of the concepts developed in Phase I through more realistic simulations. This phase of the effort is likely to include further refinement of the algorithms and techniques to better address issues identified in Phase I and further developments to meet operational requirements such as scenario enrichment. Maturity assessment will be performed to identify additional work required for transition.

PHASE III DUAL USE APPLICATIONS: Commercial applications could include Air traffic Control and collision avoidance. Medical applications could use patient histories to detect precursor conditions and reduce diagnosis costs. Another commercial application could be intelligent associative search engines. Military applications would include ISR and targeting applications.

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KEYWORDS: Cognitive reasoning, Data association (spatial and temporal) algorithms, Data fusion, Tracking and Identification

AF02-227 TITLE: Ultra-Wide Band Perimeter Surveillance Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an automated and unmanned Ultra-Wide Band (UWB) Perimeter Surveillance Sensor, designed to operate alone or in concert with other sensors.

DESCRIPTION: With decreasing manpower resources available to the U.S. military, the need to exploit advances in technology for the protection of military bases, critical assets, and other facilities is essential. It is anticipated that a UWB Perimeter Detection Sensor, with detection ranges of up to 5 kilometers for individuals and 10 kilometers for vehicles from a central location, may be cost-effectively achieved. The number of sensors to be deployed is site specific and not identified here. A minimum number of sensors are desirable for a reduced infrastructure and maintenance footprint.A single UWB sensor should provide all weather, all terrain, wide area (360 degrees) capability to detect and track intrusions in open areas. It should detect during both day and night in atmospheres containing rain, fog, smoke, haze, dust, and clear air. Detection ranges for this sensor should be: (a) Walking/Running, 500 meters required, 5000 meters desired; (b) Crawling, 250 meters required, 750 meters desired; and (c) Vehicles, 1000 meters required, 10,000 meters desired. The UWB sensor should localize target range within 10 meters and target azimuth within 10 degrees. It should provide the capability for area mapping. False alarm rates should be less than three per 24 hours and less than two nuisance alarms per hour. The UWB sensor can be commercial or battery powered with an objective of charging the battery via solar power. Production unit costs should not exceed $50,000 per copy.A compact and lightweight sensor is requested. As such, COTS technology, no matter how desirable, may not be appropriate for this UWB perimeter surveillance sensor. Some designs may incorporate UWB radio frequency (RF) sensors operating (radiating) simultaneously throughout an area. As such, self-jamming must be mitigated via signal processing for ease of deployment. Primary reporting should be made to a central security location. As an additional objective, it would be desirable to report detection and tracks to responding forces equipped with hand-held viewing devices much like commercially available Palm Pilots. Communications from the UWB perimeter surveillance sensor over ranges of 3 to 10 km is envisioned. As a baseline, a short-pulse, active UWB radar operating in the VHF/UHF frequency bands should be considered for foliage penetration. Fopen is essential to the success of this effort. This allows for minimal propagation attenuation, while high range resolution permits coherent scene change detection optimized for moving troop/vehicle detection. The R&D technical risks associated with this topic arises out of concern over the selection of suitable technologies for waveform generation, timing and control. Here the tradeoff is between short pulse and spread spectrum waveforms. Compatibility with antenna and receiver technology is of lower risk. Suitable signal and data processing technology for detection, track and reporting exist in the open literature. A wide range of UWB radar technologies, systems and conops will be considered under this effort, and are not limited to the illustrative examples and discussion provided herein, so long as detection ranges in foliage or in open areas are met.

PHASE I: Develop a baseline design and an integrated approach to a UWB Perimeter Surveillance Sensor that will accomplish the tasks discussed above. Identify high-risk technology and long lead time components. Perform preliminary simulations that indicate how well the proposed concept addresses the stated tasks. Demonstrate adaptive algorithms to be used in the UWB Perimeter Surveillance Sensor on the simulation data generated as a part of this Phase I task. Design an experiment for demonstration of the proposed sensor at the Griffiss Business and Technology Park, NY, or a suitable alternative.

PHASE II: Breadboard prototype and demonstrate the UWB Perimeter Surveillance Sensor designed under Phase I at the Griffiss Business and Technology Park.

PHASE III DUAL USE APPLICATIONS: Dual use applications in the commercial arena include UWB Perimeter Surveillance of construction sites, storage sites, and mining operations. Additionally, the need to protect intruders from harm at hazardous sites is also of high interest in industry today. Civilian applications include UWB Perimeter Surveillance of airports, borders, international shipping ports, truck depots, and prisons.

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KEYWORDS: Ultra-Wide Band, Radar, Monostatic, Multistatic, Adaptive

AF02-228 TITLE: Move-Stop-Move Signature-Aided Tracking

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Associate reports from multiple Radar sensor modes to improve tracking of ground targets that transition between moves and stops.Warfighter Impact: By improving continuity of track, this effort will improve target prosecution performance by weapon delivery platforms such as Joint Strike Fighter as well as battlefield awareness by surveillance systems such as JSTARS and Global Hawk.

DESCRIPTION: This topic considers the registration of reports from dissimilar sensor modes to maintain continuous track of objects. In many data fusion systems, continuity of track is required so that information can be accrued about each object. Accrual of information allows decisions about what each object is and what is it doing. Having the ability to continuously track an object that repeatedly moves and stops will improve Air Force capabilities in critical areas such as maintenance of battlefield awareness and tracking of time-critical targets. Revolutionary approaches will be developed to improve tracking performance in move-stop-move scenarios by allowing association of moving target radar signatures with stopped target radar signatures. Association of moving target signatures to stationary target signatures is not well understood so any research accomplished can provide cutting edge developments. As used here, radar signatures can range from specific features extracted from the radar return to results of advanced radar modes such as synthetic aperture radar (SAR) imagery, high-range resolution (HRR) 1-D profiles, and moving target imagery (MTIm). On-the-fly signatures will be developed that essentially fingerprint the target and allow tracking the target through move-stop-move transitions. For example, a Ground Moving Target Indicator (GMTI) radar mode can track a moving target, but loses detections when the target drops below its minimum detectable velocity and stops. At this point, the radar can use its SAR mode to determine the signature and location of the motionless target. Similarly, advanced GMTI radar modes such as HRR and MTIm also produce moving target signature information. The concept developed here is that stopped target signatures can be compared to moving target signatures to determine which moving targets actually stopped and where. When the target begins to move again, the new moving target signatures can be compared to both stopped target signatures and previously-collected moving signatures. Thus, continuous track of the target through the full move-stop-move sequence is obtained. This likely requires extracting signatures in new ways from the video phase history (VPH) received from the stopped and moving targets. The robustness of the overall association process with respect to signature variations due to pose, depression, and squint angle along with moving target signature effects will likely be an issue. The DARPA's Moving Target Feature Phenomenology for Track Maintenance (MTFP) program will provide an excellent basis for the effort. The MTFP will provide motion compensated VPH of a number of targets while they are both moving and stopped. The MTFP program will also provide studies of moving target features and methods for extracting them but does not consider stationary target features. DARPA's Moving and Stationary Target Acquisition and Recognition program may provide insight into suitable features. New algorithms for performing association within the multi-target tracker will be proposed and studied. The algorithms should allow the tracker to associate sensor reports from dissimilar sensor modes.

PHASE I: The feasibility of associating stopped target radar signatures with moving target radar signatures shall be studied. Radar signature processing methods for both moving and stopped targets shall be defined and implemented as necessary to support the study. Tradeoff studies and analyses will be used to identify and understand significant issues. For example, robustness with respect to target pose and radar squint angle is expected to be issues. The study should indicate how well the association process should work. Multiple-target tracking algorithms that allow continuous tracking of the target shall be identified. This includes developing new concepts for how to modify the trackers report association process.

PHASE II: Develop a prototype system that demonstrates improved tracking of targets that repeated move and stop. This includes developing a signature-aided, move-stop-move, dwell-based tracker and establishing the technologies impact. The offeror may incorporate their algorithms into Air Force simulators resident at AFRL/SNA that can incorporate real data from radar collections. Other tasks could include maturity assessment and risk reduction as time permits. Other potential issues that could be investigated include the benefit of adaptive waveform design, and effective methods for mutual scheduling of radar identification modes from multiple platforms. Efforts should help determine tasks for a potential Phase III effort.

PHASE III DUAL USE APPLICATIONS: Many applications require the ability to track objects through move-stop-move transitions that could benefit with the decision logic and concepts developed. The research is directly applicable to border surveillance for the Drug Enforcement Agency and the Immigration and Naturalization Service. Decision algorithms developed are applicable to intelligent vehicle highway systems (IVHS) and law enforcement applications that use GMTI along with EO/IR sensors. Robot applications exist which require tracking objects through move-stop-move transitions using sensors that have modes similar to radars. Military applications include battlefield surveillance and sensor-to-shooter.

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KEYWORDS: Multiple Target Tracking, High-Resolution Radar, GMTI Radar, Report Association, SAR

AF02-229 TITLE: Analog to Digital Coverters

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a low power, high-resolution analog to digital converter on an ASIC chip.

DESCRIPTION: As signals and interference powers increase, navigation, communications, radar and computer systems must be able to operate effectively with higher resolution analog to digital converters and their corresponding increases in dynamic range. A need exists for the development and demonstration of a low power, low cost and small size Analog to Digital Converter (ADC) prototype chip which can be integrated in a handheld receiver with the following specifications:- 16-bit resolution- 50 MHz bandwidth (min)- 100 MSPS- 100 mw - Signal to Noise Ratio: 90 dB (min)- Spurious Free Dynamic Range: 100 dB - Two's complement output format - CMOS digital output levels

PHASE I: 1) Investigate technologies applicable to the design of a low power, low cost, small size ADC meeting the requirements above. 2) Develop detailed models of candidate ADC designs. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of- concept demonstration to mutually (Air Force/contractor agreed specifications. The basic focus would be the integration by simulation with a Global Positioning System (GPS) receiver in the loop.

PHASE II: 1) Produce final detailed design of the ADC. 2) Produce a proof of concept prototype ADC capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify the ADC performance. 4) Provide final ADC cost/power analysis.

PHASE III DUAL USE APPLICATIONS: Development of the ADC has both DOD and Commercial applications in the future for navigation, communications, radar and computers.

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KEYWORDS:

AF02-232 TITLE: Accurate Computational Electromagnetics (CEM) Techniques for High Frequency Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop Accurate and Efficient Computational Electromagnetics (CEM) Techniques for Radar Signature Prediction of Airborne Targets at Frequencies up to X-band.

DESCRIPTION: The Air Force increasingly relies on the advanced computational electromagnetics (CEM) tools for its low-observable weapon systems design and synthesis data generation for automatic target recognition, as budgets cannot support extensive design testing and flight data collection. While CEM tools have matured tremendously in the last decade, accurate radar cross section (RCS) prediction of a real airborne target at X-band, such as a fighter aircraft, remains a technical challenge. The challenge arises from the fact that, at X-band, target physical dimensions (60 ft length and 40ft. wingspan are typical) and surface area are very large compared to the wavelength (1.18” at 10 GHz.). Properly resolving the wave physics at X-band for such targets leads to prohibitively large computer memory and run time requirements for first principles CEM prediction methods. While the advent of high performance computing (HPC) and fast matrix solver technology in the 1990s has increased the problem size one can solve using first principles CEM techniques, such as the method of moments (MoM), it still has not overcome the order of magnitude increase in computational resources required for accurate X-band prediction. Thus, the less-accurate CEM techniques based on the asymptotic methods, such as the physical theory of diffraction (PTD) and the Uniform Theory of Diffraction (UTD), are still methods of choice for X-band predictions. Attempts have been made to increase the accuracy of the asymptotic techniques by adding higher-order scattering effects, such as traveling waves and tip diffractions. But even for some simple classes of targets the accuracy of such attempts can fall far short of first principle computations. In this effort, the Air Force is seeking innovative CEM techniques that further increase the problem size one can solve with controllable accuracy and increased efficiency. Potential approaches could be, but are not limited to, hybridizing the asymptotic methods with the first principle methods and/or further exploring fast matrix techniques and algorithms that exploit HPC architectures.

PHASE I: Develop the framework for the innovative CEM technique and demonstrate its potential for accurate RCS prediction of an airborne target.

PHASE II: Develop a CEM code coupled with HPC technology to demonstrate the feasibility of the innovative technique. Validate the code using existing RCS benchmark data.

PHASE III DUAL USE APPLICATIONS: The resulting CEM code could be further developed or integrated into existing CEM codes (military or commercial) and used to more accurately predict: 1) terrain and urban center wave propagation and multi-path effects on wireless communication systems, 2) antenna-to-antenna coupling or isolation in ground, airborne and space-based communication systems, 3) antenna/platform integration effects on antenna performance for commercial aircraft, 4) the location and detection of buried objects and 5) biomedical diagnostic imaging.

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KEYWORDS: Computational Electromagnetics (CEM), Radar Cross Section (RCS), First Principle Technique, Asymptotic Technique, High Performance Computing, Fast Matrix Solver

AF02-233 TITLE: Integrated Electro-Optical and Radio-Frequency Aperture

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop architecture, components, and integration technologies to enable common apertures from radio to optical frequencies.

DESCRIPTION: Almost all Air Force missions require some form of sensing. The predominant methods of sensing employ transmission and reception of radio frequency (RF) or electro-optical (EO) wavelengths. Historically, these two sensing modalities have not been considered in common because of the 4 to 5 orders of magnitude difference in wavelengths. The RF systems have long made use of phased arrays of emitters and receivers as a means of implementation. Recent advances in EO technology have produced corresponding phased array concepts in the EO domain. These advances now make it possible to consider the integration of the RF and EO aperture into a common component. Such a common aperture will reduce space requirements on platforms that are already crowded, and will enable the use of the best sensing modality for the specific conditions and mission. This topic seeks to define the basic architecture of a common RF and EO aperture for both transmission and reception of electromagnetic energy. It will define the component technologies needed to implement the integrated aperture. Necessary components will be fabricated and tested, and a proof-of-concept aperture will be built and demonstrated.

PHASE I: The basic architecture for an integrated RF/EO aperture will be defined. Component technology requirements will be generated and simple feasibility experiments on the component level will be accomplished as appropriate. Modularity of the components will be stressed.

PHASE II: Design of the integrated aperture will be accomplished, components will be fabricated, tested, and integrated. A proof-of-concept RF/EO aperture will be demonstrated and its applicability to military missions will be defined.

PHASE III DUAL USE APPLICATIONS: A particular application will be identified that employs both RF and EO energies. An integrated aperture for this application will be designed, fabricated, and demonstrated. Any platform in which both RF and EO sensors are employed can benefit from this effort. Commercial aircraft and possibly automobiles of the future can employ modules developed under this topic.

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KEYWORDS: Electromagneic and Optical Apertures, Optical Phased Arrays, Multifunction Apertures.

AF02-234 TITLE: Truth Quest: Enabling Operational/Exercise Data

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To investigate innovative processes for collecting and truthing realistic sensor data for automatic target recognition (ATR) development and test.

DESCRIPTION: A new system or toolset must be developed to process operational and exercise data for use in ATR development and testing. Although the requirement for ATR systems is driven by the growing volume and complexity of operational sensor data, ATR research and development is limited by a lack of realistic training and test data. This apparent contradiction results from a lack of truth for the realistic operational data. Truth, as defined by the ATR community, is the knowledge of where targets are in the collected imagery. Truth information is essential for determining ATR performance. Current methods of image truth rely on controlled collections, manual operation, and are time intensive. Controlled collections are typically performed to enable truthing, but they necessarily compromise realism. New technologies must be developed to define truth conditions for realistic data collected operationally or at training exercises. Research may fall into one of three categories: postcollection image-based truthing, precollection instrumentation, or assessment methods when the truth is uncertain or otherwise degraded. Example approaches are provided to help define the research problem; they are not necessarily recommended.Postcollection technologies may leverage the fact that human analysts routinely exploit the data. Tools and procedures are needed that capture exploitation results, refine and augment those results, and create truth in the form used in ATR research. An example refinement method would be to fuse exploitation results across time or sensor modality to improve truth estimates for a particular image.Precollection instrumentation used at exercises could also be improved. As an example, equipment may be added to targets to record, time stamp, and direction-find sensor illumination. A system might then take sensor data and target illumination data to compute elements of image truth. An unmanned aerial vehicle (UAV) might repeatedly visit and image beacon equipped vehicles to provide articulation, configuration, background, and obscuration truth. An emitter might be placed on a target to mark itself in sensor data. One challenge is that the emitter must not overly corrupt the signature of interest.Finally, new technologies are needed for scoring procedures and metric uncertainty characterizations when the truth associated with this realistic data may not match the quality of conventional collections. An example scoring tool extension would be one that made detection-truth associations dependent on the truth location uncertainty.Truthing systems would ideally be fully automated and result in a data product with truth and characterized uncertainty, be low cost, be applicable to stationary and moving targets, and be unobtrusive to the exercise or operational collection. Sensed data products of interest include SAR (high and low frequencies), high range resolution (HRR) radar, spectral imagery, and ladar. Targets of interest include ground vehicles and natural and manmade confusers (buildings, roads, trees, etc.). Target states of interest as truth include position, velocity, pose, type, version, configuration, background, and environment. These lists are not exclusive.

PHASE I: Phase I would develop a system concept for post collection truthing,precollection instrumention or algorithm assessment and prove technical feasibility.

PHASE II: Phase II would build and demonstrate the truthing and/or scoring system.

PHASE III DUAL USE APPLICATIONS: Phase III would develop and apply a product or service based on the truthing system.

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KEYWORDS: Truth Data, Truthing, Image Truth, Ground Truth, Sensor Data, Sensor Data Exploitation, Automatic Target Recognition (ATR), Target Position, ATR Evaluation

AF02-235 TITLE: Opportunistic Sensor Resource Management for Extended Operating Conditions

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate algorithmic methods providing the capability to control distributed sensor networks in extended operating conditions.

DESCRIPTION: In general, distributed sensing systems today place unprecedented demands upon the software that controls them. Over the last two decades, diverse sensing applications such as video surveillance, automated manufacturing, intelligent traffic control, and military surveillance, have experienced similar growth and challenges. Advances in electronics, communication, and networking technologies have enabled larger arrays containing more sophisticated, durable, and programmable sensors. This has provided increased coverage and flexibility for sensor arrays, making it possible to deploy them in more complex environments. Sensor systems are increasingly required to face extended operating conditions in which objects may be obscured or hidden, sensor performance may be degraded due to environmental conditions, and there may be a large number of tasks compared to available resources. Further, in more stressful applications both the sensor and the objects of interest may be in motion. Under such conditions the control of distributed sensing systems becomes an extremely difficult combinatorial optimization problem. A large number of sensors must be assigned to specific sensing tasks, and subsequently moded, and pointed to provide maximum effectiveness in a given amount of time. This effort shall seek to advance the state-of-the-art in distributed sensing applications through the development and demonstration of foundational algorithmic methodologies for the control of sensor arrays operating under extended operating conditions. The methods developed should balance sensor usage to supply adequate spatial coverage while focusing in to discriminate necessary information, and be opportunistic in that they hedge against future extended operating conditions by collecting data at favorable times (e.g., when objects are not hidden, when sensing is available, etc.) and using that data for inference when extended operating conditions are encountered. As this effort is concerned with the development of an extendable algorithmic methodology, proposers need not be experts in sensor or environmental modeling for any particular application -- course statistical models are favored. For example, a sensor's classification capability may be modeled by a confusion matrix relating discrimination capability against a few object classes, and subject to a few pertinent situational parameters (sensing geometry, environmental conditions, etc.).

PHASE I: Identify a focus problem generally representative of a military surveillance mission and define extended operating conditions. Develop algorithmic methods to solve the focus problem. Demonstrate the methods developed using a simulation and test. Analyze test results and determine technical feasibility of approach for more realistic military surveillance missions.

PHASE II: Improve focus problem (and simulation) developed in Phase I by incorporating more realistic sensor and environmental models. Develop, and demonstrate algorithmic methods developed under Phase I.

PHASE III DUAL USE APPLICATIONS: The development of robust distributed sensor control methods for extended operating conditions has applicability to video surveillance, intelligent traffic control, automated manufacturing, and a large variety of remote sensing applications including military intelligence, surveillance, reconnaissance, and strike missions. Algorithms devised may also have applicability for distributed control of complex switches in communications and power networks.

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KEYWORDS: Multi-sensor Resource Management, Sensor Management, Distributed Control, Distributed Sensing, Intelligence, Surveillance, and Reconnaissance (ISR) Missions

AF02-236 TITLE: Novel Concepts for Multi-Mission Radar

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: This effort addresses techniques for the simultaneous detection, track and geo-location of air and ground targets.

DESCRIPTION: The requirement for multidimensional situation awareness is increasing for both military and commercial sensors. Dominance in the military theater demands systems that can perform multiple functions such as airborne moving target indication (AMTI), ground moving target indication (GMTI), synthetic aperture radar (SAR), and ELINT, as well as have the capability to defeat CCD (using FOPEN, Ground Penetrating Radar, Special

Observable Exploitation, etc.). Current solutions to solve this problem revolve around the incorporation of shared aperture techniques. Limitations in physical implementation of the shared apertures, prime power availability, and basic phenomenology associated with the multiple functions must be balanced against command situational awareness constraints. In developing this functionality, time, frequency, polarization, and mission priority conflicts need to be resolved while maximizing output of required information in these radar modes. The integration of these modes may be a matter of carefully scheduling each function in time, or allocating based upon prime power, or prioritized based upon mission directive, or if necessary, ways of implementing the modes simultaneously needs to be developed.

PHASE I: Given the goal of precision location of air and ground targets using a single radar sensor, this effort will identify, define and model the necessary radar technologies required to accomplish these functions either simultaneously or in a manner that appears simultaneous to the radar operator. Computer simulation will bound the problem providing performance envelops under various prime power, update rate and field of regard conditions. Measures of effectiveness will be developed and used to assess the techniques developed.

PHASE II: Reduction to Practice -The goal of this phase of the effort is the demonstration of long pole technologies resulting from the phase one effort. These technologies will be demonstrated through either hardware demonstration of selected techniques or computer analysis of data cubes representative of the stressing technologies being reduced to practice.

PHASE III DUAL USE APPLICATIONS: Not only will this work be instrumental in developing a DOD radar surveillance and tracking system, but would also be applicable to many commercial applications.- Airport surveillance of ground traffic to help avoid collisions with aircraft that are landing and taking off- Phenomenology exploitation for civil engineering applications- Navigation and geodetic research in marine applications- Remote sensing

REFERENCES:

KEYWORDS: Multi-mission Radar, Radar, Radar Scheduling, Airborne Moving Target Indication (AMTI), Ground Moving Target Indication (GMTI), Synthetic Aperture Radar (SAR), Foliage Penetration Radar (FOPEN), Intelligence, Surveillance and Reconnaissance (ISR), Concealed Target Detection, Knowledge Based Techniques, Multifunction Waveforms, Multi-Platform Techniques, Simultaneous Transmit and Receive.

AF02-237 TITLE: Innovative Phenomenology Characterization and Advanced Algorithms

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop collection methodologies and algorithms to accurately characterize the dielectric constant at VHF/UHF/HF radar frequencies.

DESCRIPTION: In order to develop multi-mission sensors with the capability to detect difficult targets in foliage and below the earth's surface in the presence iof ECM and RFI, the Air Force must develop a means to effectively characterize the phenomenology associated with foliage penetration at UHF/VHF wavelengths and various geologies at HF and then exploit this phenomenology via advanced processing for mitigating interference, reducing false alarms, and enhancing target detection. The Air Force must acquire the capability to accurately characterize and model these scattering environments over wide frequency ranges to be used by future foliage and ground penetrating radar systems. The research of characterizing the dielectric constant of a forested environment will include the design of techniques to measure the desired biomass charateristics over frequency ranges from 20 to 600 MHz. The data collection system shall implement the techniques to provide measurements that will have to be conducted through mature forest stands for a variety of tree types, during all seasons and through various geologies, reaching different penetration depths, and in different soil and moisture characteristics. The data will be used to develop and validate RF interation models needed for the assessment of future surveillance and communications system operating in dense foliage environments and various surveillance and geo-science applications requiring the characterization and detection if objects buried below thr earth's surface. In concert with the development of techniques to measure phenomenology, algorithms and modeling and simulation tools will be developed to exploit this phenomenology. False alarm control, interference mitigation, and adaptive algorithms will be developed.

PHASE I: (1) Develop conceptual design of measurement technique(s) for wideband characterization of the dielectric constant of forested environments and subsurface geologies. (2) Using these conceptual techniques, design a measurement system that will collect the required data. (3) Develop innovative signal processing approaches that exploit findings in foliage and ground penetration phenoimenology to better control false alarms, mitigate interference, and improve target detection.

PHASE II: (1) Develop proof of concept prototype data collection system based on the techniques and system design on work done in under Phase I. (2) Identify issues pertinent to the accurate data collection of dielectric constant characterization data from mature forest stands and subsurface geologies. (3) Refine the prototype for data collection and analysis of data. (4) Develop modeling and simulation approaches to generate multi-channel data for FOPEN and GPEN data analysis, aid in the analysis of collected data, and advanced algorithm development.

PHASE III DUAL USE APPLICATIONS: The commercial potential is excellent. The implementtion of a device that measures the dielectric constants of forested environments and subsurface geologies over wide bandwidths has never been done before. Biomass characterization like this will be of great interest to the communications community as they migrate to ultra-wideband in the future for a complete wireless environment for the transfer of telephone and data signals between clients and service providers. Geoscience applications requiring a means to characterize the earths subsurface structure and detect underground structures and geological features could have commercial and military significant. Algorithms that utilize this improved phenomenology understanding to reject interference and enhance signal detection will be of key interest as spectrum crowding and increased channel utilization become limiting factors in markets such as the commercial wireless industry.

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KEYWORDS: phenomenology, foliage, foliage penetration radar, FOPEN radar, ground penetrating radar,subsurface target detection, signal processing, phenomenology exploitation

AF02-242 TITLE: Variable Speed Aerial Refueling Drogue

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies to provide aerial refueling from hose/reel systems at airspeeds ranging from 95 through 280 knots.

DESCRIPTION: Current air platform hose/reel refueling systems are only useful in a narrow airspeed range due to the nonlinear dynamic instabilities of the hose & drogue with airspeed. A novel system capable of controlling these instabilities such that we can refuel vehicles over a wide airspeed range will fill a void currently existing in the USAF tanker inventory. For example, USAF tankers are unable to use the same drogue to refuel both helicopters and fighters on the same sortie. This deficiency is exacerbated by the advent of tilt-rotor aircraft that fly in an intermediate airspeed regime non-optimum for existing drogues. Additionally, drogues currently in use have no overlap in airspeeds and there exists no aerial refueling capability for airspeeds of 130 through 180 knots, a favored range of the CV-22. The identification of innovative technologies and concepts are needed to overcome these limitations, and could be aided by the use of modeling and simulation. Such technologies are broad but could include, for example, adaptive structural concepts that actively modify the aerodynamic shape of the hose or drogue and possibly used in conjunction with a broad range of active flow control devices. The challenge will be to develop and integrate these emerging technologies into an operational, robust refueling system. If successful, the system may also serve as a prototype refueling system for Unmanned Air Vehicles (UAVs). UAVs will require precise active control of the drogue to successfully coordinate hookup without a pilot on-board.

PHASE I: Identify and define concepts to achieve refueling capability over desired airspeed range. Establish performance goals. Perform modeling and simulation analyses of defined concepts to determine technical feasibility. For each concept estimate the weight, system (refueling system & tanker) integration impact, and development costs.

PHASE II: Based on Phase I modeling, design and develop the most promising concept into a prototype. Perform hardware experiments of pressurized system to quantify/verify performance. Provide risk/feasibility analysis of integrating prototype to operational flight system, including safety concerns. Provide revised cost, weight, and system integration analysis from Phase I.

PHASE III DUAL USE APPLICATIONS: Technology developed under this effort will be directly applicable to aerial refueling systems worldwide, thus the technology could be licensed to U.S. and non-U.S. aircraft manufacturers, providing the contractor a much wider customer base. There are also plans to augment expensive space-based satellites (commercial and military) with cheaper, more assessable, high altitude, and very long endurance UAVs. These UAVs will require precise, periodic refueling to maintain their position. In addition, these technologies could be applied in other cases where precise aerial control of a pressurized hose could improve current performance. One could envision, for example, adapting this work using various nozzles and accounting for aircraft velocity, wind speed, and spray pattern to allow more precise aerial discharge of fluids for application to aerial fire fighting or crop dusting.

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KEYWORDS: Drogue
Refueling
Tanker
Helicopter
Tilt-rotor
Flow Control
Adaptive Structures

AF02-243 TITLE: Logistics and Maintenance System Model Development and Integration into Real-Time Mission Level Simulation Environment

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To create a simulation architecture that models mission level air vehicle life-cycle logistics and maintenance support.

DESCRIPTION: Over the years the Air Force has had numerous logistics and maintenance computer programs developed for specific purposes that are difficult to integrate together and into the emerging mission environment. The Air Force has an interest in innovative and state-of-the-art approaches to manage and minimize air vehicle life-cycle logistics and maintenance support systems costs. The techniques sought should be capable of evaluating “Legacy Aircraft” (i.e., F-15, F-22, C-17…) support systems. Functionality should include the identification of accumulated labor maintenance and acquisition costs, from the flight line to the depot. The techniques should be compatible with real-time, full mission simulation tools to allow the Air Force to determine the most effective methods to identify and mitigate total ownership, supply, and acquisition costs; assess technology insertion and performance; reduce maintenance actions, and reduce operational and safety costs. The technology will allow the Air Force to develop techniques to enhance the readiness, responsiveness, and agility of combat support systems in a relevant mission level environment.

PHASE I: Evaluate and identify existing appropriate air vehicle logistics and maintenance support systems models, simulation environment, and developmental and assessment tools for integration into the appropriate mission environment. Total system capability should accommodate the development of an open system environment to allow the user to insert customized or commercial cost and logistics/maintenance support systems algorithms. The selected models and tools should address supply costs, acquisition costs, mission capable rates, mission effectiveness, cost algorithms, and evaluation metrics. Investigate the adequacy of existing maintenance databases and information systems to provide baseline maintenance cost information for the model. An approach for a proof-of-concept demonstration to be executed in Phase II should be formulated.

PHASE II: Incorporate the air vehicle logistics and maintenance support systems models, simulation environment, developmental and assessment tools, cost algorithms, and evaluation metrics into an automated simulation software architecture module. Perform an F-15 proof-of-concept demonstration using actual flight data and support hours and costs. Required demonstration data will be supplied by the F-15 SPO, ASC/FBA at no cost. Accomplish simulations and show results of introducing upgraded subsystem examples into the air vehicle. Examples should include both near-term, conventional improvements and longer range, new technology.

PHASE III DUAL USE APPLICATIONS: The technology developed under this effort has diverse military and commercial applications. Any military or commercial activity with large material inventories and distribution network could utilize this technology. Target areas include terrain, marine, and air shipping and cargo services facilities, logistics and maintenance consulting firms, city and state rapid transit authorities, major retailers, warehousing and order processing companies, and transportation simulation and modeling facilities.

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KEYWORDS: Cost Modeling
Logistics
Modeling and Simulation
Mission Effectiveness
Management Algorithms
Total Ownership Costs
Life-Cycle Costs
Air Vehicle Support
Labor Maintenance
Acquisition Costs

AF02-244 TITLE: Rapid Fatigue Life Projection for Thermal and Acoustic Loads

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this research is to develop the relationships between the probability density function (PDF) and the power spectral density (PSD) of the nonlinear response of a structure. Given those expressions, more realistic fatigue life approximations are possible.

DESCRIPTION: Current frequency domain fatigue life estimation tools do not take into account geometric nonlinearities, nor the instabilities associated with thermal buckling. Ideally, the analytical expressions developed in this SBIR would be coupled with developing nonlinear structural analysis programs, to provide a comprehensive nonlinear response/fatigue life estimation tool. Technical challenges include establishing the relationship between the structural nonlinear strain-displacement response, PSD and the PDF. The purpose of this research is to develop analytical expressions for the unstable random vibration fatigue life of composite structures with simultaneous thermal and acoustic loads, using frequency domain methods. Improvements are needed for the estimation of the fatigue life due to the thermal acoustic loads on current and future short take-off and landing (STOL) and hypersonic vehicle structures, as well as developing commercial reusable space access vehicles. Traditionally thermal-acoustic fatigue problems were solved with Palmgren-Miner's rule together with a time domain method, i.e., a given stress time-history and corresponding cycle counting method. More recently, frequency domain methods have been developed that deal with the limitations of the narrow band solution procedure, and allow a fatigue life estimation to be accomplished without the need for an experimental time-history. Consideration should be given for developing expressions for PDFs of the 'rainflow ranges' in the fatigue model, specifically for a geometrically nonlinear system. The solution procedure should account for the multimodal frequency response instability of restrained plates under acoustic and thermal loading. Consideration should also be given to the critical temperature change that produces plate buckling, temperature gradients along the edge, and improvements in iterative procedures. Finally, the analytical techniques should include the use of high temperature composite materials such as ceramic matrix composites.

PHASE I: The Phase I product would be the newly developed dynamic fatigue models, or analytical expressions, relating the structural nonlinear response, PSD and PDF, for composite panels.

PHASE II: Demonstrate the validity of the new models by example and validate using an experimental, sponsor provided database.

PHASE III DUAL USE APPLICATIONS: Incorporate the new fatigue model into a comprehensive, commercial finite element analysis package. Dual use applications include STOL aircraft, military space plane, and commercial reusable launch vehicles.

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KEYWORDS: Dynamic Fatigue Model
Random Vibrations
Thermal Buckling
Composite Plates
Snap Through
Probability Density Functions
Acoustic Excitation
Spectral Moments
Rainflow Cycle Counting
Frequency Domain

AF02-245 TITLE: Crack-Growth Methodologies for Cold-Worked Fastener Holes in Aluminum and Titanium Alloys

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a methodology for predicting crack growth from and around cold-worked fastener holes and determine the stress-intensity factor solutions for cracks at or near these holes.

DESCRIPTION: Cold working fastener holes in aluminum and titanium alloys is a widely used technique in the aerospace industry for improving the fatigue performance of structures. A compressive tangential stress introduced in the material during the cold working of the hole reduces the natural tendency of the material to crack at the holes under cyclic tensile loading. It is a lucrative technique for the aerospace industry in that it provides an increase in performance without any weight cost.The technique most commonly used to cold-work fastener holes is a process of pulling an oversize mandrel through the hole to be cold worked. A thin lubricated sleeve is inserted between the hole and the mandrel before cold working in order to limit material flow in the direction of mandrel movement. The process calls for an optimum radial expansion of the hole and then subsequent reaming. The process yields the plate material and creates a compressive residual stress around the hole. Research has shown that this cold expansion can greatly extend the life of the part in question and is currently widely used in both military and commercial aircraft.However, the introduction of a compressive stress will cause a residual tensile stress further away from the hole. It is possible that this tensile stress field away from the fastener hole may cause cracks to develop away from the fastener hole. The concern is that most inspection procedures focus on the fastener hole itself and if cracks are forced away from the hole they might be missed by current inspections. Analysis methods or solutions for this type of cracking are not available in the current literature and should be developed.

PHASE I: Investigate methods of crack growth that can occur away from a cold-worked fastener hole. This should include a literature search of previous work done in this area as well as those aircraft and hardware that have exhibited this problem. Develop preliminary analysis of the hole and surrounding area with stress intensity solutions and expected crack growth rates, as well as the rational cause of such off-hole cracks.

PHASE II: Develop methodology to predict crack growth rates from off-hole cracks and determine the stress-intensity factor solutions for cracks at or near the holes. Integrate methodology into crack growth module for life prediction. Confirm the methodology, verify module accuracy and publish the verified results.

PHASE III DUAL USE APPLICATIONS: Crack growth methodology for off-hole initiation is needed by the military and commercial aviation industries, as well as benefiting the automotive industry or any industrial area where cold working of holes is required. This will have application in a number of military and commercial environments including aircraft, navel vessels, and vehicles.

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KEYWORDS: Fatigue
Fracture Mechanics
Cold Working
Life Prediction Methodology

AF02-246 TITLE: Lightning Protection of Revolving Aircraft Turrets

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative lightning protection technology for revolving composite aircraft turrets in flammable leakage zones.

DESCRIPTION: Composite materials are being used extensively to lower the weight and improve the performance of modern aircraft, but composites cannot survive the large currents produced by a lightning strike. Current state-of-the-art lightning protection systems such as metal screens and coatings have proven successful in protecting nonrotary composite aircraft structure but are insufficient to transfer the high current from a revolving composite turret to an aircraft fuselage as in a Boeing 747 airborne laser weapon system. Since lightning commonly attaches to an aircraft at its extremities, composite nose-mounted turrets are extremely vulnerable. An innovative, lightweight approach to shield and conduct lightning energy away from a revolving composite turret needs to be developed. The approach must include a grounding path across the rotary interface between the turret and the fuselage that does not induce sparking or arcing even at high turret rotational rates. This requirement exists to protect a flammable leakage zone from being exposed to an ignition source. Also, the lightning protection system must not interfere with the optical quality of a glass lens contained within the turret.

PHASE I: Define the proposed lightning protection system concept and concept requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype lightning protection system and laboratory demonstration to mutually agreed performance parameters. Demonstrate that the lightning protection system is capable of supporting flight demonstration at a government facility and qualifies for an airborne experiment. The prime consideration must be the deliverable of a lightweight lightning protection system with a clear demonstration to protect composite and optical glass turret structures while providing a nonarcing grounding path over the turret to fuselage interface.

PHASE III DUAL USE APPLICATIONS: Any airborne system, current or future will be susceptible to lightning strikes. Airborne system platforms, such as the 747, have commercial and DoD application. These systems, in order to reduce weight, and improve performance and range, have applied the use of composite materials. Specific potential military applications for the lightning protection system include nonstationary interfaces such as turrets on the airborne laser weapon system and tanks, rotary domes on AWACS, trailing wire antenna on the E-4B, tilt-rotor bodies, and composite rotor blades. Composite rotor blades, tilt-rotors, and other aircraft parts with nonstationary interfaces make up some potential commercial applications for the lightning protection system.

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KEYWORDS: Lightning Protection
Composite Structures
Turret
Dynamic Interface
Lightweight Grounding Path
Build-up of Static Charges
Optical Qualities

AF02-247 TITLE: Supportable Sandwich Control Surfaces

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and demonstrate new and highly innovative sandwich structure control surface concepts that are highly producible, low cost, and are not susceptible to structural degradation due to moisture intrusion, impact damage, and damage growth.

DESCRIPTION: Structual design trade studies have traditionally shown that sandwich structures are the most weight efficient concept for stability-critical components such as control surfaces. Prior applications of sandwich structure on in-service vehicles has resulted in costly manufacturing and supportability problems. Manufacturing problems have been caused by core materials that are difficult to machine and difficult to bond, difficulties in panel joining, and difficulties with integration of hard points for concentrated load introductions. Supportability problems have resulted largely due to the integration of materials and concepts that are highly susceptible to impact damage and moisture intrusion which leads to corrosion, mechanical degradation of the sandwich core, and delamination in core-to-facesheet bond. This program seeks innovative sandwich structure solutions that are producible, mitigate the historical shortfalls of sandwich, and provide high structural efficiency. Sandwich structures which feature integral core and skins, damage and moisture resistant materials, and net shape cores may be considered.

PHASE I: The Phase I program will involve identifying and assessing the payoff of a unique sandwich structural configuration that minimizes structural weight and cost and is highly producible and damage resistant. The feasibility of the concept shall be demonstrated experimentally.

PHASE II: The Phase II program will further develop and demonstrate the producibility and robustness of sandwich control surface concept on a generic component whose design is derived from an existing or emerging air vehicle weapon system. This will involve design, analysis and fabrication of a subcomponent. This subcomponent should be subjected to environmental conditioning, simulated flight loads, and impact. A repair concept should also be developed and demonstrated.

PHASE III DUAL USE APPLICATIONS: This program will offer significant improvements in reliability and maintainability by reducing acquisition cost, reducing inspection intervals, extending the damage tolerance threshold and improving design efficiency. The technology will be transitioned by directly involving systems representatives in the progress and results of the program. This will include keeping representatives from the Joint Strike Fighter (JSF), F-22, C-17 and Air Logistics Centers (ALC)cognizant of the program's successes so that direct application of opportunities can be exploited. Commercial aircraft applications are expected to be similar to military applications, and initial uses are likely to be in lightly-loaded structures. In general aviation, perhaps primary structure, where similar technology is in use today. Nonaerospace uses of similar structure can be visualized within transportation equipment.

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KEYWORDS: Sandwich Structure
Woven Fiber Preforms
Foam
Composites
Honeycomb
Truss Core
Weaving
Braiding
Net Shape

AF02-248 TITLE: Structurally Efficient Composite Concepts with Non-Traditional Load-Paths

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Demonstrate new and novel aircraft structural concepts to significantly increase mechanical performance of advanced composite structures while maintaining affordability.

DESCRIPTION: Composite structures for military air vehicles are generally constructed from a standard set of product forms such as prepreg tape and fabric, and molded structures reinforced with woven or braided preforms and fabrics. These materials and product forms are generally applied in structural configurations and arrangements that mimic traditional metallic structure. Traditional metallic structural arrangements rely on the isotropic properties of the metal. Composite materials provide the capability for a high degree of tailoring which should provide an opportunity for very high structural efficiencies. This project seeks to develop approaches for applying composite materials and product in new and novel arrangements specifically suited to composites with the goal of significantly increasing the strength, stiffness, durability, and damage tolerance of advanced composite structures. Specific areas of interest include concepts to increase: compression strength, buckling stability, concentrated load introduction, out-of-plane strength, impact resistance, load transfer through joints and intersections, and complex combined loading capability. Very novel approaches such as biomimicry, prestressing may be considered. The goal is to enable reduced structural weight and increase survivability over state-of-the-art structures technology while maintaining affordability. The concept must be broadly applicable to all classes of Air Force air vehicles. Specific emphasis will be placed on secondary structure application concepts. The overall objective of the program is to demonstrate the feasibility of new design concepts enabled by new emerging material and manufacturing processes, and to identify the benefits of applying these technologies.

PHASE I: The feasibility of the concept shall be demonstrated through fabrication and test of a representative structural component.

PHASE II: The Phase II program will further develop and demonstrate the concept on a generic component whose design is derived from an existing or emerging air vehicle weapon system. This will involve design, analysis and fabrication of a subcomponent. This subcomponent should be subjected to environmental conditioning, simulated flight loads, and impact damage.

PHASE III DUAL USE APPLICATIONS: This program will provide highly efficient structural concepts with broad applicability to a variety of Air Force systems. The technology will be transitioned by directly involving a major airframe partner and systems representatives in the progress and results of the program. This will include keeping representatives from the JSF, UCAV, Sensorcraft and the ALC communities cognizant of the programs successes so that direct application of opportunities can be exploited. Civil applications are somewhat difficult to determine at this time, as the specific concepts to be demonstrated are not yet selected. Application to civil aerospace and ground transportation can be visualized.

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KEYWORDS: Composites
Biomimicry
Weaving
Braiding
Pinning
Pultruded Rods
Truss
Cellular Structures
Prestressing

AF02-250 TITLE: Aerial Targets Modernization and Integration

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies, manufacturing and integrating concepts for aerial targets that increases their capabilities.

DESCRIPTION: The Air Armament Center is interested in innovative concepts to improve the performance and operability of aerial targets. The Aerial Target Program Office develops and acquires aerial targets and payloads for the Air Combat Command to test and evaluate radar and infrared aerial weapons. Aerial targets include both a full-scale aerial targets (i.e., QF-4) and subscale aerial targets (i.e., BQM-34 and MQM-107). Advanced concepts and innovations will be applied to several technologies and target-operable areas. Airborne technology areas under consideration, but not inclusive, include radio frequency (RF) missile-scoring techniques, flight endurance and engine performance, target control techniques, integrated and water-survivable payload concepts, carriage and threat replication payloads (electronic, chaff, infrared), aircraft manufacturing techniques, simulation and modeling, signal processing, and common aperture antennas.

PHASE I: This phase will determine the scientific or technological merit and feasibility of the concept, approach, and its cost effectiveness. Merit and feasibility must be clearly illustrated during this phase through a combination of analytical, empirical and experimental approaches. A technical evaluation of the concept or methodology; a demonstration of proof of principle; or a thorough description of the technical approach, cost effectiveness, alternative approaches, and risk factors may be appropriate in this phase. Examples of innovative ideas that are desired for subscale aerial targets include 75 minutes of mission time at 15,000 feet at military power and 45 minutes of mission time at 500 feet at military power; inexpensive turbojet engine subsystems that will improve performance between 250 KCAS to 1 Mach at 15,000 feet and 200 KCAS to 1.5 Mach at 15,000 feet; and inexpensive-commercial grade composite airframe structures that can sustain 10 Gs at 10,000 feet and sustained turn rates 20 deg/sec.

PHASE II: The effort in this phase is expected to produce a well-defined deliverable product or a process. Demonstration of the concept, process or idea is desired on a representative model, avionics suite, or a full-scale representation of the air vehicle. Any development of the software coding that is required to demonstrate the idea or process in the avionics, engine, and airframe shall have a written description of the intent of the subroutines. If the idea, process and concept has considerable technical payoff, affordable to demonstrate, and is flight survivable, a subscale aerial target may be provided to demonstrate the idea.

PHASE III DUAL USE APPLICATIONS: Each proposal that is submitted under this general topic should have associated dual use commercial applications of the planned technology, process, and concept. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

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KEYWORDS: Aerial Targets
Missile Scoring
Target Control
Infrared and Electronic Warfare Payloads
Simulation and Modeling
Aircraft Manufacturing
Signal Processing
Antennas
Aircraft Engine

AF02-251 TITLE: Integration of Hypersonic Vehicle Inlets, Isolators and Exhaust Nozzles for Multiple Engine Flowpaths

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an analytical design and evaluation tool for hypersonic cruise and space access vehicle inlets, isolators, and nozzles

DESCRIPTION: Space access and hypersonic cruise vehicle operating velocity range is so varied that multiple engine cycles with multiple engine flow paths are mandatory. Integration of these flowpaths through highly efficient, relatively lightweight inlets, and exhaust nozzles is a formidable task. This is especially challenging for engines where there can be as many as eight axisymmetric flowpaths that may have to transition from square, round/half circle to an unknown configuration to a planar afterbody. Engine types include turbine-based combined cycle (TBCC) engines, rocket-based combined cycle (RBCC) engines, pulse detonation engines (PDEs), or other possibilities. The first two engine systems are possibly two completely separate systems with varying flow requirements throughout the Mach range. The combined cycle engines will require the design capability of splitting the flow between the two engine types, and again for the individual engines of each type. Current one-dimensional codes, such as the Ram Jet Performance Analysis (RJPA) code, do not provide adequate fidelity. Three-dimensional (3D) analytical design and evaluation tools are needed, and an experimental database is required, to demonstrate the veracity of the design approach. Critical design issues are compact installation, minimizing losses, volumetric efficiency, 3D force and moment effects, high-temperature gas dynamics, finite rate chemistry in the exhaust, and mode transition dynamic analysis. The system shall be capable of analyzing a JP-7 fuel cycle with other fuels being optional.

PHASE I: Complete a search on the existing engine design techniques (software). Develop the flow analysis concept for the flow analysis tool. Present the concepts to Air Force, engine inlet analysis experts, and utilize their comments as appropriate. Identify the potential risks and capabilities of the proposed 3D analysis tool, and identify the expected benefits of the tool over existing analysis techniques.

PHASE II: Develop, demonstrate and validate the proposed concept(s) for realistic applications in the aerospace industry. The tool shall be easy to operate (i.e., pull down menus), and shall include a users guide. Data for a well-understood inlet system design shall be obtained to demonstrate and validate the new technique. A test case shall be run for a TBCC system determining the trades between individual inlets for each individual engine versus split inlets for each different cycle engine pair versus a different cycle split inlet with up to 4 engines of each cycle from 0 to Mach 17. The code shall be modular, and capable of interfacing with existing engine design codes.

PHASE III DUAL USE APPLICATIONS: This technology can be applied to both military and civilian high-speed vehicles (future strike, space access). The technology may at some future date be applied to civilian aviation as a high-speed transport. The highest payoffs could be realized for applications involving commercialization of space and hypersonic transport. Some examples include transport to and from space-based hotels and resorts, and transport across long distances in short time spans.

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KEYWORDS: Nozzles
High-Speed Nozzles
Variable-Geometry Nozzles
Flow Path
Isolator
Space Access
Airbreathing Propulsion
Combined Cycle Engines
High-Temperature Gas Dynamics

AF02-253 TITLE: Metal Deposition for Locally Tailored Properties

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Demonstrate Feasibility, Identify Payoffs, and Develop Design Data for the Use of Metal Powder Deposition Techniques for Locally Tailoring Properties for Metal Structures.

DESCRIPTION: Metal structures are susceptible to cracking due to fatigue. Additionally, there is often loss of material and associated strength and stiffness due to corrosion effects. These effects are often localized in a structure, concentrated about more intense stresses, often referred to as “hot spots”. Hot spots can result from the underprediction of loads or changes in use pattern. These hot spots may result in modifications to the structure. Repairs to the structure are often quite complex because in order to both restore strength and eliminate the “hot spot” the repair must be completed in such a manner as to not create a new, and perhaps worse, problem due to mismatch in property. Deposition used to apply form powder metals may allow the direct replacement of lost material or close a crack allowing local application of a specifically tailored material in order to eliminate hot spots. This approach may also be used in a manufacturing process to directly reinforce on local area in a structural element not requiring such reinforcement elsewhere. Other uses of the ability to deposit tailored material can be visualized. The Air Force Research Laboratory is seeking innovative concepts for the deposition of powder with locally tailored properties for purposes of repair of current or manufacture of future structural elements in order to reduce the cost and structural weight of future air vehicles. Development of this technology will enable precise, local tailoring of properties in metals during cure and or at the point of repair for which the accuracy and controllability far surpasses present state-of-art.

PHASE I: In Phase I, the ability to create an “alloy” by combining different metals in order to achieve several desired properties will be demonstrated through the creation of complex structural elements. The ability to achieve the desired properties will be demonstrated through test. These elements will be selected in such a manner as to develop reasonable confidence in the material performance cost and weight reduction potential.

PHASE II: Phase II will determine the suitability of the deposition process for manufacture and or repair of actual air vehicle structures by fabrication and test, according to a proposed plan, of a more complex aircraft structure. This is a demonstration test, and need not be conducted to the standards of a certification effort.

PHASE III DUAL USE APPLICATIONS: During Phase III, the low cost rapid manufacturing technology will be further developed and transitioned. Potential users could include but not be limited to the aerospace industry, for temporary repair or modification of airframes. Commercial applications include the commercial aerospace, automotive, infrastructure and machine design industries. Specific Air Force applications all heavy airframe structures.

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KEYWORDS: Powdered Metal
Deposition
Designer Alloys
Structural Repair

AF02-254 TITLE: High-fidelity Tools for Three-dimensional Multi-physics Computation

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop software product(s) to insert versatile high-fidelity multidisciplinary methodologies into three-dimensional high-order simulation platforms.

DESCRIPTION: The unconventional design space of future aerospace vehicles demands extensive utilization of multidisciplinary numerical modeling and simulation. Limitations in present computational capability arise both from finite computer processing power as well as accuracy and applicability confines of standard numerical algorithms. One approach to extending computational capability is through the use of highly accurate methods. For example, those exhibiting a minimum order and spectral resolution comparable to fourth-order Pade-type formulas on parallel processing multicomputers. Application of such schemes has so far been hindered by their unstable behavior in practical situations where geometrical and physical considerations dictate the use of nonideal meshes and approximate boundary conditions. Recently, several basic research efforts have overcome these constraints by introducing new elements such as highly-discriminating low-pass filtering and high-order upwinding techniques. Some of these high-order schemes have additionally exhibited superior versatility in solving governing equations describing three-dimensional, multi-disciplinary, and multi-scale phenomena in fluid dynamics (aeroacoustics and direct simulations of turbulence), electromagnetics (signature prediction), magnetogasdynamics (thermal protection in hypersonic flight), and fluid-structure interactions (buffeting and flutter). A careful and systematic analysis with a high degree of ingenuity and innovation together with an emphasis on open-architecture considerations, is required to optimize factors related to the choice of the high-order scheme with those associated with ease of implementation on scalable platforms. Such a study leads naturally to the development of a versatile modular software suite based on common elements of modern research codes and facilitates the high payoff endeavor of technology insertion into current production codes.

PHASE I: Determine feasibility and define scope of the proposed concept(s) for developing a general purpose software suite. Select platform and develop high-order methodology. Identify common elements of production codes suitable for technology upgrades. Develop plans to test software.

PHASE II: Develop software suite. Verify and validate accuracy. Test and document scalability. Demonstrate applicability through a large-scale test problem analysis on selected parallel platform.

PHASE III DUAL USE APPLICATIONS: The large body of proprietary production software currently utilizes standard low-order procedures which incur significant limitations. Considerable opportunity exists therefore for insertion of the high-order multidisciplinary software suite to upgrade the capability of such production codes. From the DoD standpoint, this software suite will make feasible presently unachievable proof-of-concept studies utilizing revolutionary multidisciplinary technologies.

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KEYWORDS: High-order Computational Methods
Multi-disciplinary Simulation
Turbulence Simulation

Computational Electromagnetics
Magnetogasdynamics Simulation

AF02-255 TITLE: Reactive Flow Control for Virtual Aerodynamic Shaping

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To develop and demonstrate reactive control mechanization concepts to improve the aerodynamic performance of air vehicles.

DESCRIPTION: Given the many successes in open-loop aerodynamic flow control, the use of feedback combined with flow control actuation makes virtual aerodynamic shaping an achievable goal. Virtual aerodynamic shaping involves manipulating the flow field so that it reacts as if it encounters a geometry other than what is physically present. Achievement of this goal would allow air vehicle designs to be optimized for criteria other than aerodynamic performance (e.g., radar cross section or embedded sensor effectiveness) without adversely impacting – or perhaps enhancing – aerodynamic performance (e.g., lift-to-drag ratio). Such flow field manipulation may also allow for the partial or complete replacement of hinged flight- control surfaces through the manipulation of sectional lift properties.The objective of this research is to demonstrate the meaningful manipulation of the flow field over a generic three-dimensional (3-D) body, including the ability to control incipient separation and reattachment throughout flow conditions typical of an operational flight envelope. An integrated system of sensors and actuators coupled through feedback control is desired. A successful program would be strong in each and all of the following areas: aerodynamics, actuators, sensors, and control law design. Consideration should also be given to air vehicle integration, including modeling of the aerodynamic effects of the control concept, control law design for the aircraft-actuator integrated system, modeling and allocation of control power, overall control architecture, and impact on the overall air vehicle design. Both Micro Elecro-Mechanical Systems(MEMS) and non-MEMS technologies will be given equal consideration. The most appropriate feedback control technique will depend on the overall system architecture, but distributed parameter control, robust control, learning control and/or other advanced control technologies may be required to meet the large flight envelope requirement. The demonstration of the system is to be carried out through high-fidelity CFD simulation, wind tunnel testing, and/or flight testing representative of the entire design envelope.

PHASE I: Phase I shall consist of the initial design, integration and demonstration of a pilot reactive flow control system. The successful system shall demonstrate the ability to manipulate the flow field of a two- dimensional (2-D) or 3-D body on demand via the control system. This demonstration may be conducted either through simulation or wind tunnel experiment over a subset of the ultimate design space.

PHASE II: Phase II shall consist of the design, integration and demonstration of the reactive flow control system developed in Phase I over a range of flow-field/flight conditions. The successful system shall be robust toward changing flow state while maintaining the ability to manipulate the flow field over a 3-D body on demand via the control system. Preference shall be given to a demonstration that balances both simulation and physical experimentation.

PHASE III DUAL USE APPLICATIONS: All classes of air vehicles may benefit from this technology. This capability will ultimately be useful for improving the aerodynamic performance of nonaerodynamically-optimized designs as well as enabling hingeless flight control. Further, significant duel-use potential for air, ground, and water-borne vehicles exists for this technology.

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KEYWORDS: Reactive Flow Control

Flow Separation Control
Feedback Control
Control Law Design

AF02-256 TITLE: Distributed, Embedded Sensing for Quasi-Static Shape Control of Wings

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To investigate and develop methodologies for shape determination of deformed wing sections using state-of-the-art distributed and embedded sensor devices.

DESCRIPTION: This topic addresses deformation shape sensing and mapping of wing structures for applications such as airfoil shaping, wing warping or twisting, or other adaptive structures applications where knowledge of the true deformation shape of the wing is required. This information can be fed back to the controller for closed-loop control of aerodynamic or aeroelastic phenomenon, or can be provided to other subsystems for performance adjustment (such as embedded antenna performance). In an airborne environment, these measurements must be made in-situ, which suggests the use of distributed and embedded sensors. This system requires a combination of hardware, including the sensors themselves, wiring, signal conditioning, associated electronics, and processing equipment, as well as software, which consists of signal processing and data reduction algorithms. In addition, the observability of a particular shape is dependent on the type and spatial resolution of the sensors. Therefore, techniques for determining the optimum sensor number and placement are also important, based on observability requirements of the expected deformation space.

PHASE I: Phase I will concentrate on determining a representative aircraft wing type to use in the study, determining the type of sensors to be used, optimizing the number and placement of sensors, and developing an algorithm to combine the data from the suite of sensors to measure the deformed wing shape.

PHASE II: In Phase II, it is envisioned that a scaled wing section will be fabricated with the embedded sensor suite, and the system will be demonstrated as a static load test using expected ranges and types of aeroelastic and active flow control wing deformations.

PHASE III DUAL USE APPLICATIONS: In Phase III, additional testing of the shape sensing system will be conducted. Alternate air vehicle platforms could also be investigated. Nonmilitary uses of the technology include drag minimization and performance enhancement on commercial aircraft, as well as sensing and control of precision deformable antennas and shape sensing and control of inflatable antennas and other inflatable structures.

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KEYWORDS: Sensor Fusion
Optimal Sensor Placement
Wing Deformation
Shape Sensing
Embedded Devices

AF02-257 TITLE: Biologically Inspired Autonomous Control Technologies

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop affordable, task oriented, airborne agents using technology based on natural systems.

DESCRIPTION: The Air Force is exploring the development and deployment of revolutionary unmanned air and launch space vehicles. These vehicles may be operated in isolation, in multi-vehicle groups, swarms, or as part of a cooperative force structure involving large numbers and varieties of both manned and unmanned vehicles. However, there are a several practical considerations that need addressing before flying autonomous systems can be fielded. Software Cost: current multi-agent telerobotics research is heavily vested in artificial intelligence techniques that require large software algorithms, huge processors, and global information availability. Projected program size for even simple multi-vehicle autonomous control system operational flight programs range from 1,200,000 to 4,500,000 lines of higher-order language code, an order of magnitude beyond today's manned aircraft programs. Flight certification of current software costs roughly $500 per line of code, meaning that anything more than simple autonomous control system software could be prohibitively expensive. Information Requirements: in addition, the same state-of-the-art autonomous agents based on artificial intelligence rely on the fact that each agent knows what all the other agents are doing all the time, in other words, global knowledge is required. This quickly results in impractical communication schemes due to huge information bandwidths for anything but the simplest of tasks (communication requirements grow exponentially with the number of nodes in the system), not to mention the information security and low-probability-of-intercept (stealth) issues. New innovative research based on natural systems hold the promise of reducing software costs, processing requirements, and explicit communications in multi-agent autonomous systems. For instance one could use stigmergy (agents interacting through the task or environment without explicit communications). Social insects use this as one method of communication, such as cooperative transport, locating food, or building nest structures. Using stigmergy, complex tasks can be completed without "broadcast" of information by the individual agents. Applying this to autonomous vehicles could result in significant reductions in communication requirements. Another example could be emergent behavior – complex behaviors that arise from interaction of simpler micro-behaviors. Seemingly complicated group behaviors, such as bird flocks, fish schools, and even entire social insect colonies are simply the result of an integration of much simpler behaviors interacting is such a way to produce the complex behavior. Using emergent behavior complex tasks can be completed without explicitly telling each individual what the overall goal is, or how the individual specifically fits in. Applying this to autonomous vehicles could result in enormous decreases in code size and processor throughput requirements. The integration of natural systems characteristics promises to drastically reduce the complexity of distributed autonomous systems, exhibiting simplicity, robustness, and flexibility while minimizing explicit communications. Autonomous vehicle applications using traditional artificial intelligence hindered by the computational and communication requirements could be practical using natural systems technology. The goal is to leverage prior technology development to establish requirements, designs and architectures in which natural systems technology can be used for flight critical control functions. Behaviors developed need to accommodate the full range of vehicle tasks including terminal area operations, formation management, deconfliction, and other cooperative operations, while considering affordability for flight critical application. Note that this solution does not have to be exclusively software oriented. Innovative analog hardware solutions will be considered. It is also desired to understand the trade–offs and impacts bio-inspired technology has on coordination strategy, local versus global information availability, communication requirements/degradation, and other systems-of-systems control issues such as heterogeneity. All concepts must be sufficiently generic for applicability to wide varieties of distributed autonomous systems. Technical parameters to consider include software reduction – show how innovative technology reduces the line count (lines of higher-order code) and complexity (sub-function calls) while maintaining system performance, and information/communication requirements – show how technology reduces system information and/or communication requirements. Information can be measured in Megabytes of storage and communication in both bandwidth (Hz) and reliability (acceptable drop-out rate).

PHASE I: Define the proposed concept, outline the basic principles, and establish a method of solution. Develop metrics for comparison with traditional artificial intelligence methods. Choose at least one particular multi-agent unmanned vehicle application that is to be used for analytic development of the control technique and experimental validation. This application should be one already accomplished via existing methods, and should be for aerial vehicles. 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 OR demonstration under simulated flight conditions. Verify/update initial risk and improvement predictions.

PHASE III DUAL USE APPLICATIONS: The technology developed under this effort will be applicable to a wide variety of autonomous agents including air, space, land, and sea vehicles. In addition, the methods and tools will be applicable to communication control and protocol, data analysis, and distributed control (and robotic) systems used in commercial manufacturing, process control, and material handling systems. The methods developed will enable many groups of systems to interact affordably, autonomously, and cooperatively with minimal communications and computational requirements.

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KEYWORDS: Self-organization
Biomimetics
Swarm Intelligence
Behavior-based Control
Intelligent Behaviors
Emergent Behaviors
Stigmergy
Distributed Control
Intelligent Agents
Multi-agent System
Decentralized Control
Cooperative Control
Swarms
Artificial Life
Artificial Intelligence
Robot Teams
Distributed Autonomous Systems

AF02-259 TITLE: Affordability Development and Integration into Simulation-Based Research and Development (R&D)

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and integrate a cost model into the simulation-based research and development(R&D)architecture for assessing emerging paradigm-shifting technologies.

DESCRIPTION: Revolutionary cost prediction models, not based on extrapolation of current technology trends, are needed to adequately evaluate new, paradigm shifting technologies. These are needed since existing, traditional cost models do not provide adequate insight into the impact inclusion of an emerging or maturing technology will have on the affordability of a new weapon system. Typically, these models estimate the cost benefits or penalties of an emerging technology by using prediction methods based upon component weight or number of lines of software code extrapolated from the current state of the art. Such techniques may be adequate for evolutionary technology advancements but generally completely miss the mark for revolutionary technology advancements – such as paradigm shifts. More and more designers, analysts, and planners are utilizing the output from these cost-estimating tools to establish priorities in the technology investment selection process. Limited funding and manpower resources are forcing technology planners to prioritize the development of these technologies very early in their maturation cycle; as early as during conceptual or preliminary design. Performance models exist and are currently being utilized in flight simulations to evaluate the performance of air vehicles at the vehicle level for both military and commercial air vehicles. These air vehicle level performance models have the capability of being rapidly reconfigured to evaluate the effectiveness of air vehicle configurations for a matrix of configurations and relevant mission environments.

PHASE I: The goal of this research effort is to evolve and demonstrate an architecture that supports parametric studies of cost as an independent variable (CAIV) for inserting maturing or emerging technologies into next-generation air vehicles. This architecture will draw from the latest advances in cost estimating, cost modeling, life cycle cost, total ownership cost, operations research, and decision theory. It will place maximum emphasize on the use of nontraditional techniques and tools in the performance of these parametric studies.

PHASE II: The goal of this research effort is to formulate and demonstrate a CAIV model from the architecture developed during Phase I. Approaches leading to the creation of an innovative, user friendly model that automatically translates simulation results into high-fidelity formats for next-generation air vehicles are sought.

PHASE III DUAL USE APPLICATIONS: The military systems applications include a rapid- product development capability for supporting military technology development and weapon systems development. The use of such a simulation capability to aid the laboratory in technology investment by objectively evaluating future system performance and affordability is one of the core components of simulation-based research and development. Commercial systems applications include links to the aerospace and automotive industries. Performance level models and affordability tools linked to detailed design models would lead to reduced product development time.

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KEYWORDS: Cost Modeling
Life Cycle Cost
Total Ownership Cost
Cost Estimating
Operations Research
Decision Theory
Simulation-Based Research and Development

AF02-263 TITLE: e-Learning and Aptitude Evaluation Through A Web-based Training Framework

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a framework that would allow any DoD depot to a) evaluate a worker's training needs and b) provide that training in the most efficient environment

DESCRIPTION: With a maintenance work force of over 700,000 personnel, the Department of Defense is seeking to develop effective programs for training to make this workforce more efficient. Moreover, recent data shows the average age of a DoD worker in the maintenance depots to be close to 50. While the depots are replenishing their aging workforce, they need the required training tools to quickly bring the new generation of workers up to speed.e-Learning extends learning beyond traditional classrooms to workplaces and supports life-long training. Over the last few years, e-learning has migrated more towards the Web, providing a wide range of services anytime, anywhere, to anyone. Such Web-based training is generally broken down into asynchronous and synchronous learning. In asynchronous e-learning training takes place in different time frames and trainees access information at their convenience. The synchronous training, on the other hand, takes place for all students at the same time and information is accessed instantly. The latter form of e-learning provides more interactivity, whereas the former provides more flexibility.A web-based training framework must a) provide an evaluation environment such that the educational needs of any depot worker is quickly determined, and b) provide a web-based tool for accessing any training material on any platform and in any environment. The evaluation center for the framework must be supported by a database of relevant questions that are given in a random manner and are graded by the system automatically. The training part of the framework must be easy to use and easy to implement. The framework must also follow technical standards such as Advanced Distributed learning (ADL), (website: http://www.adlnet.org) which is supported by DoD. Standards like ADL define high-level requirements for educational content such as content reusability, accessibility, durability, and interoperability. Moreover, the framework must be designed for the "lowest common denominator" such that anyone using any platform and in any environment can take the evaluations and get access to the desired training material. Key objectives to be met are an analysis of emerging network-based technologies to improve band-width of video use over the shop internets, capture of workforce knowledge for reuse to young workforce, stimulate large-scale collaboration environment across organizations, and use of ADL standards to provide a repositories of reusable, shareable, and platform-independent training material.

PHASE I: Research and analyze which type of e-learning (synchronous or asynchronous) is more effective for the depot personnel based on the above technical objectives. Identify and select a shop area within Tinker AFB and provide a conceptual demonstration of a web-based shop floor portal for the direct training needs of a shop user based on his certification, work being performed, and skill levels. Provide data to demonstrate that proposed solution will meet current network capacity.

PHASE II: Develop a prototype at Tinker AFB and use the metrics defined in phase I to demonstrate its success. Also, prepare a detailed report describing the challenges faced during the pilot implementation, and the methods used to deal with them, and present it to appropriate individuals.

PHASE III DUAL USE APPLICATIONS: The implemented framework could be utilized for training by any commercial or educational institution interested in e-learning.

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5) ADL Website " http://www.adlnet.org "

KEYWORDS: e-Learning, Web-Based Training

AF02-264 TITLE: Simulation of Repair and Rebuild Processes

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a Monte Carlo simulation model of some process in a depot shop.

DESCRIPTION: Many companies use Monte Carlo simulation of their processes to detect and eliminate inefficiencies. These processes include but are not limited to:1. The flow of parts across departments on a factory floor, done to reduce the amount of work in process;2. The flow of chemicals through a refinery;3. The movement of products between factories and from factories to the customer, done to ensure the timely delivery of product to the customer.A Monte Carlo model consists of elements, each element representing one item at the level of resolution of the mode. The elements in a high-resolution model would represent the activities of individuals, single parts, single machines, single conveyors, and single trucks. The elements in a lower resolution model would represent the activities of a department of several individuals, a factory, complete products, and a fleet of trucks.If two elements in a model represent a part casting and a drill press, then the process of using the drill press to drill holes in the casting is simulated by computing how long it would take to mount the part in the drill press, remove the metal by drilling, and remove the part from the drill press. During this time, the element representing the part is not available to other machine tools and the element representing the drill press is not available to process other parts. The model does not actually drill the holes in the part, but simulates this drilling process by computing the time delays, labor requirements, and other costs.A completed model will have many elements, all the elements interacting with each other. The face mill is idle because the part is still being drilled in the drill press. If the face mill is idle too much of the time, the model would reveal this fact and help determine the causes. The model can be easily modified to determine the impact of proposed fixes or modifications to the process.Applied to the operations at a depot shop, the real benefits of this approach become evident during the phase when the depot personnel gain understanding of how their shop actually functions by digging for answers to questions raised in order to complete the model.

PHASE I: Perform a feasibility analysis to select a DoD depot and an appropriate process from that DoD depot. This will involve visiting the depot, presenting the capabilities and limitations of Monte Carlo Simulation, and discussing the various attributes of the possible processes with the appropriate personnel from the depot. Then, perform the necessary research and development of a Monte Carlo Simulation concept package that demonstrates concept with defined metrics for assessing the requirements.

PHASE II: Develop the prototype based on Phase I analysis and defined requirements and test the developed model (the prototype) in a real environment and prove its viability to the management of the depot using the metrics set in Phase I. During this phase, there will be a lot of discussion of the attributes of the processes with the appropriate personnel from the depot. Prepare a detailed final report on the lessons learned and implementation procedures. Based on results, tailor the completed prototype for commercialization and availability for full implementation.

PHASE III DUAL USE APPLICATIONS: With minor modifications, the implemented model could be utilized in any industry.

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KEYWORDS: Repair Simulation, Monte Carlo Model

AF02-265 TITLE: Aircraft Wiring Characterization, Tracking, and Testing System (AWCTTS)

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a low-cost, light-weight, easy-to-operate portable testing system (AWCTTS) for characterization, monitoring, and testing of aircraft wiring.

DESCRIPTION: The USAF has a fleet of aging aircraft. The electrical wiring on these aircraft is in various stages of wear and aging. This wiring is inspected at regular intervals, however many areas are either hidden and/or inaccessible. Chaffing, aging, heat induced cracking in insulation, and damaged connector bodies can go undetected until it causes an electrical failure. This project seeks innovative research to develop a new technology to characterize, monitor, and test aircraft wiring systems. This project should address: (1) ability to characterize the wiring systems of multiple aircraft platforms by weapon system, tail number, wire bundle, individual wire, and connector all by part number. (2) Ability to track, recharacterize, and compare characteristics of wire bundles, individual wires, and connector, all by part number as they age. (3) Ability to locate failures and damage to include but not limited to: shorts to ground, shorts to other wires, breaks, partial breaks, chaffing, cracking in insulation or connectors, dirty, worn, bent or broken contacts. (4) the portable AWCTTS would be easily transportable between aircraft by a trained technician. (5) Tester shall be modular, expandable, and flexible to allow for insertion of faster processors, and expanded volatile and nonvolatile memory, etc. (6) Functions shall be software programmable and PC/Laptop based.

PHASE I: Conduct research to determine feasibility of developing an AWCTTS tester with the following target capabilities: (1) low cost, (2) simplified operation and output, (3) high speed operations, storage and retrieval of data and (4) portable. Determine any required additional test and characterization software and the database and parameters to be used to store, display, analyze and manipulate wire harness characterizations. Develop a planned approach for completing the rest of the system final hardware and software configurations. Demonstrate its capabilities with several types of wire bundles of different lengths, cable types, etc.

PHASE II: Develop the AWCTTS design into a prototype unit, which meets the Phase I target capabilities. Design the tester to provide the user; flexibility, ease of use, instant visual recognition, data input integrity, and the ability to capture and transfer test results. Verify the test set capability on an operational aircraft weapon system. Deliver a working prototype with all software programs, and hardware drawings.

PHASE III DUAL USE APPLICATIONS: This topic is applicable to a wide variety of applications. It is particularly relevant to commercial aircraft wiring, plant maintenance, industrial process control, medical and other applications where system performance is critical and precise and quick repair is needed.

REFERENCES:

KEYWORDS: Automatic cable testing, Wire harness characterization, Aging Aircraft, Reliability and Maintainability

AF02-266 TITLE: Active Bus Analysis and Failure Forecasting

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop hardware and software for automated testing equipment for active bus analysis.

DESCRIPTION: Conduct research to determine feasibility of developing a technically advanced and automated testing system to exercise and monitor active bus operations for the purpose of identifying current bus failures, marginal bus component performance, and predict potential failures on electrical bus systems. Bus wire insulation degrades by chaffing and polymer breakdown due to flight stress, maintenance wear, and age. These conditions cause arcing, shorts, high impedance leaks, and intermittent grounding of communication signals. Bus connectors and pins/sockets loosen, break, and bend during maintenance causing unreliable electrical contact. Matrix relays degrade from both weakened electromagnetic flux for contact, and contact pitting/corrosion. This relay degradation ultimately results in unreliable signal routing operations. Bus transformers often short-to-ground, change impedance/resistance values, and develop improper ratios due to flight stress, cracking, water intrusion, and corrosion. These failures cause noise, lost signal data, and other degradations to bus communication abilities. Degraded buses provide weak signal communications between Line Replaceable Units (LRUs) and bus controllers; this heightens the occurrence of bus faults causing erroneous errors that indicate LRU failures. Degraded bus operations diminish reliable electronic communication among aircraft systems; therefore the mission safety and mission capability is compromised. Poor bus communications that induce erroneous LRU faults and other false indications incur misdirected troubleshooting and maintenance, causing lower FMC Rates, longer aircraft down-time, higher technician workload, and significantly increased maintenance costs at the operations, intermediate, and depot levels. All unsubstantiated and bogus fails caused by degraded bus operations skew trend analysis and failure forecasting systems that engineering and management use to ultimately reduce total ownership cost of the airframe.   Bus maintenance increases proper bus operation and reduces unsubstantiated bogus fails caused by degraded bus components; therefore only real and actual MFL and LRU fail data is input to failure forecasting systems. The refined input data for failure forecasting allows more accurate predictions, which in turn produces more reliable analysis for leaner logistics and advanced maintenance intelligence. Current equipment has proven to be technically inadequate for thorough troubleshooting and fault identification (i.e., no active bus testing capability, improper testing frequencies, no testing frequency flexibility, non-user friendly test equipment, extreme learning curves even for minimal technician familiarity, minimal testing automation, inadequate ability to test for marginal or intermittent components).

PHASE I: Conduct research to develop hardware configurations and intelligent user-friendly software for automated testing of active aircraft buses. This technology should address the following areas: (1) aircraft maintenance history data capture, (2) software engineering for intelligent test programs sets, (3) history data basing for maintenance and failure trend analysis, (4) accurate aircraft bus and electrical systems fault forecasting, and (5) accelerated aircraft bus and electrical system fault isolation.

PHASE II: Develop and demonstrate a prototype system that will meet or exceed the objectives of phase I. Conduct prototype effectiveness on selected aircraft for documentation of prototype operation, and the effects on aircraft failure forecasting input data.

PHASE III DUAL USE APPLICATIONS: The development of active bus testing technology can be adapted to support all military, government, and commercial air frames, technologically advanced naval vessels, command and control center electronics, and other federal, state and local governments that use equipment with similar type electronic bus systems. Commercial computer systems have a broad array of bus and wiring systems for communications, which provides an enormous potential commercial market.

REFERENCES:

1. Cynthia Furse & Randy Haupt, "Down to the Wire", IEEE Spectrum, FEB 2001, pp 35-39

2. MBFI World Wide Conference 2000, Hill AFB, UT, JUN 00

3. Proud Falcon Report, 93rd Fighter Squadron, Homestead AFB, FL, OCT 1997

4. Mako Proud Falcon Report, 93 FS Homestead AFB, FL, NOV 2000

5. Proud Falcon Successes Report, Falcon Sq. Nellis AFB, SEP 1994

KEYWORDS: Aircraft Fault Analysis, Preemptive Maintenance, Aircraft Failure Forecasting, Reduce Total Ownership Cost, Mux Bus Maintenance

AF02-267 TITLE: Sound Technology For Test And Diagnosis

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and implement methods for analyzing component defects using Sound Technology.

DESCRIPTION: The purpose of this topic is to focus on testing and diagnosing failures in printed circuit board components utilizing sound/ultrasound technology. The topic specifically focuses' on using Sound Technology hardware and software methods to test printed circuit board components for defects. Sub-micron analysis could be achieved utilizing reflective technology. Sound reflection is proportional to a material's density creating a time (depth) dependent signature that can isolate problems at their level of occurrence. It should be possible to identify defective component substrates utilizing reflective sound technology. The technology could focus on methods of scanning circuit boards with a sound wave component to determine defects. Dynamically controlled motion is preferred so a 3-D measurement can be achieved, and a clear view of a component's structure is visible. New software allows the stacking of multiple images for multi-dimensional analysis.

PHASE I: Conduct research and determine feasibility of focusing on hardware and software methods to analyze component defects using Sound Technology.

PHASE II: Develop a detailed prototype design to create and implement the technology of Phase I.

PHASE III DUAL USE APPLICATIONS: The technology is applicable to a wide variety of applications and processes. It is particularly relevant to aircraft, plant maintenance, industrial process control, medical and other applications where system performance is critical and repair should be quick and precise.

REFERENCES:

KEYWORDS: Test & Diagnosis, Sound Technology, Hardware and Software

AF02-268 TITLE: Advanced Composite Materials Replacement on Metal Structures/Shelters

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Provide and identify suitable composite materials to replace the existing heavy and corrosion-prone materials in metal-based structures or shelters.

DESCRIPTION: DOD spends millions of dollars every year to repair and refurbish numerous metal structures or shelters located all over the world. Composite materials, which are not prone to corrosion, have the potential to offer a lighter weight replacement material for structure or shelter, thereby reducing cost. The proposed objectives for this composite material replacement process are as follow: (i) Reduce manufacturing costs (ii) Reduce shelter foot-print to comply with the Air Force Expedition Force requirements (iii) Shall be environmentally safe for human occupation per ASTM E1925.

PHASE I: Conduct research and determine feasibility of replacing current metal-based materials with composite materials in the manufacturing process with the following target capabilities: (i) The materials shall be of low cost and readily available (ii) The materials shall be non-toxic and fire resistant/retardant (iii) The structure or shelter main components (such as I beam, wall panels, trusses etc.) shall be made of 100% composite materials (to minimize galvanic corrosion), and these components shall have the same or greater strength as their metal counterparts (iv) Shall meet current requirement of the metal structure or shelter as specified in ASTM E1925 (v) Final total life cycle cost should be significantly less (50% or better) than a comparable metal structure or shelter.

PHASE II: Design and develop a process to construct a commercially viable composite structure or shelter. Structural analyses by computerized simulation shall be conducted to ensure the structure will meet or exceed ASTM standard E1925. Build and test a prototype composite structure or shelter using the proposed process in according with ASTM E1925.

PHASE III DUAL USE APPLICATIONS: The proposed composite structure or shelter will have numerous benefits to the military and industrial communities. They are as follow: Commercial trailers for trucking and railway. Offshore applications for ships, shipping containers, service vessels, platform, and undersea facilities etc. Composite structures for residential dwelling as well as commercial service “bare base” hangar. Replace numerous existing corrosion-prone and aging DOD metal shelters and containers.

REFERENCES:
1. ASTM E1925, Specification for Engineering and Design Criteria For Rigid Wall Relocatable Structures
2. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000
3. Advanced Composite Structures: Fabrication and Damage Repair, Abaris Training, May 1998.
4. Paints, Coatings, and Corrosion Control in Manufacturing, University of Wisconsin-Madison, March 1999.
5. MIL-STD-1472D, Notice 3, Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

KEYWORDS: Composites, structure or shelter, ASTM E1925, reduce foot-print, environmentally safe

AF02-269 TITLE: Performance Based Support Model

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop new and innovative affordable processes to logistically support systems and equipment developed under Performance Based Acquisition (PBA) policies.

DESCRIPTION: Department of Defense PBA policies have provided new opportunities to reduce defense costs while taking advantage of commercial advances in technology. The resulting Flexible Sustainment Initiative by the Joint Aeronautical Commanders has extended these policies to include the logistical support of fielded and mature weapon systems. In the past, the government has paid a premium to repair and replace high failure assemblies and components with identically configured technology, which tended to exacerbate both cost and obsolescence problems. The new business practices that incorporate performance based concepts, provide opportunities to reduce total ownership cost by inserting current technology that increases reliability and performance, while eliminating obsolescence problems. These new opportunities also present some unique challenges in logistic support. Assembles and components procured with a performance based specification may have different configuration and parts from the original equipment and therefore have different support requirements. Traditional logistic practices are based on identical configuration, internal operation, and parts for replacement equipment at all levels. As technology evolves, system sustainment managers are faced with the challenge of supporting totally integrated functions comprised of firmware, hardware and software, that require rigorous integration testing to ensure they operate seamlessly with the entire weapon system. The new paradigm requires only identical form, fit, interfaces and functional equivalence. In each case, the benefits of PBA must be optimized in terms of cost, reliability, performance and obsolescence. New logistic support process models are required for the functionally equivalent equipment that will continue to be procured under PBA policies. Research is required to develop new process models to evaluate the most mission effective and cost efficient means to logistically support equipment and replenishment spares acquired in the PBA environment. The research should explore new ways to detect degrading performance prior to failure, and alternatives to the traditional integrated logistic support functions of provisioning and resupply, from a cost/benefit perspective. It should also consider the evolving concepts of an autonomic supply system envisioned for the joint strike fighter.

PHASE I: Conduct research and focus on identifying new logistic support process models. Develop one or more models that will demonstrate their effectiveness. Develop detailed design and evaluation criteria for each model.

PHASE II: Develop a prototype to demonstrate and evaluate methods defined during Phase I.

PHASE III DUAL USE APPLICATIONS: Commercialization will be based on the ability of the process models to support PBA integrated logistic support processes. Significant government and commercial markets exist for this technology in industrial processes. The product will be a software Decision Support System (DSS) product that considers cost and responsiveness. The PBA products that enter the DoD inventory through acquisition reform, employ new technology, which is typically much more reliable.

REFERENCES:
1. Joint Logistics Commanders Performance-Based Business Environment (PBBE), Flexible Sustainmnet Guide, August 1997.

2. "Final Report for the JAST Advanced Strike Integrated Diagnostics (ASID) Concept Definition and Design (CDD)," Joint Advanced Strike Technology Program TML - Advanced Integrated Diagnostics, Arlington, VA, 1996.

3. F-16 Falcon Flex Guide, Ogden Air Logistics Center, F-16 Management Directorate (00-ALC/LF), Hill AFB, UT, June 30, 1998.

KEYWORDS: Performance models, Acquisition, Flexible Sustainment, Logistics Support

AF02-270 TITLE: Advanced Molecular Coating Process

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Provide a low-cost, effective process to stop corrosion on any surface.

DESCRIPTION: DOD spends billions of dollars every year to repair/refurbish equipment/shelters/weapon systems due to the corrosion problems that caused by exposure to the environment, especially severe weather such as high humidity and salty coastal air. There are many current coating techniques that can be used (conventional painting, powder coating, electro-plating, composite coverings etc.), but some of these processes are not environmental friendly, required intensive preparations, and none offer long-term protection. This project seeks a low cost coating process that will offer long-term protection against the above problems. Additional objectives are as follow: (1) The process shall be non-toxic & environmental friendly, (2) it shall be easy to apply (using conventional means) and storage, (3) and it shall be easy to use at the field maintenance level.

PHASE I: Conduct research and determine feasibility in designing a low cost coating formula with the following target capabilities: (1) Provide corrosion protection for major DOD weapon systems (shelters, ammunitions etc.), (2) the coating formula shall be able to work with different type of substrates (bare metal & painted surface etc.)

PHASE II: Develop a commercially viable prototype coating product, which will meet or exceed all EPA guidelines for coating materials. Proof of concept to be proving on a wide variety of test subjects under severe weather condition in different remote area.

PHASE III DUAL USE APPLICATIONS: The proposed coating process will have numerous benefits to the military and industrial customers as well as the environment. They are as follow:- Applications on machinery exposed to severe coastal weather.- Off-shore applications for freighters, service vessels, platform, and undersea facilities.- Replacing toxic electro-plating processes for corrosion control purposes.

REFERENCES:
1. ASTM E19252. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000

KEYWORDS: Coating, Corrosion, low cost, Corrosion Inhibitors

AF02-272 TITLE: Semi-automatic or automatic development of Test Program Sets (TPS) without a board model using hardware reconstruct

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and implement automated methods to create a TPS without using a board model.

DESCRIPTION: Standardized model-based simulation methods presently used to develop Test Program Sets, which are used for testing and repair of aircraft avionics systems, are problematic and high cost. Board model methods use theoretical philosophies that endeavor to duplicate the actual functionality of the Unit Under Test (UUT). Test Program Sets (TPS) for UUTs should be developed automatically or semi-automatically without using a board model of the actual avionics hardware. Applying techniques to perform TPS development using random generation of stimulus signals and monitoring a typical response from the actual UUT hardware can be used to determine UUT functionality. Hardware modeling presently exists to perform UUT duplication, so random but controlled pattern sets can be applied and the responses monitored to create a TPS. There are systems available to reconstruct or duplicate a hardware configuration on a test platform. A software method and hardware configuration needs to be developed to create Test Program Sets (TPS) automatically or semi-automatically.

PHASE I: Conduct research and determine the feasibility of a software method to control Automatic Test Equipment (ATE) instruments and a hardware duplicator to automatically or semi-automatically develop a TPS.

PHASE II: Develop a prototype software program to control Automatic Test Equipment (ATE) instruments and a hardware duplicator to automatically or semi-automatically develop a TPS.

PHASE III DUAL USE APPLICATIONS: The technology underlying this topic is quite generic, and is applicable to a wide variety of applications and technologies. It is particularly relevant to aircraft and plant maintenance, industrial process control, medical, and other applications where large numbers of diverse signals are monitored, and overall system performance is characterized through the interpretation of the combination of signals, in addition to the discrete interpretation of individual signals.

REFERENCES:
SYNOPSIS www.synopsys.com/products/lm/hw_models/hw_systems.html

KEYWORDS: 1. Automatic Test Equipment 2. Stimulus devices 3. Sensors 4. UUT Hardware Imitators 5. Hardware Models

AF02-276 TITLE: Compact Hydrogen Storage using Metal Hydride

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop innovative methods to store hydrogen on-board vehicles and ground support equipment using a metal hydride, cryogenic hydrogen, or other innovative technology such as graphite nano fibers.

DESCRIPTION: A major drawback to using hydrogen to power a fuel cell is storage procedures. Current methods of storing hydrogen in a gaseous or liquid form do not offer the energy density of conventional gasoline per unit volume. This leads to a host of problems. The goal of this SBIR project is do applied research that will gain knowledge and understanding necessary to produce a useful method to store Hydrogen using a metal hydride or other high-density hydrogen medium. The medium will be deployed on a vehicle or ground support equipment to power a fuel cell and should strive to provide comparable energy density per unit volume to gasoline. The technology must also demonstrate a reasonable re-fuel rate.

PHASE I: Research will determine which particular hydride or other medium will result in the desired energy storage density. Integration of this technology to the ground support equipment must also be explored. The study will investigate existing gravimetric, volumetric and refueling parameters with improved storage performance parameters.

PHASE II: Develop a prototype storage unit using the metal hydride or other technology to produce the desired energy storage density and other parameters.

PHASE III DUAL USE APPLICATIONS: The storage device would provide a leap forward in providing a commercialized fuel cell power generation for aviation and other transportation industries. While fuel cells are coming at a rapid rate we must be ready with the technology to provide for their fuel.

REFERENCES:
1. MSGT Robert Wertz, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Metal Hydride, Fuel Cell, Hydrogen, Electric Vehicles, and Graphite Nano Fibers

AF02-277 TITLE: Micro JP8 Fuel Reformer

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop a miniature JP8 Hydrogen fuel reformer to produce high quality Hydrogen.

DESCRIPTION: Currently, efforts are underway to reform JP8, the single battlefield fuel, into hydrogen for use in fuel cells for power generation. Present day reformers are large, heavy and provide little commercial or warfighting potential due to limited mobility. This SBIR project will minimize JP8 reforming while maintaining production levels of 150 cfm @ 5000 psi of high quality hydrogen. The reformer must fit on a light duty (½ ton or ¾ ton) truck or vehicle and must be able to be off loaded with the use of heavy machinery.

PHASE I: Research the feasibility to produce a JP8 reformer with the hydrogen production capability as well as the mobility requirements stated in the description.

PHASE II: Develop a prototype for initial test and evaluation of this new technology.

PHASE III DUAL USE APPLICATIONS: Since JP8 is one of the most difficult fuels to reform into hydrogen, making this technology mobile will allow it to be taken forward by the military. However, it will also advance reforming technology promoting civilian use of JP8 and diesel reforming. The prototype will allow future fuel cell powered Aerospace Ground Equipment and other fuel cell technologies, for military and commercial industry, greater access by increasing fuel availability worldwide.

REFERENCES:

1. www.hydrogen.no/Wurster/lecture.htm,

2. http://www.calstart.org/about/pngv/pngv-0305.html

KEYWORDS: JP8, Hydrogen, Reforming

AF02-278 TITLE: Advanced Electric Vehicle Research

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research the feasibility of emerging electric drive technology based on Air Force vehicle fleet needs and operational parameters and demonstrate that new technology can meet these needs.

DESCRIPTION: Perform initial applied research to gain knowledge and understanding with follow on technology demonstration to provide the next step in electric vehicle transportation technology. The focus of the applied research is to gain knowledge on various types of new battery chemistries currently being developed. Combine these new battery types with various new types of power conditioning and power electronics and the potential exists for a new generation of electric drive technology to be created. Currently the Air Force has over 80 S10 electric pickup trucks that will be used as a baseline and platform for the phase II demonstration effort.

PHASE I: Gain knowledge and understand of the new types of electric drive component technologies and using this applied research, develop a systems integration plan that will allow the technology to be demonstrated in phase II. Computer simulations provide significant feasibility and practicality of design and that components are nearly available for manufacturing. Plan should ensure system meets environmental issues, including electromagnetic interference, safety, and possesses a lower life cycle cost than current configurations.

PHASE II: This demonstration phase will showcase the performance parameters discovered during the applied research phase will meet Air Force needs in the commercial vehicle fleets.

PHASE III DUAL USE APPLICATIONS: This technology could provide an almost pollution free source of public transportation for the commercial sector and government use. Since the Army has now said all of its vehicles will be electric drive by 2010 it provided more advanced technology for not just the Air Force but DoD as a whole.

REFERENCES:

http://www.epri.com/

KEYWORDS: Batteries, Electric Drive, Buses, Clean Air, S10 EV

AF02-279 TITLE: 72kw Hydrogen Fuel Genset

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop a mobile Fuel Cell meeting current military –60 power generator configuration and requirements for Joint Strike Fighter/F-22 weapon systems.

DESCRIPTION: Currently the Air Force has a growing need for clean support equipment. This SBIR will conduct applied research into which fuel cell technology can meet that need to power aircraft with 400Hz and 270vDC, similar to our existing –60 and –86 Mobile power generators that are used on flight lines. 72kw should be available to a single or combination output of 100V AC single/three phase 60/400 Hz and or 28/270 V DC. Expand on the commercial leaders methods, for portable energy generation that specifically meets the needs of Air Force and Department of Defense yet is flexible enough for commercial use. This level of loading and transient response profiling has never been accomplished nor attempted from fuel cells before. The physical design must meet or exceed the existing platform for an improved and seamless integration this alone is another large technical barrier that must be addressed.

PHASE I: Conduct applied research into various fuel cell and power conditioning technologies that meet or exceed the current –60 power generator specifications while analyzing the best fuel source considering battlefield availability. The research must consider mobility, safety, and environmental issues.

PHASE II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

PHASE III DUAL USE APPLICATIONS: Civilian as well as military flightlines use mobile gensets as well as other non-flightline applications where mobile power is required. Current diesel non-road engines are large sources of air pollution and impending regulation from EPA will force both civilian and military to clean up.

REFERENCES:
1. MSGT Robert Wertz, AEF Battlelab, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Genset, Fuel Cell, Hydrogen, Aircraft Power, Mobile Power

AF02-280 TITLE: Aircraft Wiring Inspection System

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a wire inspection system/technique that can non-intrusively inspect aircraft electrical wire preferrabley without disconnecting the cannon plugs.

DESCRIPTION: Aging Aircraft wire related Mishaps have received a lot of attention since the TWA 800 accident. Methods and techniques must be developed to allow determination of the wiring systems in aircraft structure. Wiring failures are causing mission loss and are a major contributor to mishaps related to electronics. Wiring failures also require extensive diagnostic testing, troubleshooting and repair, which significantly add to Air Force sustainment costs.

PHASE I: Preliminary/conceptual design for the wire inspection system will be developed and its feasibility will be demonstrated. A test of at least one set of critical wiring bundle will be performed to prove the efficacy of the wiring inspection system. Develop a sensory and prognostic system design and methodology that includes sensor specifications and software support for prognosis and diagnosis for wiring the prognostic and diagnostic system must account for fiber performance, connector interface performance, and signal attenuation. The prognostic algorithms must also estimate the time element for future performance degradation. The prognostic/diagnostic system should demonstrate a proof-of-principal prototype incorporating selected sensors. Demonstrate detection and prognosis capability with near location of suspected fault indication, connector or fiber.

PHASE II: Develop diagnostic equipment and procedures necessary to assess the integrity and residual life of the optical wiring. Build an optical test system to demonstrate portable field and or space application inspection capability of the system. The wire inspection concept developed in Phase I will be applied to wiring systems in the actual F-15 aircraft.

PHASE III DUAL USE APPLICATIONS: Aircraft certification, vehicle safety and manufactureer liability concerns are major reasons for utilization of this technology. With the continued aging of both commercial and military fleets, wiring problems will continue to grow. The ability to easily replace metallic wiring systems with optical systems is needed in the aerospace, automotive and construction industries. The diagnostic tools developed under this SBIR wil have widespread use.

REFERENCES:
1. Proceedings of the SAE Aircraft Safety Conference, April 1999

2. "Prognostics for Wiring: Managing the Health of Aging Wiring Systems," Third Joint FAA/DOD/NASA Conference on Aging Aircraft, September 1999, with G. Smith, J.B. Schroeder, Air Force Research Lab, R. McMahon Raytheon, K. Blemel, Management Sciences, Inc.

KEYWORDS: Optics, Prognostics, Diagnostics, Sensors, Wavelength Division Multiplexing, Portable/miniaturized

AF02-281 TITLE: Inspection of Subsurface Flaws Around Fasteners on Aircraft

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an inspection system/technique that can inspect for subsurface flaws around fasteners on the aircraft.

DESCRIPTION: With the many aircraft within the Air Force becoming older there is a need to inspect for cracks and flaws at the origination of these cracks. Presently these cracks are not found until the aircraft has been removed from service and some disassemble done and or during flight some problems occur. These cracks and flaws are causing troubleshooting and repair, which significantly add to Air Force sustainment costs. A major drawback to utilizing current methods of inspection requires the aircraft to be removed from service and disassembled for inspection. This leads into a host of problems. The goal of this SBIR project is to research a method to inspect for these subsurface flaws without removing the skin of the aircraft.

PHASE I: Research and develop a method to detect subsurface cracks in aerospace vehicles. Demonstrate the ability to detect 0.050-inch corner flaws emanating from fastener holes located on the wing of the aircraft. Demonstate concept feasibility. Demonstrate the ability to detect corner flaws between layers 1 and 2, 2 and 3, and 3 and 4 is necessary. Design the prototype system to be built in Phase II.

PHASE II: Develop and demonstrate a portable, easy to use, and cost effective system to be used on the outside of the aircraft. This system should be able to detect the subsurface flaws on the aircraft without removing the skin of the aircraft. Develop and demonstrate the system prototype on a demonstration article representative of the actual C-141/F-15 structure. Review prototype design with AF personnel for robustness, integration with existing practices and ability of AF personnel to have the prototype unit maintained and repaired. Buid the prototype unit. Demonstrate the operability to AF personnel and provide a users/maintenance manual for expected operation.

PHASE III DUAL USE APPLICATIONS: Potential applications include inspection of metallic structures including commercial aircraft, naval vessels, automobiles, and rail systems or building structures. Potential customers include aerospace, nuclear, marine, and automotive concerns, FAA, DoD and the DOE.

REFERENCES:
1. ASM Handbook, Nondestructive Evaluation and Quality Control, vol. 17, J.R. Davis, S.R. Lampman, ASM International, 1994, Ultrasonic Testing of Materials, Krautkramer, Krautkramer, Springer Verlag, 1990.

KEYWORDS: Nondestructive inspection, Crack detection, Inspection

AF02-282 TITLE: Inspect Composite Components of the Aircraft

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an inspection system/technique that can inspect the composite components of the aircraft.

DESCRIPTION: Many types of aircraft components are now made of composite materials. There remains the need to continually inspect critical areas for disbonds and delaminations within the core of the component. These critical areas include everything from speed brakes, rudders, propellers, aeirons, and other airframe components. The disbonds and delaminations can occur for a variety of reasons i.e. bird strikes, mechanics dropping tools or running equipment into the components. Damage to a component allows water to be trapped thus causing extensive diagnostic testing, troubleshooting and repair, which significantly adds to Air Force sustainment cost. A method or instrument is sought with the ability to detect subsurface flaws in composite materials. The instrument should be portable, easy to use, and cost effective.

PHASE I: Research and develop a method to detect damage/flaws in composite components in aerospace vehicles. Demonstrate the ability to detect disbands and delamations within the composite material on an F-15 component.

PHASE II: Develop and demonstrate a portable, easy to use, and cost effective system to be used on the outside of the aircraft. This system should be able to detect the subsurface flaws on the aircraft. Apply the results of Phase I to the design, fabrication, and experimental validation of the prototype unit. Demonstrate the operability to AF personnel and provide a users/maintenance manual for expected operation.

PHASE III DUAL USE APPLICATIONS: Potential applications include inspection of composite structures including commercial aircraft. Potential customers include aerospace, FAA, DoD and the DOE.

REFERENCES:

KEYWORDS: Aging aircraft, NDE, NDI, inspection

AF02-283 TITLE: Sled Vehicle Aerodynamic Load Prediction Capability

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Develop a rapid and accurate computation capability to determine aerodynamic forces and heating on test track ground test vehicles.

DESCRIPTION: The Holloman High Speed Test Track (HHSTT) at Holloman Air Force Base, New Mexico, is a ground-based aerospace test facility used for testing various DoD systems including missile guidance, aircraft crew egress, weapons, and countermeasures. Testing is conducted with single-stage and multiple-stage rocket boosters to accelerate test articles to desired speeds. The test speeds range from the subsonic regime of a few hundred feet per second to hypersonic speeds of ten thousand feet per second. For all missions, rocket sled vehicle aerodynamics in proximity to the ground is a major consideration for structural and thermal design. Test Track engineers normally use hand calculations and past experience to make pre-test loads and trajectory performance estimates. However, new test requirements result in the need to reduce design margins to meet higher velocity/payload requirements. To reduce design margins, load estimates need to be more accurate than the current techniques. Currently, when very accurate estimates are needed, Computational Fluid Dynamics (CFD) is used to estimate the aerodynamic conditions. Unfortunately, CFD analyses are often very time-consuming and do not meet customer's schedule requirements. Therefore, the Holloman High Speed Test Track has a need to develop procedures and tools that test engineers can use to accurately and rapidly predict aerodynamic forces acting on test vehicles as well as aerodynamic heating on high speed sleds. For example, the build-up or "stacking" of 3-D geometrical components is one possible procedure for computing aerodynamic and aerothermal loads on any arbitrary sled vehicle. Since the 1970's, NASA/Goddard Sounding Rocket Division has successfully used a concept of building-up or "stacking" of 3D geometrical components with known aerodynamic characteristics to quickly and accurately generate aerodynamic forces on supersonic atmospheric flight vehicles. This concept is implemented in commercial software products such as JA-70, LANMIN, AVID, SHABP, and others developed under funds provided by NASA and the DoD. Unfortunately, these software products do not account for ground plane effects on the aerodynamics. Other concepts for the development of a flexible, accurate, and responsive aerodynamic prediction tool and/or tools to solve these problems could also be developed. Integrating the effects of the Test Track ground plane shock reflection and multiple body interference will be the highest risk area in this effort.

PHASE I: Determine the technical feasibility of a quick and accurate aerodynamic load prediction tool that includes the effects of complex ground planes and multiple bodies. Conceptually design the engineering tool that can be used to generate aerodynamic data for real-world sled vehicles.

PHASE II: Complete the design and development of the aerodynamic prediction software tool. Based on actual sled test data and CFD, validate the prediction accurately models the range of sled test vehicles including: dual rail sleds, monorail sleds, velocities from low subsonic to Mach 10, multiple stages, etc.

PHASE III DUAL USE APPLICATIONS: 1. Any and all military ground vehicles could benefit from this tool. With the tool operational, ground vehicle designers could produce more effective designs and ultimately more efficient vehicles. 2. Automobile Industry: To design safer, more fuel-efficient consumer automobiles by populating the database with tailored or unique performance test data. 3. Railroad Industry: To design faster, more stable passenger and freight rail systems. 4. Commercial Aircraft Industry: To provide a database specifically designed to evaluate new designs during transition from taxi-to flight.

REFERENCES:
1. AIAA 96-0290, Aerodynamic Computation of Integrated Missile-on-Sled Vehicles, S.C. Praharaj and R.P. Roger, AIAA 34th Aerospace Sciences Meeting, Reno, NV, January, 1996.

2. AIAA 2000-2288, Requirements for Upgrading the Holloman High Speed Test Track Computational Fluid Dynamics Analytical Capability, William P. Schoenfeld, 21st AIAA Advanced Measurement and Ground Testing Technology Conference, Denver, CO, June 2000.

KEYWORDS: GROUND VEHICLE DESIGN, GROUND EFFECT AERODYNAMICS, AERODYNAMIC DESIGN TECHNIQUES, HYPERSONIC ROCKET SLEDS,

AF02-284 TITLE: Cellular Telemetry of Flight Test Data

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Conduct a systematic study to gain knowledge and understanding necessary to determine the means and feasibilty of a real-time flight test data acquisition, display and analysis capability for a large quantity of measurement parameters in multiple Inter-Range Instrumentation Group (IRIG) formats that uses low-cost, commercial cellular and satellite telephone technology and systems as an alternative to dedicated ground stations. The techical risk is developing encoded, encrypted and errorless data compression techniques at narrowband telemetry equivalency while addressing the ciritcal requirement for accurate time-tagging using commericial celluar telephony technology.

DESCRIPTION: Telemetry is used to transmit flight test data from aircraft to ground-based stations where it is recorded, analyzed, and displayed in real time. Current systems employ high frequency radio transmission that requires a ground station within line-of-sight to the test aircraft. This traditional method of test uses established range facilities or requires the use of mobile ground stations, both of which have limited geographical coverage and are costly to establish and operate. Further, current systems compete with other commercial and government users for diminishing spectrum bandwidth, which severely limits the number and timing of critical test programs. Cellular and satellite telephone technology has the potential to eliminate dependence on fixed geography ranges and mobile ground stations, there by allowing tests to be performed anywhere access to a cellular network or satellite is available. It has the further potential to substantially lower the cost of obtaining flight test data by leveraging commercial data networks and telecom equipment. Flight test data in standard IRIG formats can be sent to data recording, analysis and display centers by existing cellular or satellite telephone networks or by a dedicated network of low-cost cell sites. Techniques are available for encrypting and compressing the data to overcome bandwidth limitations of telecommunications protocol.

PHASE I: Conduct a systematic study of the compression, transmission (by cellular telephone network), decommutation, and display of telemetry data based on emerging celluar telephony technology. The study will address those critical elements and the basic components of the technologies to meet the operational requirements. Produce an unconstrained plan that will address the approach, technology (available and required), schedule and cost to achieve the requirement objective. The goal of the study is to identify potential data compression techiques and protocols to include visually lossless compression that would provide errorless data transmission equivalency. Maximum anticipated data rates will be identified.

PHASE II: Select the most promising approach to meet the stated objectives and conduct development and integration efforts of hardware for field experiments and test. The results of this effort would be a proof of technology feasibilty and would include an assessment of operability and producibility of a flight test rated data acquisition system that will encode, encrypt and send multiple Pulse Code Modulated (PCM) streams of data. Conduct a proof-of-principal demonstrations of a laboratory system that will recover record and display the data, including parameters mathematically derived using multiple data channels from any stream, in real time. The system will be validated by recorded measurements taken during flight-testing that would be used as source data and compared to the results obtained from conventional telemetry.

PHASE III DUAL USE APPLICATIONS: Numerous applications exist for low-cost, wireless data communications that can be used over a broad geographical area. Spin-on examples include flight-testing of commercial aircraft; vehicle health monitoring for cars, trucks, ships, busses and aircraft; medical monitoring of patients; biological monitoring and tracking of animals; and machinery monitoring and diagnostics from a remote location.

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KEYWORDS: Cellular Digital Packet Data, Cellular Telemetry, Data Acquisition, Flight Test Data, Cell Phone Applications, Cell Phones in Airplanes

AF02-286 TITLE: Electromagnetic Modeling and Simulation (EMMS) Capability

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine if system level electromagnetic (EM) analyses of complex aircraft configurations are possible through integration of component level analysis techniques.

DESCRIPTION: Deployment of modern weapons systems on operational aircraft requires an intensive system level engineering analysis of EM effects to assure aircraft/store compatibility and safety of flight. An urgent need currently exists in all system program offices to evaluate weapon system performance in realistic operational environments. In addition, as emphasis on development and deployment of directed energy weapons proliferates, a critical need exists for methods to evaluate operational suitability, safety, and effectiveness (OSS&E) of systems operating in hostile and friendly (fratricide) EM environments. The growing complexity of electronic systems and the resulting increase in susceptibility to EM effects, coupled with the over-crowding of the EM spectrum, dictate a critical need for improved analysis methods for the evaluation of EM effects. Traditionally, EM analysis has relied almost exclusively on extensive and very costly ground-based tests like anechoic chamber testing of complete aircraft/weapon systems that provide only limited insight. The numerous combinations of test parameters required for an overall EM effects analysis make complete testing of complex configurations prohibitively expensive. A computer-based system level simulation and analysis capability could significantly improve the efficiency of ground-based testing and substantially reduce certification time and costs. While component level computational analysis techniques are well developed and well understood, the same is not true for system level analysis. Research is needed to bridge the gap between component level and system (e.g., aircraft) level EM phenomenology understanding. Knowledge gained from this research can then be applied toward the development of high-fidelity system level analysis techniques that can be used to streamline the aircraft-store certification process.

PHASE I: Develop and demonstrate the feasibility of combining component level EM analysis methods to perform accurate system level analysis. Propose a methodology for validating the system level EM analysis.

PHASE II: Develop and demonstrate a prototype EMMS computer program in a geometrically complex system environment. Conduct testing to prove feasibility of EMMS system level analysis.

PHASE III DUAL USE APPLICATIONS: In addition to Air Force and other service applications, any organization concerned with EM effects in EM rich environments will benefit from the EMMS concept. Commercial manufacturers can use EMMS technology to design and evaluate electronic suites to minimize mutual interference between various electronics components. EMMS technology will allow commercial manufacturers the ability to evaluate EM compatibility with realistic external EM environments.

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1. Advances in Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove, Artech House, 1998.

2. The Finite Element Method in Electromagnetics, Jianming Jin, John Wiley and Sons, Inc., 1993.

3. Computational Electromagnetics, ed. E.K.Miller, L. Medgyesi-Mitschang, E.H. Newman, IEEE Press, 1992.

4. Computational Methods for Electromagnetics and Microwaves, Richard C. Booton, Jr., John Wiley & Sons, Inc, 1992.

5. Computational Methods of Electromagnetic Scattering, Andrew F. Peterson, Scott L. Ray, and Raj Mittra, IEEE Press, 1998.

KEYWORDS: Electromagnetic; Electromagnetic Fields; Electromagnetic Pulse; EMP; Electromagnetic Interference; EMI

AF02-287 TITLE: Hybrid Computational Fluid Dynamics (CFD) Analysis System for Rapid Assessment of Store Separation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine if a structured/unstructured (hybrid) CFD analysis system can provide rapid assessment of store separation.

DESCRIPTION: Certification of new weapon systems and new weapon combinations (configurations) on operational aircraft requires intensive engineering analysis of store separation behavior to ascertain operational limits to maintain safety of flight. The acquisition of high-fidelity aerodynamic data plays a critical role in this analysis process. Traditionally, wind tunnel data have provided the bulk of the data used in store separation analysis. Unfortunately, the acquisition of new wind-tunnel data generally requires long lead times and incurs significant costs. Methods are sought that can augment and possibly supplant wind tunnel data by providing high-fidelity aerodynamic data and analysis on a significantly shorter time schedule. A CFD based store separation analysis computer program (BEGGAR) exist that meets the basic requirements. While BEGGAR has proven effective in accurately predicting store separation trajectories from aircraft, it is still a very labor-intensive and time-consuming process to build and assemble the three-dimensional structured grids upon which aerodynamic flow solutions are computed. While structured grids, offer advantages in solution and memory usage efficiency, they are ill suited for automated adaptation to aerodynamic flow features such as shocks and vortices and are difficult to construct around the complex surface geometry associated with some modern air-delivered weapons. Unstructured grids offer advantages such as adaptive mesh refinement and simplified grid construction around complex shapes, but they require more memory and are generally less efficient from a flow solution standpoint. With these concepts in mind, an innovative methodology is sought to combine the advantages of both types of grids/flow solvers into a single program for rapid assessment of store separation characteristics from combat aircraft. This methodology should allow the assembly of unstructured and structured grids into a hybrid assembly using automated chimera functions/structures, provide a means to compute Navier-Stokes and Euler CFD solutions on the complete hybrid grid assembly, and account for time-accurate independent motion of grids (necessary for store motion relative to the parent aircraft). Ideally, the methodology will use object-oriented design and programming techniques (modular design) for code re-use in other applications.

PHASE I: Investigate the feasibility of combining a chimera type of structured CFD algorithm with an unstructured CFD program to form a hybrid chimera-CFD program. Provide an assessment of the improvement (if any) over existing methods for performing store separation analysis. Improvements should address reducing grid generation time, reducing grid assembly time, and adding solution adaptation capability. Identify and evaluate suitable algorithms that could become components in a hybrid CFD store separation analysis program. If a hybrid chimera-CFD program is feasible, a preliminary design should be developed. The design should consider best methods for exchanging data between structured and unstructured grids, including methods for exchanging turbulence model data. Modularity should be emphasized. The end-product shall be a detailed report, and the report should include end-user requirements, a conceptual methodology, and a design for assembling unstructured grids with structured grids for the purpose of store separation simulation.

PHASE II: Evaluate the Phase I preliminary design and modify as required. The design will include parallelization and must be modular to facilitate independent development and revision of the parent codes from which the hybrid system is derived. Develop and deliver a prototype hybrid CFD store separation analysis system based on the revised design. Perform verification of the design by computing store separation trajectories and comparing with benchmark cases. Provide an assessment of the improvement over the existing CFD methodology by comparing grid generation and assembly time of the new approach with the previous, structured-grid-only approach. Identify areas for potential improvement and propose design improvements.

PHASE III DUAL USE APPLICATIONS: A modular design will allow other chimera CFD developers to rapidly integrate the unstructured features (module) into their applications. Military and commercial applications include helicopter rotor aerodynamics simulation, rocket booster separation analysis, multi-element wing design, and many other simulations involving bodies in relative motion in complex flow fields.

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1. Jolly, B. A., and M. Rizk. 1999. A Newton-relaxation Finite Volume Scheme for Simulation of Dynamic Motion. In Finite Volumes for Complex Applications II Problems and Perspectives, ed. R. Vilsmeier, F. Benkhaldoun, and D. Hanel. 2nd Annual International Symposium on Finite Volumes for Complex Applications Problems and Perspectives, 19-22 July, Duisburg, Germany. Paris: Hermes.

KEYWORDS: CFD, Fluid Dynamics, chimera, unstructured grids, object-oriented programming (OOP), multidisciplinary design, parallel programming

AF02-288 TITLE: Global Positioning System (GPS) Simulator Phase Calibration

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate an automated integrated GPS Radio Frequency (RF) phase calibration method to interface directly with existing GPS satellite constellation simulators. Measure the relative phase delays that exist between RF outputs for multiple simulated satellite channels, and calibrate the simulator to compensate for these delays.

DESCRIPTION: GPS Real-Time Kinematic (RTK) techniques utilize the RF characteristics as transmitted from the satellites to compute very accurate vehicle position data. To simulate this environment, an identical carrier frequency has to be generated for each satellite across multiple RF outputs. Because of the architecture, firmware, etc. of existing satellite constellation simulators, the simulated carrier frequencies for each GPS satellite (simulator channel) are not in phase across multiple RF outputs, thus producing a signal delay that does not exist in the "real world". This limits submeter rather than millimeter position accuracy when RTK techniques are used. The need exists for a system capable of interfacing with the RF outputs of existing GPS simulators and measuring the phase delay for both L1 and L2 GPS frequencies across all the simulator channels. This must be accomplished at an operational power level of approximately -163dBw. Currently, no equipment exists to measure and calibrate per satellite GPS RF signals, which are well below the RF noise level.

PHASE I: Research the feasibility of developing technology capable of meeting the technical description specified, which has the potential to calibrate any GPS simulator.

PHASE II: Design a prototype system and demonstrate proof-of-concept capability.

PHASE III DUAL USE APPLICATIONS: Military application of this technology would be for the modeling and simulation of RTK scoring of GPS guided weapons using carrier phase differential techniques such as advanced missile instrumentation and Enhanced Time-Space-Position Information (E-TSPI). Applications in the civilian world might include modeling and simulation of GPS guidance systems in commercial aircraft, future improvements in automobile technology, and/or snowplow guidance where carrier phase differential technology would produce significant improvements to GPS code techniques.

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KEYWORDS: Real Time Kinematic, GPS satellite constellation simulator, modeling and simulation, GPS guided weapons, GPS carrier frequencies, carrier phase differential techniques.

AF02-291 TITLE: High Performance Real-Time Synchronization Clock

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Technological feasibility of a high performance real-time synchronization clock for Hardware-In-The-Loop Testing.

DESCRIPTION: Hardware-In-The-Loop (HITL) testing is the laboratory testing of a hardware system by stimulating the system inputs, capturing the system outputs, and modeling the physical environment. An example of this would be evaluating the performance of a missile guidance system. Computer simulation models would provide feedback to the system to “fool” it into thinking it is in operational flight. But in order to successfully fool the system, the computer models must provide feedback at a rate that the system would encounter in the real world. This is where a real-time clock comes in. A real-time clock provides a reference for the computer models to use in communicating with the system. Considering that a typical HITL system needs to be updated about 2,000 times per second with very low latency, it is easy to show how the accuracy of a real-time clock could directly affect the ability to “fool” the system. Equally important is the ability to maintain time synchronization with an absolute time source such as Global Positioning System (GPS) or Inter-Range Instrumentation Group (IRIG). Currently, the best resolution from a commercial off-the-shelf (COTS) real-time clock is 50 nanoseconds. The resolution is the time in between clock ticks. Current COTS real-time clocks are barely meeting present requirements and, to meet the future needs, a clock with resolutions in the range of 10 to 20 nanoseconds is expected. Future real-time clock systems should provide for a drift rate of less than 1 millisecond over a 24 hour period with latency of less than 2 microseconds. Any clock system which meets AF needs will utilize a PCI Local Bus Controller bus interface. Of course the clock would have to include a number of programmable features allowing a user to set timer intervals (50-300 microseconds), timer increments (10-20 nanosecond increments, and timer pulse width (100 nanoseconds to 4 milliseconds) along with the ability to set pulse polarity at either positive or negative."

PHASE I: Investigate high-payoff approaches for the development of next generation real-time synchronization clocks. Perform design analysis through modeling and simulation. Develop initial concept design and demonstrate feasibility through a breadboard demonstration device.

PHASE II: Finalize the initial designs developed in Phase I. Develop software drivers for multiple operating systems, to include DOS, OpenVMS, Linux, QNX, and WindowsNT, to ensure adaptability. Based on final design, develop and test pre-production prototype system which includes software drivers.

PHASE III DUAL USE APPLICATIONS: Military applications would include: DoD HTIL Testing Facilities. Commercial applications would include: HTIL Testing Facilities, Real-time Industrial Control, and Applications requiring low-latency precision timing.

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2. MicroMentor, Understanding and Applying MicroProgrammable Controllers, Allen-Bradley Company, Inc., (1995).

KEYWORDS: Modeling & Simulation, Real-time, Hardware-In-The-Loop, High performance Timing, Real-time Clock

AF02-292 TITLE: Ultra High Speed Framing Pulsed X-ray System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an ultra high speed framing x-ray system for viewing ballistic impacts.

DESCRIPTION: Current X-ray imaging systems used in the ballistic range area are single pulsed one image per film plane systems. There is need for an ultra high speed framing x-ray system to view multiple images from one location. The requirement for this system is to produce multiple x-ray images on a single digital large format screen that can be captured and stored electronically at the rate of 1 megahertz. The large format screen (approximately 36 inches square) could be a compilation of smaller screens but they must be integrated to produce one continuous image. The refresh rate of the imaging screen should not exceed 1 microsecond and the storage medium should accommodate at least a 100 frames. The imaging screen will be located in a shrapnel prone impact area and should be either low cost (disposable) or have an alternate method of preventing damage to high cost components. The X-ray system should have adequate resolution to image small particles (1/8 inch aluminum) and should have a power level of 150kv or higher.

PHASE I: Demonstrate the critical aspects of the proposed system. The system should capture and store at least two images at the 0.5 megahertz rate with adequate resolution. The two images can be from two x-ray sources but should be imaged on a single screen and stored electronically.

PHASE II: Develop and demonstrate the prototype system as described in the topic description.

PHASE III DUAL USE APPLICATIONS: A high speed framing X-ray device would have multiple uses in numerous ground test facilities, government labs, and commercial testing organizations where the velocity of high speed particles must be tracked in harsh environments. In addition a system such as this would be useful in the medical industry for motion diagnostics of joints. A portable system of this type might also be useful for the health monitoring of industrial equipment during operation.

REFERENCES:
1. X-ray Phosphors and Screens; ASTM stp-716,J.D. Kingsley,AD#ADD311763.

2. Catoptrical X-ray Optical System;AFOSR-78-3480; James F. McGee; AD#ADA084688.

3. Tunable, Short Pulse Hard X-Rays from a Compact Laser Synchrotron Source; NRL/MR/4790-92-6973; Philip Sprangle, Antonio Ting, Eric Esarey, Amnon Fisher, AD# ADA254288

KEYWORDS: Ultra High Speed Framing, X-ray, Digital Screen, Electronic Storage

AF02-293 TITLE: Exhaust Gas Trace Species Detection System for Turbine Engines

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop the ability to detect component wear through the detection of very low concentrations of their material emissions signature in the engine exhaust stream.

DESCRIPTION: The ability to detect elements of these engine components in very low concentrations in the exhaust stream would enable the early detection of component failure. For example, if a seal fails catastrophically, then aluminum seal fragments may impinge on vanes and blades, which has the resultant effects of blocking component cooling passages and alloying of the aluminum with the vane or blade material resulting in a severe degradation of the blade or vane material strength. After an hour or so of this alloying process, the component will need to be scrapped. This represents a very expensive consequence. The signature for blade or vane failure would be one of the metals of the component's alloy such as nickel since this element is the principal constituent of high temperature nickel alloys. The technology makes use of atomic emission spectroscopy. It uses a novel method to generate robust and large volume atmospheric air plasma that can handle high flow loading and excite the elements. A specially designed high-sensitivity spectrometer is used to detect the light emissions. At any given moment, the spectrometer has the ability to extract very low signals from a high background. A gas sample is continuously drawn from the jet engine exhaust and injected through the microwave-generated plasma. The hot plasma volatilizes any particulate in the gas stream and excites the atomic species that emit light at specific wavelength. Parts per billion (ppb) detection levels have been achieved in the laboratory for metals such as mercury, chromium and lead.

PHASE I: Develop and demonstrate a Trace Species Detection System for turbine engine health monitoring system in the laboratory. The Phase I demonstration can be extractive (probe based) or totally non-intrusive (optically based).

PHASE II: Develop and demonstrate a turbine engine health monitoring system based on the detection of species from component wear in the turbine engine exhaust plume.

PHASE III DUAL USE APPLICATIONS: Both military and commercial applications exist for this system. Turbine engine developers have expressed an interest in a system capable of detecting component wear or the precursors to component failure during development testing. Both the military and commercial aircraft communities are searching for engine diagnostic / prognostic capabilities to help them better schedule maintenance.

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2. "OPAD Data Analysis", T.L. Wallace (Svt), W.L. Buntine (NASA), AIAA 29th Joint Propulsion Conference, June 28-30,1993, Monterey, CA..

3. "Space Shuttle Main Engine Plume Diagnostics: OPAD Approach to Vehicle Health Monitoring, " T.L. Wallace et al, SAE Aerotech `93, September 28-30, 1993, Costa Mesa, CA.

KEYWORDS: Turbine Engine Health Monitoring, Exhaust Plume Diagnostics, Trace Species Detection

AF02-294 TITLE: Determination of Airframe and Weapons Bay Acoustic Signature in High Subsonic Speed Wind Tunnel Tests

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a method/means to accurately determine and characterize acoustic sources in a wind tunnel.

DESCRIPTION: Accurate determination of the acoustic signature (airframe noise and weapons bay acoustics) generated by test articles in a wind tunnel at high subsonic speeds is of high importance to many applications. In-flow phased microphone arrays have been used with success in low speed tunnels with solid walls to determine airframe noise. Critical to the success of the in-flow approach is the accounting for the effects of the boundary layer noise contaminating the measurement. Transonic wind tunnels are more complicated since the porous walls of the tunnel generate a noise signature that is of the order of three to four times that of the boundary layer noise. Other noise sources such as compressor blade passing noise and jet interactions in the diffuser also generate significant disturbances in the spectra. For weapons bay acoustics measurements, the background noise can mask the noise generated by shear layer interacting with the cavity. The shear layer distorts transmission of sound through the shear layer. Consequently, the accurate determination of aerodynamic noise from the test article requires a phased array system that can provide an accurate assessment of all external noise sources and a means for correcting for transmission losses caused by both shear and boundary layer interactions. Development of such a phased array system and appropriate validated computational fluid dynamics augmentation is anticipated.

PHASE I: Develop and demonstrate a phased array system suitable for a wind tunnel. Provide supporting analytical/empirical measurement correction methodology for acoustic measurements in wind tunnels.

PHASE II: Develop and validate a phased array system that has empirical methodology for correcting for effects of shear & boundary layers and can extrapolate the Reynolds number effects to flight conditions.

PHASE III DUAL USE APPLICATIONS: The potential for application to other wind high subsonic wind tunnels within the United States is high.   A portable phase array system would find application to noise source location in manufacturing processes (eg. bearing failure).

REFERENCES:
1. A.Vakili, and Springer,R" Acoustics Measurements and Prediction technique in Wind Tunnels" AIAA Paper No.99-2170, Joint Propulsion Los Angeles, CA 1991)

2. "Acoustic Measurements and Background Noise Separation in Wind Tunnels", Sekhar Radhakrishnan and Ahmad D. Vakili, AIAA paper 99-1990, Proceedings of the 5th AIAA/CEAS Aeroacoustic Conference. 1999.

3. "Review of Acoustic Measurement Techniques in Wind Tunnels (Invited)", A.D. Vakili, and S. Radhakrishnan, 21st AIAA Advanced Measurement Technology and Ground Testing Conference, June 2000.

KEYWORDS: acoustics, noise, weapons bay acoustics

AF02-295 TITLE: Integrated Visible/IR Calibration Source

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an integrated dual band radiation source for sensor calibration and testing.

DESCRIPTION: A means of combining blackbody radiation (2 to 12 µm) and continuous visible radiation (0.5 to 1.0 µm) in an efficient manner is needed so that both wavebands can be presented from the same optical port. Standard integrating sphere coatings have poor efficiency at either the visible end of the spectrum or the infrared. The challenge is to find a high efficiency source over a wide range of spectral content at 2500 Deg F. An innovative technique is desired that can integrate the disparate visible and long wavelength infrared sources producing the two wavebands simultaneously so that minimal losses (< 10%) to each are incurred. The character of the infrared spectrum must be preserved as much as possible. Preservation of the visible spectrum is also desired, but is secondary in importance. The technical risk for achieving this level of throughput is high.

PHASE I: Develop and demonstrate the feasibility of providing high power infrared and visible radiation from the same orifice.

PHASE II: Develop a practical prototype, which is capable of producing high power infrared (2 to 12 µm) and visible radiation (0.5 to 1.0 µm) from the same orifice.

PHASE III DUAL USE APPLICATIONS: This technology will be useful for a variety of sensor test activities where a dual band (visible and IR) source is needed for calibration and dynamic simulation. As surveillance and process control moves toward dual wavelength sensing development facilities can benefit from such a calibration source.

REFERENCES:
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3. Nicholson, R.A., and Steele, C.L., "AEDC Focal Plane Array Test Capability", AEDC-TR-90-31.

KEYWORDS: sensor, infrared, IR, radiation source, visible, radiometric calibration

AF02-296 TITLE: Non-Intrusive Flow Visualization Diagnostic System for Aircraft Flow Fields

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a non-intrusive, cost-effective wind tunnel technique for measuring aircraft flow field properties.

DESCRIPTION: Characterization of the time-dependent, three-dimensional flow fields associated with wind tunnel aircraft and missile models is often required during testing for system performance estimation, electromagnetic and aerodynamic field interaction, and towed decoy dynamics studies. The current techniques are limited to more-or-less qualitative flow field characterization using laser vapor-screen, shadowgraph, and Schlieren techniques.

PHASE I: Research and demonstrate technical feasibility to characterize the time dependent three dimensional flow field in the laboratory.

PHASE II: Develop, demonstrate a non-intrusive flowfield characterization system (hardware, software, methodology) for use in a wind tunnel environment. Demonstrate the ability to quantitatively relate flowfield properties, including unsteadiness, to sensor measurements for time-dependent, three-dimensional flowfields behind wind tunnel models. High accuracy is desired. Allowable two standard deviation error at 95% confidence interval between sensor and non-intrusive results is 0.4% of full-scale sensor range.

PHASE III DUAL USE APPLICATIONS: In addition to high subsonic speed wind tunnel application, a cost-effective, efficient remote sensor system would have applications in chemical continuous process control. Additional applications of the technology include automotive aerodynamic flow characterization in both wind tunnel and outdoor track environments, wind hazard studies and analyses in dense-structure environments, aircraft trailing flow-field hazard analyses, and characterization of industrial airflow systems.

REFERENCES:
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2. Chadwick, R. B., et al., "Radar Detection of Wingtip Vortices," Reprint Volume of Extended Abstracts: Ninth Conference on Aerospace and Aeronautical Meteorology, Boston, MA, June 1983.

3. Bilbro, J. W., "Laser Doppler Velocimeter Wake Vortex tests," Federal Aviation Administration, FAA-RD-76-11, NASA/MSFC, Huntsville, AL, March 1976.

KEYWORDS: Visualization Non-Intrusive Flowfield

AF02-297 TITLE: Vortex Flow Detector for Turbine Engine Test Facilities

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a flow-field monitoring system that may be used to detect the development of bellmouth vortices in direct-connect turbine engine test facilities.

DESCRIPTION: Direct-connect turbine engine tests often use a bellmouth as the transition between the facility plenum chamber and the engine air supply duct. This bellmouth may be used to determine the airflow rate supplied to the engine to accuracies as low as 0.5%. The engine airflow rate is a critical measurement for the determination of engine performance parameters such as thrust and fuel consumption. Measuring airflow using the bellmouth requires suitable measurements of pressures, temperatures, and throat area as well as knowledge of the bellmouth flow coefficient. However, flow anomalies in the bellmouth flow, most notably vortices, may cause significant errors in the airflow inferred from the bellmouth measurements. Bellmouth inlet induced vortices have been previously observed in ground test facilities, and design modifications have been adopted to prevent their formation. However, the effectiveness of each test installation with respect to flow quality must be ensured. Therefore, a system that monitors the inlet flow field and senses the presence of vortical flow, from whatever source is needed to alert the test team in the event that unacceptable conditions develop. The system must provide near-real time results and must be passive in the sense that it must operate during and without interference to test operations and without requiring manual operations or user intervention.

PHASE I: Research and demonstrate technical feasibility of the selected method.

PHASE II: Develop and demonstrate the prototype vortex monitoring system in a turbine engine test facility utilizing bellmouth flow measurement system.

PHASE III DUAL USE APPLICATIONS: Autonomous flow monitoring system that may be used to monitor flow quality in aerospace ground test facilities and industrial plants.

REFERENCES:
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KEYWORDS: Bellmouth Vortex

AF02-298 TITLE: Microsensors for Gaseous Emissions Analysis

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop species-specific sensors for monitoring turbine exhaust in-situ (in the exhaust stream).

DESCRIPTION: Current gas analysis instrumentation used to detect or measure engine emissions are costly and intrusive. They are also inadequate for use as controls sensors. Recent advances in MEMS technology suggests that microsensors are capable of measuring exhaust gases in the high temperature exhaust environment. A need exists for real-time measurement of the following chemical species: CO, CO2, SOX, NOX, O2, and total hydrocarbons. Microsensors offer a new technology approach that would add controls capability and significantly reduce emissions measurement costs. The availability of point contact chemical sensors will allow real-time determination of spatial and temporal distributions of emissions gases and catalyze the development of more efficient gas turbine and auto engines. Standard emissions instrumentation sensor specifications for turbine engines can be found the SAE Aerospace Recommended Practice 1256B, available from the SAE. These specifications are very similar to the specifications for automobile and stationary source power generation industry. Controls sensors may require higher frequency response. No specifications exists for the turbine engine controls instrumentation so I suggest the submitter design to auto industry emissions control sensor specifications.

PHASE I: Develop and demonstrate a microsensor packaged for the analysis of one or more chemical gas species in a turbine engine exhaust flow.

PHASE II: Demonstrate a chemical gas analysis system based on microsensors packaged for operation in harsh environments capable of replacing a standard gas sampling and emissions measurement system.

PHASE III DUAL USE APPLICATIONS: Development of single chip microsensors with chemical sensing capability and associated signal conditioning, will provide real-time monitoring of gas turbine, combustion ignition, and spark ignition exhaust gases.

REFERENCES:
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KEYWORDS: Microsensors , MEMS, Chemical Gas Sensors, Aircraft Emissions, Auto Emissions, Stationary Source Power Generation.

AF02-301 TITLE: Subminiature GPS Instrumentation (SGI)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop a subminiature instrumentation package combining state-of-the-art GPS/Inertial Navigation System for Time Space Position Information (TSPI) use.

DESCRIPTION: Tightly coupled GPS/Inertial Measurement Unit (IMU) receiver technology has proven to be an effective tool for determining time space position information (TSPI) for aircraft. However, GPS TSPI data is not readily available for platforms with extreme space and weight constraints. Current methods for collecting TSPI for these objects are to treat them as non-cooperative targets and track them with radar or optical ground systems. Radar TSPI data is time consuming to process, and does not satisfy accuracy requirements of most current test platforms and weapons systems. Optical systems produce excellent accuracy using multi-lateration (multiple stations), but the process is extremely labor intense, costly in terms of equipment required, data turn-around time is very slow, and the system is not available in reduced visibility situations. Current industry trends in GPS/IMU technology trade size and cost for accuracy. The smaller and cheaper the unit is, the less accurate the system will become. The capability to instrument an object to self-track and report its position to ground stations would be a valuable asset to the test community. This capability could be achieved by an instrumentation package consisting of a tightly coupled GPS receiver, and an IMU. The end state objectives for this effort are: to develop a GPS/IMU package that is no larger then four cubic inches, the unit must be capable of performing in a high dynamic platform (20G's), the GPS receiver must be capable of providing carrier phase measurements for Kinematic processing, maintain lock though maneuvers greater than 10G's, update rates of 20 Hz, provide compatibility with other IMU systems, and the eventual production instrumentation package should not exceed $3000 per package when purchased in quantity (50 or more units).

PHASE I: Research a proposed instrument to achieve the goals of the project, including feasibility analysis and cost analysis.

PHASE II: Develop a proposed instrument to achieve the goals of the project.

PHASE III DUAL USE APPLICATIONS: The end product of this SBIR is a miniature, highly accurate navigation device that is more reliable then the current GPS solution. This device will have a wide area of application in both the government and commercial sector. Some of its possible uses include autonomous vehicle navigation for cars, trucks and tractors, tracking of payloads, pallets and small private aircraft navigation.

REFERENCES:
1. J. M. Cullen, and Ed. Keller, "Subminiature Telemetry for Multiple Munitions (Technology Transition)", Proceeding of the 1995 International Telemetry Conference, Volume XXXI, 58-65, Las Vegas, NV, 30 Oct - 2 Nov 95.

2. William R. Thursby, Jr., and Benjamin M. Shirley, "Low Cost Subminiature Telemetry Spread Spectrum Technology Demonstration/Validation", Proceeding of the 1995 International Telemetry Conference, Volume XXXI, 74-78, Las Vegas, NV, 30 Oct - 2 Nov 95.

KEYWORDS: subminiature GPS receiver, subminiature inertial measurement unit

AF02-302 TITLE: Wireless Solutions for Time Space Position Information (TSPI) Data Links

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop an advanced Time Space Position Information (TSPI) data link using commercial wireless standards and technology.

DESCRIPTION: The DoD and other U.S. Government agencies have a severe need for more efficient utilization of the spectrum for range Time Space Position Information (TSPI). The allocated test spectrum continues to shrink while bandwidth requirements are expanding due to increased requirements for accuracy on high dynamic vehicles that have increasingly complex internal systems. Shorter schedules and cost constraints for testing programs are also encouraging the use of real-time data processing rather than post-mission processing. In addition, some test programs rely on real-time TSPI for flight safety information. Another change in the range testing of high dynamic systems is the shift towards network connectivity. The use of networking for TSPI and telemetry data is expected to cause significant increases in productivity and cost effectiveness in flight research as it has and will in other industries. However, wireless networks have significant technical difficulties because of the lack of available bandwidth and the inherent noise, interference and non-uniformity of wireless links. If networked systems are to be used in an environment of combined TSPI and other real-time communication systems with bandwidth at such a premium, efficient use of spectrum will be critical in all layers of the communication stack. The proposed system must allow for at least 20 simultaneous users with varying data rates and ranges. Data rates should accommodate up to 3 Mbps and operate at ranges up to 140 nautical miles. Dynamic assignment and reassignment of operating frequencies and various Multiple Access schemes should be explored. The TSPI data link must be robust, offering data quality bit error rates of 1x10-6 or better and must be capable of operating in harsh environments with multi-path and adjacent channel interference. TSPI data link power cannot exceed 80 watts and antennas cannot interfere with aircraft performance. TSPI data links must not cause interference to other airborne data links. The design should include a description of recommended network- and transport-layer protocols. The goals of this unit is a size not to exceed 3"X4"X4" with a cost not to exceed $10,000.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Develop and demonstrate a prototype system.

PHASE III DUAL USE APPLICATIONS: Numerous applications are easily envisioned. High data rate users with long-range requirements would benefit from this capability. The operational suitability of future field deployable Phase III systems will be inferred from the Phase II results.

REFERENCES:
1. "Time Space-Position Information (TSPI) Multimedia Course", Defense Test and Evaluation Professional Institute (DTEPI), (most current edition)

KEYWORDS: Commercial Wireless, Aeronautical Telemetry, Multiple Access, Variable Data Rates, Telemetry Networks

AF02-303 TITLE: Improved Aeronautical Global Positioning System (GPS) Antenna Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop GPS antenna systems for aeronautical use, which are capable of operating properly in the presence of strong Radio Frequency fields from nearby Telemetry and Data Link antenna systems.

DESCRIPTION: GPS systems have become an important part of testing aircraft, missiles and other airborne systems at DoD Test Ranges. These systems are sometimes installed on test vehicles in order to obtain high accuracy Time Space Position Information (TSPI) data from high dynamic test vehicles. Additionally, many aircraft are now built with production GPS systems as part of an integrated GPS Inertial Navigation System (INS). The potential for other aeronautical communication systems to interfere with the weak GPS signals becomes higher every time a new system is installed on the test vehicle. There is a need to improve the Radio Frequency Interference performance of GPS antenna systems used on test aircraft at Edwards AFB. The primary objective is to develop GPS antenna systems that will function properly in the presence of strong RF signals from telemetry and/or data-link antennas located near them on the vehicle. Many telemetry and data link systems operate in L-Band, on frequencies close to the GPS L1 and L2 frequencies, so the interference potential is high. There is also signal interference generated from these telemetry and data-link systems that interferes with adjacent transmissions. These spurious signals also cause problems that could be addressed using anti-jam type GPS antenna systems. Also, due to the limited amount of space available on test aircraft fuselages, it would be beneficial to develop a dual use integrated GPS receiver and telemetry/data-link transmitter antenna system. This would allow simultaneous operation while saving weight and space on board test vehicles.

PHASE I: Conduct a feasibility analysis and prepare a prototype system design.

PHASE II: Develop and demonstrate a prototype system. The prototype will be evaluated to determine if it operates properly in close proximity (> 4") of L-band telemetry transmitter antennas.

PHASE III DUAL USE APPLICATIONS: The commercial aviation industry may benefit from this, if the appropriate system can be developed. The operational suitability of future field deployable Phase III systems will be inferred from the Phase II results.

REFERENCES:
1. "Interoperability of L-band Telemetry Systems with GPS Receivers Aboard Military Flight Test Aircraft", Johns Hopkins University Applied Physics Laboratory, Daniel G. Jablonski, ARTM Program, 7 June 2000.

KEYWORDS: GPS Antenna System, Time Space Position Information (TSPI), Inertial Navigation Systems (INS), Radio Frequency Interference (RFI)

AF02-304 TITLE: High Power, Miniature Infrared (IR) Sources

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop small programmable Infrared (IR) sources with outputs that are controllable, calibrated, and can achieve high Jammer-to-Signal (J/S) ratios.

DESCRIPTION: The goal is to develop an IR source that increases the simulations J/S ratio output. Wires that allow horizontal and vertical source motion will suspend the IR source. The IR source is to have an iris and associated motor for control of IR intensity. A cooling fan will be placed in the IR source housing to reduce the heating caused by the IR source. The IR source can be any source whose irradiance is equal to or greater than the output produced by a one-inch xenon arc lamp at wavelengths between 1.5 and 5.5 microns. The calibrated J/S ratio should be at a level of at least 100 or more for at least 10 seconds for a specific waveform. After 10 seconds there will be a 35-second down time before being turned on again for the next 10 second up time. This cycle time will continue through an average eight-hour workday. The line length of the power lines will be 50 feet and move with the source over pulleys, necessitating flexible lines.The units should fit in a 2 3/8" diameter by 9" length. Proper cooling (<30 C external housing) and intensity control (0 - 100%) must be achievable. The source must have the capability of being square wave modulated to frequencies of 5000Hz and have a flat (90 - 100%) angular distribution of irradiance over ± 5 degrees. This is needed to maintain calibration as the sources move in the IR foreground. Power enters from the top of the housing and is in line with the mounting wires on the top of the housing.

PHASE I: Research and develop a proposed system design and make recommendations on the construction of the system using multiple sources. Submit a report covering the research approach, design and results.

PHASE II: Prototype, integrate, and demonstrate a working system. Submit a final report documenting the intensity range, control repeatability, and positioning accuracy and speed.

PHASE III DUAL USE APPLICATIONS: This will be a new product that has potential use in (1) IR countermeasure needing closely placed sources; (2) Aircraft landing lights; (3) IR communication (Land, sea, air, and space); (4) Satellites IR sources; (5) Portable IR sources.

REFERENCES:
1. "The International Countermeasures Handbook", Englewood, CO, Cardiff Publishing, (most current edition).

2. "The Infrared Handbook", The Infrared Information Analysis (IRIA) Center, Environmental Research Institute of Michigan, (most current edition).

KEYWORDS: Infrared, Calibration, Optical, Real-time, Missile, Infrared, IR target, Optical, Real-time, Missile countermeasures, Xenon arc lamps

AF02-305 TITLE: Clutter Model Based on Real-Time Terrain

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop a realistic clutter model for airborne radar based on a real-time terrain database.

DESCRIPTION: One aspect of an Installed System Test Facility (ISTF) is the testing of aircraft avionics and the airborne radar providing the avionics data. Ground testing requires presenting the test radar with an accurate representation of the radio frequency (RF) environment as would be seen in flight.Modern radar needs to minimize the effects of clutter and to increase the probability of correctly locating and tracking targets in the real world clutter environment. These radar measurement techniques use the return signal amplitude, Doppler shift, angle of arrival (azimuth and elevation), and time variations in these parameters to help improve the probability of correctly detecting and tracking targets in clutter. Development of a radar return signal, including a background based on the viewed real-time terrain with clutter superimposed on it, will significantly enhance the ground testing capability for an ISTF. This solicitation is for the development and implementation of the background clutter model, which will eventually be integrated into the Government’s Generic Radar Target Generator (GRTG). The characteristics of this clutter model are as follows:>   The clutter model should be derived from recognized research and should be theoretically defensible as properly simulating terrain and sea radar returns.>   The clutter model should include main lobe clutter (MLC), side lobe clutter (SLC), and altitude line return (ALR). >   The clutter will be added to the surface returns of the terrain and have mean backscatter coefficients and amplitude statistics based on topographic data of the terrain, urban or rural. >   The angle of viewing should be used in determining the backscatter, scintillation, reflection, and grazing angle effects that account for the amplitude and spectral representation of the main lobe and side lobe clutter. >   The clutter model should provide for all reasonable and defensible probability density functions (PDFs). Suggested PDFs include Gaussian, Rayleigh, LogNormal or Weibull, independent, temporally, or spatially correlated. However, it is the responsibility of the vendor to determine which PDFs are needed and desirable. >   The clutter should provide the Doppler components to account for the radial velocity of the radar relative to the clutter surface, the radar antenna pattern, and the texture and slope of the clutter surface. Consideration should be given to both the radar’s main antenna beam pattern and the pattern of any guard antenna present. >   The clutter characteristics should be predictable and repeatable when viewed from the same angle and velocity.>   The clutter model should be capable of generating clutter returns for sea states 0 to 6.The project will be divided into two phases:

PHASE I: The following activities comprise Phase I:>   Research the literature and physics that provide the basic mathematical theory for calculating real-time clutter based on the terrain radar return. >   Develop the algorithms necessary to generate the real-time radar signal directly from the real-time database information. > Define the processing capability necessary to provide the clutter and superimpose it on the real-time terrain data. >   Produce a report that summarizes the above efforts.

PHASE II: The following activities comprise Phase II:>   Implement the clutter model algorithms developed in Phase I and produce digital simulated clutter data to drive GFE RF vector modulators to produce composite RF signals. The model will eventually drive the Government's Generic Radar Target Generator, and consideration needs to be given to this fact. >   Analyze the effective performance of the simulated clutter. >   Produce a report documenting the performance and effectiveness of the real-time, terrain-based-clutter model.

PHASE III DUAL USE APPLICATIONS: The clutter models developed under this effort may be used for development testing for commercial aviation collision avoidance systems and advanced air traffic control radars, and advanced aviation weather radar systems.

REFERENCES:
1. Skolnik, Merrill: "Radar Handbook (Second Edition)", McGraw-Hill Inc, 1990, Chapter 12.
2. Stimson, George W.: "Introduction to Airborne Radar (Second Edition)", SciTech Publishing, Inc., 1998, Chapter V.

KEYWORDS: Radar Clutter, Surface Return, Sea Clutter, Real-time Terrain, Terrain Based Clutter, Airborne Radar

AF02-306   TITLE: Real-Time Infrared (IR) Source Calibration

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop an IR instrumentation subsystem to measure Infrared (IR) irradiance at specific positions simultaneously and display the results without causing optical interference in the primary optical path.

DESCRIPTION: The project will research and develop a real-time IR measurement device that can be placed in a free-space optical path to monitor IR emissions during operation. The subsystem r should be a passive measurement device that can be operated without obscuring the primary optical path. The output of the monitor should be a user-friendly instrumentation display, shown in real-time giving accurate irradiance levels from the sources being measured.One application for this capability that the Air Force is interested in would place the instrumentation subsystem at the end of an optical path to monitor the calibration of IR sources during real-time testing. The subsystem shall not use transmissive optics or beam-splitters between the infrared sources and the System Under Test (SUT). All infrared sources used have an angular intensity distribution that overfills the area around the SUT, i.e., the source illuminates a 12-inch by12-inch area at the SUT, which is centered in the illuminated area. The SUT resides at the rotation point of a 3-axis flight motion simulator and rides on the pitch and yaw axes. The instantaneous simulation field-of-view from the missile towards the target sources is +/-5 degrees in pitch and yaw. The field-of-regard between the missile dome and the target sources is +/-5 degrees in pitch and yaw. The field-of-regard between the missile dome and the target sources is +/-75 degrees. That is, a small 10-degree cone of a possible 150-degree cone is presented at any one time to the SUT, but that small cone can be located anywhere within the large cone and moves with time. The unused area of the illuminated field can be used for real-time calibration. The infrared monitoring band should span form 1.5 to 5.5 microns. The intensity range can traverse 3 orders of magnitude during a single real-time event and the response of any detector will need to be linear over that range. Though only 3 orders of intensity change occur during a single simulation run, more than 6 orders of magnitude change could occur from one simulation run condition to another. Parallax issues due to placing detectors within the illuminated field, but not exactly at the SUT, need to be addressed. No interference with the field-of-view of the SUT is tolerable, e.g. scattering light. Miniaturization of components is desirable.

PHASE I: Research and analyze development methods and propose a system design. Build a representative deliverable prototype that can be a subsystem of a final product (such as 1 member of an array). Submit a final report covering the research approach, design and results.

PHASE II: Prototype and demonstrate the working instrumentation system.

PHASE III DUAL USE APPLICATIONS: (1) Laser measurement devices. (2) Eye protection. Laser Surgery. (3) IR sensor development.

REFERENCES:
1. "The International Countermeasures Handbook", Englewood, CO, Cardiff Publishing, (most current edition).

2. "The Infrared Handbook", The Infrared Information Analysis (IRIA) Center, Environmental Research Institute of Michigan, (most current edition).

KEYWORDS: Infrared, Instrumentation, Optical, Real-Time, Missile

AF02-307 TITLE: Advanced Airspace Modeling, Characterization, and Planning

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Research, design, and develop an airspace management tool that is capable of correlating previously scheduled air/ground missions to actual real time usage. The system should also be capable of predicting future requirements based on historical and actual airspace usage data.

DESCRIPTION: With increased use of the FAA managed national airspace system (NAS) being all but certain, DOD managers of special use airspace are under increased public pressure to better utilize the airspace under their control. As a result, there is a need for automated, reliable and user-friendly Special Use Airspace Management Systems as well as advanced methods of displaying and analyzing airspace information. Presently, the Air Force Flight Test Center, R-2508 Central Coordinating Facility at Edwards Air Force Base, California uses the Airspace Utilization and Reporting System (AURS) to display limited airspace information within the R-2508 Complex. The system proposed in this investigation is not an extension of current technology but a radically new approach to airspace management and utilization systems. The proposed system would provide models for aircraft density and better flight route prediction. The system should also provide real time special use airspace information (such as current airspace activity) and aircraft scheduling information within the airspace. Such a system would better aid special use airspace managers make real time prediction on when to release airspace back to the Federal Aviation Administration for joint public/military use. Demands by the airline companies, the Federal Aviation Administration, and the general flying public require that a system capable of depicting an accurate, real time, geographical representation of the airspace and the operations being conducted within that airspace be researched and designed, and developed.

PHASE I: Conduct a feasibility analysis of current and planned airspace utilization systems (both military and commercial systems) to determine the extent the information collected therein can be used to improve airspace management. Research current limitations and constraints (including policy matters) on current airspace management methods and develop alternate solutions to requirements involving airspace management issues. Make recommendations based on surveys of potential users and related technologies. Submit a final report covering the results of findings, analysis and proposed recommendations.

PHASE II: Develop the software to implement airspace management tool for predicting aircraft density and performing fly route planning. Deliver final product and report.

PHASE III DUAL USE APPLICATIONS: This will be a new product with customer applications in the fields of military and airlines route planning, airline hub density predictions and national airspace management by the FAA. Product benefits will also be found in Free-Flight implementation and environmental impact modeling do to aircraft activities.

REFERENCES:
www.faa.gov

KEYWORDS: airspace, airspace management, environmental impact.