AIR FORCE
SBIR 07.3 Proposal Submission Instructions

The AF proposal submission instructions are intended to clarify the DoD instructions as they apply to AF requirements.

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 Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. For general inquires or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (19 Jul through 19 Aug 07), contact the Topic Authors listed for each topic on the website. For information on obtaining answers to your technical questions during the formal solicitation period (20 Aug through 19 Sep 07), go to **http://www.dodsbir.net/sitis/.**

The Air Force SBIR Program is a mission-oriented program that integrates the needs and requirements of the Air Force through R&D topics that have military and commercial potential

PHASE I PROPOSAL SUBMISSION

Read the DoD program solicitation at www.dodsbir.net/solicitation **for program requirements.** When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. For the Air Force, the contract period of performance for Phase I shall be nine (9) months, and the award shall not exceed $100,000. We will accept only one cost proposal per topic proposal and it must address the entire nine-month contract period of performance.

The Phase I award winners must accomplish the majority of their primary research during the first six months of the contract. Each Air Force organization may request Phase II proposals prior to the completion of the first six months of the contract based upon an evaluation of the contractor's technical progress and review by the Air Force Technical point of contact utilizing the criteria in section 4.3 of the DoD solicitation The last three months of the nine-month Phase I contract will provide project continuity for all Phase II award winners so no modification to the Phase I contract should be necessary. **Phase I technical proposals have a 20 page-limit (excluding the cost proposal, cost proposal itemized listing (a – h), and Company Commercialization Report).** The Air Force will evaluate and select Phase I proposals using review criteria based upon technical merit, principal investigator qualifications, and commercialization potential as discussed in this solicitation document.

ALL PROPOSAL SUBMISSIONS TO THE AIR FORCE PROGRAM MUST BE SUBMITTED ELECTRONICALLY.

Limitations on Length of Proposal

The technical proposal must be no more than 20 pages (no type smaller than 10-point on standard 8 1/2 " X 11" paper with one (1) inch margins). The Cost Proposal, cost proposal itemized listing (a-h), and Company Commercialization Report are excluded from the 20 page limit. Only the Proposal Cover Sheet (pages 1 & 2), the Technical Proposal (beginning with page 3), and any enclosures or attachments count toward the 20-page limit. In the interest of equity, pages in excess of the 20-page limitation (including attachments, appendices, or references, but excluding the cost proposal, cost proposal itemized listing (a-h), and Company Commercialization Report, will not be considered for review or award.

Phase I Proposal Format

Proposal Cover Sheets. Your cover sheets will count as the first two pages of your proposal no matter how they print out. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary information in these sections.

Technical Proposal: The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Cost Proposal information should be provided by completing the on-line Cost Proposal form and including the cost proposal itemized listing (a-h) specified in the Cost Proposal section later in these instructions. This itemized listing should be placed as the last page(s) of the Technical Proposal Upload. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the cost proposal itemized listing (a-h) information.

Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your uploaded file will be virus checked and converted to PDF within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk at 1-866-724-7457 (8am to 5pm EST)..

Key Personnel

Identify in the technical proposal key personnel who will be involved in this project, including information on directly related education and experience. A resume of the principle investigator, including a list of publications, if any, must be included. Resumes of proposed consultants, if any, are also useful. Consultant resumes may be abbreviated. **Please identify any foreign nationals you expect to be involved in this project, as a direct employee, subcontractor, or consultant. Please provide resumes, country of origin and an explanation of the individual's involvement.**

Phase I Work Plan Outline

NOTE: PROPRIETARY INFORMATION SHALL NOT BE INCLUDED IN THE WORK PLAN OUTLINE. THE AF WILL USE THIS WORK PLAN OUTLINE AS THE INITIAL DRAFT OF THE PHASE I STATEMENT OF WORK (SOW).

At the beginning of your proposal work plan section, include an outline of the work plan in the following format:

1) Scope
   List the major requirements and specifications of the effort.
2) Task Outline
   Provide a brief outline of the work to be accomplished over the span of the Phase I effort.
3) Milestone Schedule
4) Deliverables
   a. Kickoff meeting within 30 days of contract start
   b. Progress reports
   c. Technical review within 6 months
   d. Final report with SF 298

Cost Proposal

The on-line cost proposal must be at a level of detail that would enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information (a through h below) on how funds will be used if the contract is awarded. Include the itemized cost proposal information (a-h) as an appendix in your technical proposal. The itemized cost proposal information (a-h) will not count against the 20 page limit.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and / or automatic test equipment.

b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, and price and where appropriate, purposes.

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals, which include leased hardware, must provide an adequate lease vs. purchase justification or rational.

d. Direct Labor: Identify key personnel by name if possible or by labor category if specific names are not available. The number of hours, labor overhead and / or fringe benefits and actual hourly rates for each individual are also necessary.

e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each trip. Recommend budgeting at least one (1) trip to the Air Force location managing the contract.

f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal. Please note that cost share contracts do not allow fees.

g. Subcontracts: Involvement of university or other consultants in the planning and / or research stages of the project may be appropriate. If the offeror intends such involvement, described in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases or usage fees and other subcontract or purchase agreements may not exceed one-third of the total contract price or cost, unless otherwise approved in writing by the contracting officer.

(NOTE): The Small Business Administration has issued the following guidance:
" Agencies participating in the SBIR Program will not issue SBIR contracts to small business firms that include provisions for subcontracting any portion of that contract award back to the originating agency or any other Federal Government agency." See Section 2.6 of the DoD program solicitation for more details.

Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e. cost proposal). At the very least, a statement of work with a corresponding detailed cost proposal for each planned subcontract.

h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required and hourly rate.

PHASE I PROPOSAL SUBMISSION CHECKLIST

Failure to meet any of the criteria will result in your proposal being **REJECTED** and the Air Force will not evaluate your proposal.

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

2) The Air Force will accept only those proposals submitted electronically via the DoD SBIR website (www.dodsbir.net/submission).

3) You must submit your Company Commercialization Report electronically via the DoD SBIR website (www.dodsbir.net/submission).

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST, 19 September 2007 deadline.** A hardcopy **will not** be accepted. Signatures are not required at proposal submission when submitting electronically. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

The Air Force recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and could slow down the system. **Do not wait until the last minute.** The Air Force will not be responsible for proposals being denied due to servers being “down” or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of September, you will receive an e-mail serving as our acknowledgement that we have received your proposal. The Air Force is not responsible for notifying companies that change their mailing address, their e-mail address, or company official after proposal submission.

AIR FORCE SBIR/STTR VIRTUAL SHOPPING MALL

As a means of drawing greater attention to SBIR accomplishments, the Air Force has developed a Virtual Shopping Mall at http://www.sbirsttrmall.com. Along with being an information resource concerning SBIR policies and procedures, the Shopping Mall is designed to help facilitate the Phase III transition process. In this regard, the Shopping Mall features: (a) SBIR Impact / Success Stories written by the Air Force; and (b) Phase I and Phase II summary reports that are written and submitted by SBIR companies. Since summary reports are intended for public viewing via the Internet, they should not contain classified, sensitive, or proprietary information. Submission of a Phase I Final Summary Report is a mandatory requirement for any company awarded a Phase I contract in response to this solicitation..

AIR FORCE PROPOSAL EVALUATIONS

Evaluation of the primary research effort and the proposal will be based on the scientific review criteria factors (i.e., technical merit, principal investigator (and team), and commercialization plan). 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. The Air Force anticipates that pricing will be based on adequate price competition. The next tie-breaker on essentially equal proposals will be the inclusion of manufacturing technology considerations.

The Air Force will utilize the Phase I evaluation criteria in section 4.2 of the DoD solicitation in descending order of importance with technical merit being most important, followed by the qualifications of the principal investigator (and team), and followed by commercialization plan. The Air Force will use the phase II evaluation criteria in section 4.3 of the DoD solicitation with technical merit being most important, followed by the commercialization plan, and then qualifications of the principal investigator (and team).

NOTICE: Only government personnel and technical personnel from Federally Funded Research and Development Center (FFRDC), Mitre Corporation and Aerospace Corporation, working under contract to provide technical support to Air Force product centers (Electronic Systems Center and Space and Missiles Center respectively), may evaluate proposals. All FFRDC employees at the product centers have non-disclosure requirements as part of their contracts with the centers. In addition, Air Force support contractors may be used to administratively process or monitor contract performance and testing. Contractors receiving awards where support contractors will be utilized for performance monitoring may be required to execute separate non-disclosure agreements with the support contractors.

On-Line Proposal Status and Debriefings

The Air Force has implemented on-line proposal status updates and debriefings (for proposals not selected for an Air Force award) for small businesses submitting proposals against Air Force topics. At the close of the Phase I Solicitation – and following the submission of a Phase II via the DoD SBIR / STTR Submission Site (https://www.dodsbir.net/submission) - small business can track the progress of their proposal submission by logging into the Small Business Area of the Air Force SBIR / STTR Virtual Shopping Mall (http://www.sbirsttrmall.com). The Small Business Area (http://www.sbirsttrmall.com/Firm/login.aspx) is password protected and firms can view their information only.

To receive a status update of a proposal submission, click the “Proposal Status / Debriefings” link at the top of the page in the Small Business Area (after logging in). A listing of proposal submissions to the Air Force within the last 12 months is displayed. Status update intervals are: Proposal Received, Evaluation Started, Evaluation Completed, Selection Started, and Selection Completed. A date will be displayed in the appropriate column indicating when this stage has been completed. If no date is present, the proposal submission has not completed this stage. Small businesses are encouraged to check this site often as it is updated in real - time and provide the most up - to- date information available for all proposal submissions**. Once the “Selection Completed” date is visible, it could still be a few weeks (or more) before you are contacted by the Air Force with a notification of selection or non – selection.** The Air Force receives thousands of proposals during each solicitation and the notification process requires specific steps to be completed prior to a Contracting Officer distributing this information to small business.

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by Email regarding proposal selection or non - selection. The Email will include a link to a secure Internet page to be accessed which contains the appropriate information. If your proposal is tentatively selected to receive an Air Force award, the PI and CO will receive a single notification. If your proposal is not selected for an Air Force award, the PI and CO may receive up to two messages. The first message will notify the small business that the proposal has not been selected for an Air Force award and provide information regarding the availability of a proposal debriefing. The notification will either indicate that the debriefing is ready for review and include instructions to proceed to the “ Proposal Status / Debriefings “ area of the Air Force SBIR / STTR Virtual Shopping Mall or it may state that the debriefing is not currently available but generally will be within 90 days (due to unforeseen circumstances, some debriefings may be delayed beyond the nominal 90 days). If the initial notification indicates the debriefing will be available generally within 90 days, the PI and CO will receive a follow – up notification once the debriefing is available on - line. All proposals not selected for an Air Force award will have an on – line debriefing available for review. Available debriefings can be viewed by clicking on the “ Debriefing “ link, located on the right of the Proposal Title, in the “ Proposal Status / Debriefings “ section of the Small Business Area of the Air Force SBIR / STTR Virtual Shopping Mall**. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced. Also observe the status of the debriefing as availability may differ between submissions (e.g., one may state the debriefing is currently available while another may indicate the debriefing will be available within 90 days).**

IMPORTANT: Proposals submitted to the Air Force are received and evaluated by different offices within the Air Force and handled on a topic - by- topic basis. Each office operates within their own schedule for proposal evaluation and selection**. Updates and notification timeframes will vary by office and topic. If your company is contacted regarding a proposal submission, it is not necessary to contact the Air Force to inquire about additional submissions.** Check the Small Business Area of the Air Force SBIR / STTR Virtual Shopping Mall for a current update. Additional notifications regarding your other submissions will be forthcoming

We anticipate having all the proposals evaluated and our Phase I contract decisions by mid-January. **All questions concerning the status of a proposal, or debriefing, should be directed to the local awarding organization SBIR Program Manager.** Organizations and their Topic numbers are listed later in this section (before the Air Force Topic descriptions).

PHASE II PROPOSAL SUBMISSIONS

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees that are **invited** to submit a Phase II proposal and all FAST TRACK applicants will be eligible to submit a Phase II proposal. The awarding Air Force organization will send detailed Phase II proposal instructions to the appropriate small businesses. Phase II efforts are typically two (2) years in duration and do not exceed $750,000. (NOTE) All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system**. Get your DCAA accounting system in place prior to the AF Phase II award timeframe. If you do not have a DCAA approved accounting system this will delay / prevent Phase II contract award. If you have questions regarding this matter, please discuss with your Phase I contracting officer.**

All proposals must be submitted electronically at www.dodsbir.net/submission. The complete proposal - Department of Defense (DoD) cover sheet, entire technical proposal with appendices, cost proposal and the Company Commercialization Report – must be submitted by the date indicated in the invitation. The technical proposal is **limited to 50 pages** (unless a different number is specified in the invitation). The commercialization report, any advocacy letters, SBIR Environment Safety and Occupational Health (ESOH) Questionnaire, and cost proposal itemized listing (a through h) will not count against the 50 page limitation and should be placed as the last pages of the Technical Proposal file that is uploaded. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.) The preferred format for submission of proposals is Portable Document Format (PDF). Graphics must be distinguishable in black and white. **Please virus check your submissions**.

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 with all AF Phase I selection E-Mail notifications. 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.

NOTE:

1) Fast Track applications must be submitted not later than 150 days after the start of the Phase I contract.
2) Fast Track phase II proposals must be submitted not later than 180 days after the start of the Phase I contract.
3) The Air Force does not provide interim funding for Fast Track applications. If selected for a phase II award, we will match only the outside funding for Phase II.

For FAST TRACK applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offeror will not be considered for any Phase II award. 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 II ENHANCEMENT PROGRAM

On active Phase II awards, the Air Force will select a limited number of Phase II awardees for the Enhancement Program 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 $500,000 of non-SBIR government matching funds. Contact the local awarding organization SBIR Manager for more information. (See Air Force SBIR Organization Listing) . If selected for a Phase II enhancement, the company must submit a Phase II Enhancement application through the DoD Submission Website at www.dodsbir.net/submission.

AIR FORCE SBIR PROGRAM MANAGEMENT IMPROVEMENTS

The Air Force reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees that 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.

PHASE I SUMMARY REPORTS

In addition to all the Phase I contractual deliverables, Phase I award winners must submit a Phase I Final Summary Report at the end of their Phase I project. The Phase I summary report is an unclassified, non-sensitive, and non-proprietary summation of Phase I results that is intended for public viewing on the Air Force SBIR / STTR Virtual Shopping Mall. A summary report should not exceed 700 words, and should include the technology description and anticipated applications / benefits for government and / or private sector use. It should require minimal work from the contractor because most of this information is required in the final technical report. The Phase I summary report shall be submitted in accordance with the format and instructions posted on the Virtual Shopping Mall website at http://www.sbirsttrmall.com.

AIR FORCE SUBMISSION OF FINAL REPORTS

All final reports will be submitted to the awarding Air Force organization in accordance with the Contract. Companies **will not** submit final reports directly to the Defense Technical Information Center (DTIC).

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF073-002 thru AF073-009	Directed Energy Directorate AFRL / DE 3550 Aberdeen Ave SE Kirtland AFB NM 87117-5776	Ardeth Walker (505) 846-4418	Susan Thorpe (505) 846-3404
AF073-010 thru AF073-014	Human Effectiveness Directorate AFRL / HE 2610 Seventh Street, Bldg. 441 Rm 216 Wright-Patterson AFB OH 45433-7901	Sabrina Davis (937) 255-2423 Ext. 226	Kellye Fisher (937) 255-5216
AF073-016 thru AF073-035	Information Directorate AFRL / IF 26 Electronic Parkway Rome NY 13441-4514	Janis Norelli (315) 330-3311	Lori Smith (315) 330-1955
AF073-037 thru AF073-047	Materials & Mfg. Directorate AFRL / ML 2977 Hobson Way, Rm 406 Wright-Patterson AFB, OH 45433-7746	Debbie Shaw (937) 255-4839	Terry Rogers (937) 656-9001
AF073-048 thru AF073-061	Propulsion Directorate AFRL / PR 1950 Fifth Street Wright-Patterson AFB, OH 45433-7251	Laurie Regazzi (937) 255-1465	Susan L. Day (937) 255-5499
AF073-063 thru AF073-084	Sensors Directorate AFRL / SN 2241 Avionics Circle, Rm N2S24 Wright-Patterson AFB, OH 45433-7320	Robin Harlow-Sammon (937) 904-9155	Ashley Edwards - PI (937) 255-0207 Kevin Riley – P II (937) 255-5762
AF073-086 thru AF073-091	Air Vehicles Directorate AFRL / VA 2130 Eighth Street Wright-Patterson AFB, OH 45433-7542	Larry Byram (937) 904-8169	Douglas Harris (937) 656-9833
AF073-093 thru AF073-103	Space Vehicles Directorate AFRL / VS 3550 Aberdeen Ave SE Kirtland AFB, NM 87117-5776	Danielle Lythgoe (505) 853-7947	Jean Barnes (505) 846-4695

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF073-105 thru AF073-109	Oklahoma City Air Logistics Center OC-ALC / ENET 3001 Staff Drive, Suite 2AG70A Tinker AFB, OK 73145-3040	Becky Roberts (405) 736-2158	Joe Starzenski (405)739-4476
AF073-110 thru AF073-115	Ogden Air Logistic Center OO-ALC / LHH 6021 Gum Lane Hill AFB, UT 84056-2721	Craig Shaw (801) 586-2721	Lt Kirk Andrews (801) 777-0199
AF073-117 thru AF073-123	Warner Robins Air Logistic Center WR-ALC / ENES 450 Third Street, Bldg. 323 Robins AFB, GA 31098-1654	Greg Sutton (478) 327-4127	Nita Steinmetz (478) 926-3695
AF073-125 thru AF073-130	Air Armament Center 46 TW / XPXR 101 West D Avenue Bldg. 1 Rm 210 Eglin AFB, FL 93524-6843	Ramsey Sallman (850) 883-0537	Daniel Burk (850) 882-0168
AF073-131 thru AF073-136	Arnold Engineering Development Center AEDC / XRS 1099 Schriever Ave Arnold AFB, TN 37389-9011	Ron Bishel (931) 454-7734	Sue Tate (931) 454-7801
AF073-139 thru AF073-145	Air Force Flight Test Center AFFTC / XPDT 195 East Popson Ave, Bldg. 2750 Rm 113 Edwards AFB, CA 93524-6843	Abraham Atachbarian (661) 277-5946	Lisa Jackson (661) 277-7708

Air Force SBIR 07.3 Topic Index

AF073-065	Tunable Filters for the Joint Tactical Radio System (JTRS)
AF073-066	Low Profile Wideband Antennas for the Joint Tactical Radio System (JTRS)
AF073-067	Efficient Radar Search Modes for Deep Space (DS) Surveillance
AF073-068	Three Dimensional (3D) Synthetic Aperture Radar (SAR) Image Formation and Exploitation
AF073-069	Featured-Aided Tracking, and Identification for Moving Targets Using Synthetic Aperture Radar (SAR)
AF073-070	Waveform Optimization Algorithms for Electronic Warfare Countermeasures Development
AF073-071	Nonlinear Signal Processing for Advanced Digital Receive Systems
AF073-072	Material/Techniques for Small/Dense Global Positioning System (GPS) Antenna Arrays
AF073-073	Digital Beam-Forming (DBF) for Satellite Operations (SATOPS) Support
AF073-074	Multi Channel Radio Frequency Application-Specific Integrated Circuit (RFASIC) for Handheld GPS Receiver Anti Jam Enhancement
AF073-075	Agile Optics and Optical Systems for Autonomous Aerial Surveillance Cameras
AF073-076	Exploitation of Large-Format Electro-Optical (EO) Data (ELF ED)
AF073-077	Enhancing Trust Via End-Node Security in Sensorweb Decision Support Systems
AF073-078	Technology Enablers for Integrated Intelligence, Surveillance, and Reconnaissance Applications
AF073-079	Reconfigurable Subaperturing for Endo-Clutter Processing
AF073-080	Managing Uncertainty in Anticipatory Exploitation
AF073-081	Anticipating Emergent Threat Propensity Using Human/Machine Perceptual Sensing
AF073-082	Vertically Integrating Sensing, Tracking, and Attack (VISTA)
AF073-083	Polarization Selective Infrared Detection
AF073-084	Actively Exited Bio-Taggant Sensor
AF073-086	Store Trajectory Response to Unsteady Aerodynamic Loads
AF073-087	Enhanced Acoustical Environment for Modern Weapons Bays
AF073-088	Innovative Structural Concepts for Deep-Winged Large Transports
AF073-089	Autonomous Control Technologies for Terminal Area Operations
AF073-090	Towards a Systematic Approach for Micro Air Vehicles (MAVs) Flight-Enabling Technologies
AF073-091	High-Speed Air-Breathing Propulsion Integration
AF073-093	Pre-processing Algorithms for Exploitation of Remotely Sensed Optical Spectral Imagery for Automated Target Recognition/Cueing and Multi-INT Fusion
AF073-094	Design-Hardened Radiation Tolerant Microelectronics
AF073-095	Radiation Resistant Solar Cell Coverglass Adhesives
AF073-096	Advanced Lithium Ion Batteries for Space Applications
AF073-097	Space Qualified SDRAM Memory
AF073-098	Thin Multi-Junction Solar Cells
AF073-099	Ultra-Dense Three Dimensional Electronics for Space
AF073-100	Ultra-Low-Power Radiation-Hard Electronics
AF073-101	Low Cost Deployable Reflector Support Structure
AF073-102	Satellite Structures with Engineered or Variable Electromagnetic Properties
AF073-103	High Performance Miniaturized Space Weather Instruments
AF073-105	Just In Time (JIT) Component Presentation
AF073-106	Penetration Material Waste Reduction and Process Improvement
AF073-107	SF6 Replacement or Reduction in high voltage switchgear and airborne radar
AF073-108	Distributed, Multi-Echelon Logistics Management
AF073-109	Airframe Structural Remote Detection for Stress and Corrosion Crack Damage
AF073-110	Handheld Real Time Climatic/environment Sensor
AF073-111	Compact Immersive Display Components
AF073-113	Hydrophobic/Non-Delaminating Radome Material
AF073-114	Identification of the Anisotropic Rigidities and Damping of Composite Panels for Radomes and Shelters
AF073-115	Restoration of Dimensional Tolerances
AF073-117	Damage Detection and Identification in Advanced Composites
AF073-118	Aircraft Corrosion Inspection
AF073-119	Inspection of Subsurface Flaws Around Fasteners on Aircraft
AF073-121	Development of Novel Cooling and Temperature Monitoring for High Velocity Oxygen Fuel (HVOF) Coating Applications

AF073-123	Trace Level Sulfur Sensor
AF073-125	Multi-Spectral Projection Sources
AF073-130	Wireless Fire Detector
AF073-131	Linear Cryo-Motion for Space Simulation Testing
AF073-132	High Temperature Hypersonic Force Measurement System
AF073-133	Mass Flow-Through Measurement System for Transient Jet Interaction Testing
AF073-134	Fiber-Based Coherent Anti-Stokes Raman Spectroscopy System
AF073-135	Vibration Analysis of Rotating Plant Machinery
AF073-136	Secure Plant Operations Data Network
AF073-138	Low Temperature Multi-Spectral Image Projector
AF073-139	Field Sensor for Measuring Total Trihalomethanes (TTHM) Concentrations in Drinking Water
AF073-140	Test and Evaluation Metadata Support Tools
AF073-141	Portable Biomass Liquid/Gaseous Fuel Reactor
AF073-142	Aeroelastic Model Updating
AF073-144	Wireless Brake and Tire Monitoring System (WBTMS)
AF073-145	Aerothermoelastic Simulation

AF073-002 TITLE: Adaptive Optics Compensation in Deep Atmospheric Turbulence

TECHNOLOGY AREAS: Sensors, Battlespace, Weapons

OBJECTIVE: Determine requirements & evaluate performance for adaptive optics prototype devices that perform well in deep turbulence. Innovation may be required in beacons, wavefront sensors & deformable mirrors.

DESCRIPTION: Adaptive optics systems can be very effective for compensating low to moderate atmospheric turbulence levels where the intensity variance is less than one. Astronomical systems and many defense applications fall in this turbulence regime. For applications that involve imaging or transmitting energy over long paths near the ground the cumulative turbulence effects can easily defeat the conventional technologies for adaptive optics. Such applications include tactical laser weapons, ground imaging systems, laser designators, and laser communications. The turbulence effects manifested in this regime are high levels of scintillation, branch points, and very small phase coherence length (r0). New approaches for turbulence compensation at this level may require many innovations, including advanced beacon concepts, new wavefront sensors, and very high resolution deformable mirrors. In addition suitable reconstruction and control algorithms for compensating phase or phase and amplitude will be required.

Proposals for novel adaptive optics prototype devices that perform well in these regimes are sought for this effort. Thorough analysis of requirements and performance evaluation should be included. This will include wave optics evaluation of performance metrics appropriate for the application, such as Strehl ratio or image quality. The proposer should demonstrate a good grasp of all realistic effects such as signal to noise in high scintillation and all forms of anisoplanatism (conventional, extended beacon, & focus).

PHASE I: The proposer should select a deep atmospheric turbulence application and develop a prototype device for the Phase I effort. A performance analysis based on wave optics simulation should be performed. Advanced hardware that will be available in the near future should be considered.

PHASE II: The Phase II effort will include a thorough analysis of the Phase I prototype device over a wide range of turbulence scenarios. Advanced performance extensions to the basic design should be considered. One or more additional applications should be addressed with perhaps other system architectures. A laboratory demonstration of one concept would be desirable for the Phase II effort.

DUAL USE COMMERCIALIZATION: Military application: Such applications include tactical laser, ground imaging systems, laser designators, and laser communications. Commercial application: Broad commercial uses such as astronomical, ground imaging systems and commercial laser communications.

REFERENCES: 1. Fried, David L., "Branch point problem in adaptive optics," JOSA A, Vol. 15, Issue 10, pp. 2759-2768.

2. Barchers, Jeffrey D., "Closed-loop stable control of two deformable mirrors for compensation of amplitude and phase fluctuations," JOSA A, Vol. 19, Issue 5, pp. 926-945.

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KEYWORDS: tactical laser,ground imaging systems,laser communications,adaptive optics,turbulence,scintillation

AF073-003 TITLE: Cryogenic High Power Laser Pump Diodes

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

OBJECTIVE: Demonstrate 77K operation of high power diode laser arrays for solid state laser pumping

DESCRIPTION: Eventual deployment of high power solid state lasers will require compact, lightweight and environmentally friendly cooling systems. In addition, the efficiency requirements of these laser systems strongly suggest the use of cryogenic cooling systems. The only viable cryogen candidate appears to be liquid nitrogen (LN). Liquid nitrogen is commonly available on Air Force bases, it is non-explosive, non-toxic and environmentally friendly. Other cryogens such as liquid oxygen, liquid air or liquid helium do not meet these criteria. Cryogens which deplete the ozone layer, are not readily available or are oxidizing/explosive are not of interest. Single diode stacks can be successfully immersed in LN but this is not the case for high power diode stacks with outputs in excess of 5kW and thermal power densities approaching 700 W/cm2. The most likely candidates for high power solid state lasers are Yb:YAG and Nd:YAG which are pumped at 942nm and 808nm at room temperature respectively. Pump diodes must be designed which will match the pump bands of Yb:YAG or Nd:YAG at cryogenic temperatures. A cooling system must be designed which will remove thermal energy and allow for prolonged operation of the diode laser at cryogenic temperatures. The successful research program will determine the parameters necessary for the successful LN operation of high power laser diode stacks for the optical laser pumping of cryogenic Yb:YAG or Nd:YAG, design a cryogenic cooling system with a non-toxic, non-explosive cryogen which is commonly available on Air Force bases or a high power diode stack of at least 5kW optical output power and then build a prototype device and demonstrate its operation.

PHASE I: Design cryogenic LN diode cooling system and determine laser diode design parameters for LN operation.

PHASE II: Build prototype cooling system and mate it to high power laser diode stack capable of optically pumping Nd:YAG or Yb:YAG.

DUAL USE COMMERCIALIZATION: Military application: Develop and market LN cooling conversion kits to DoD customers. Commercial application: Develop and market LN cooling conversion kit to commercial customers. They will find use in high power applications in the pumping of narrow pump bands such as the 975nm line of Yb:YAG.

REFERENCES: 1. R. L. Aggarwal et. al, “Thermo-Optic Properties of Laser Crystals in the 100-300 K Temperature Range: Y3Al5O12 (YAG), YAlO3 (YALO), and LiYF4(YLF),” SPIE 5707, pages 165-170.

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KEYWORDS: Liquid Nitrogen;Diode Pump Lasers;Nd:YAG;Yb:YAG;Cryogenic lasers;Solid State Lasers

AF073-004 TITLE: Integrated wide-bandgap semiconductor photoconductive switch with a terahertz antenna

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

OBJECTIVE: Develop an integrated laser-induced wideband gap semiconductor switch and terahertz antenna device based on femtosecond laser triggering and highly directional terahertz antennas.

DESCRIPTION: A high power terahertz (THz) device, operating in sub-millimeter wavelengths, offers the possibility of high resolution imaging of objects at relatively far distances (i.e., with relative to the distance seen by infrared devices) and establishing an undetectable THz communication link in the field operation. These applications demand higher power density and operating voltages of switches to enable superior performance and widebandwidth capabilities. While silicon is the material of choice for most current devices, it is not suited for high voltage/power operation due to uncontrolled generation of intrinsic carriers affecting its material properties.

Wideband gap semiconductors, specifically SiC and GaN, have large breakdown voltages and high thermal conductivities, and they are good candidates for next generation high power density switches. A major technological challenge in developing high power widebandgap semiconductor switches is the development of new switching technology that allows 500 fs risetime at 100kW peak power or 50 fs risetime at 1kW peak power. Among many design concepts investigated in the recent years, laser-induced semiconductor switches (LSS) are most likely candidates to satisfy both the high power and spectral bandwidth requirements for use in the high power wideband THz applications. Photo-excitation, with an optical pulse of 100 femtosecond duration and pulse energy of 100 pico-joule, is known to generate a THz pulse at the typical pulse energy of 0.5 femto-joule in frequencies around 5–6 THz, which correspond to the region of sub-millimeter waves. For high power terahertz applications, this topic seeks the use of currently available high quality substrates and epitaxially grown photoconductive semiconductor materials, desirably the widebandgap materials but not limited to, that are capable of releasing the stored energy by increasing the resistivity to at least 10 orders of magnitude during the carrier excitation stage, which takes place in the sub-picosecond timescale, as a result of triggering by femtosecond optical pulses. The THz antenna part of the device must be highly directional, having a low impedance mismatch with a photoconductive switch, to ensure optimum high power throughput operations.

PHASE I: Perform the survey of LSS materials and THz antenna technologies. Design and develop concepts for integrated LSS and THz antenna devices. Perform performance and reliability analysis for the initial design concept as functions of distance, triggering output power, and bandwidth.

PHASE II: Design, develop, and establish fabrication and other capabilities for one or more prototypes to yield high performance, high reliability, and reproducible THz high power device based on photoconductive semiconductor switches. Develop models to accurately predict device performance including thermal management. Conduct comprehensive reliability tests to demonstrate long-term performance.

DUAL USE COMMERCIALIZATION: Military application: High resolution imaging of objects at relatively far distances and establishing an undetectable THz communication link in the field operation. Commercial application: THz time-domain spectroscopy for unique fingerprinting of DNAs due to sensitivity of its vibrational modes. It is basically a DNA analysis tool serving as a THz micro-biosensor.

REFERENCES: 1. Y. C. Shen, P. C. Upadhya, H. E. Beere, and E. H. Linfield, A. G. Davies, I. S. Gregory, C. Baker, W. R. Tribe, and M. J. Evans, “Generation and detection of ultrabroadband terahertz radiation using photoconductive emitters and receivers,” Appl. Phys. Lett. 85 (2), pp. 164-166, 12 July 2004.

2. Masato Suzuki and Masayoshi Tonouchi, “Fe-implanted InGaAs photoconductive terahertz detectors triggered by 1.56 mm femtosecond optical pulses,” Appl. Phys. Lett. 86 (16), pp. 163504-1 - 163504-3, 18 April 2005.

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5. K. S. Kelkar, “Silicon carbide as a photo-conductive switch material for high power applications,” PhD Thesis, Electrical & Computer Engineering Department, The faculty of the graduate school at the University of Missouri‑Columbia, December 2006.

KEYWORDS: High power wideband terahertz devices,Terahertz antennas,Laser-induce semiconductor photoconductive switches,Femtosecond laser pulse interaction with widebandgap semiconductors

AF073-005 TITLE: Non-Linear Transmission Line Microwave Source

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Demonstrate and validate innovative technology that can be used to develop high Q mesoband (damped sine) microwave sources that will operate at discrete frequencies in the 500MHz-1GHz range.

DESCRIPTION: The DoD requires very effective high power microwave (HPM) sources in order to carry out their counter electronics missions. To this end, the Air Force Research Laboratory has been developing and testing lightweight, compact HPM sources suitable for portable applications such as the mesoband sources described in Reference 1 below. Such sources produce a damped sine waveform using high voltage pulsed power and an oscillator rather than vacuum electron beam technology like a magnetron. At present, mesoband sources generally produce a low Q signal with the waveform damping out in 5 to 10 oscillations, giving a 10-15% bandwidth. The thrust of this effort is to develop technology and concepts to design high Q mesoband sources to generate HPM radiation in the 500MHz-1GHz range. The final system is expected to be capable of delivering a high voltage pulse of at least 100kV, a repetition rate of 1 kHz, and have programmable frequency agility while operating into a 100-ohm load. For future DoD applications, it is necessary to develop the technology that will allow us to produce such sources. Present literature suggests a solid-state, non-linear transmission line oscillator as one possible solution. Small business bidders are invited to submit creative and innovative solutions to this challenging problem.

PHASE I: This phase will require innovative research on new high voltage, high Q repetive pulse generator technology. Design a prototype device to be fabricated in Phase II. Demonstration of the technology through a working model is desirable. Develop an initial commercialization concept and plan.

PHASE II: Execute the Phase II planning developed as part of the Phase I effort. Build and demonstrate a prototype of a high voltage, damped sine generator capable of delivering the required output. Provide a report on the technology developed. Develop an executable engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military application: Uses of this technology include airborne and ground-based pulsed radar, target identifications, and counter electronics. Commercial application: Civilian sector applications include pulsed radar, electromagnetic interference testing, counter mine, and numerous manufacturing applications.

REFERENCES: 1. W.D. Prather, et al., "Survey of Worldwide Wideband Capabilities," IEEE Trans on EMC, Special Issue on Intentional EMI, 2004, August 2004.

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3. J. Benford, J.A. Swegle, and Edl Shamiloglu, "High Power Microwaves, Second Edition," Taylor & Francis, New York, 2007.

4. Y.K. Fesitov, "Bistable microwave oscillator based on nonlinear magnetostatic wave transmission line," Journal de Physique IV, Vol. 7, No. C1, March 1997.

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KEYWORDS: non-linear,transmission line,high power microwaves,HPM,directed energy,damped sinewave,oscillator,frequency agile

AF073-007 TITLE: Intracavity Beam Control in Laser Resonators

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Beam control functions like fine steering as well as aberrations such as atmospheric disturbances could be corrected inside the laser resonator.

DESCRIPTION: Over the years of development of high energy lasers, system engineers have gravitated toward handling the generation of the laser power separately from the beam control functions, like fine tracking and beam clean-up. As the systems mature in their development, there may be good reasons to integrate the laser power generation and beam control functions. For instance, the fine tracking function, usually relegated to a final fine track mirror in the pointer tracker, could be accomplished inside the resonator at lower power and hence higher bandwidth if the intra-cavity adaptive optics system was redesigned. Other functions such as beam clean-up due to mirror thermal loading in the final optical train or even atmospheric disturbances could be handled in much lower power sections of the optical train, with significant cost and performance ramifications.The contractor should develop intracavity systems for beam cleanup, and perform modeling and experiments to validate concepts. The beam cleanup task is primary in importance. Additionally, the contractor should develop intracavity systems for fine tracking, and perform modeling and experiments to validate concepts.

PHASE I: Components, techniques and/or architectures should be designed and modeled. Experimental demonstrations of key aspects of the concepts should be performed.

PHASE II: The provider should demonstrate the proposed concepts and the ability to integrate laser resonator and beam control functions. Field tests are encouraged.

DUAL USE COMMERCIALIZATION: Military application: This technology is applicable to lightweight laser systems for multiple tactical platforms. Commercial application: There may be a significant number of industrial laser systems which have similar thermal loading or fine tracking issues.

REFERENCES: 1. X. Zhang, B. Xu, W. Yang, “Theoretical analysis of tilt perturbation and aberration correction for unstable laser resonators,” Opt. Eng., Vol. 45(10), 104203-1-9, October 2006.

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KEYWORDS: Laser resonators,fine tracking,beam stabilization,beam control

AF073-008 TITLE: Solid State Switch for high voltage sub-microsecond pulsed power

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop a compact, solid state pulsed power switch capable of switching 20-50 kV, and I > 5 kA with low-jitter, fast rise time (~20 ns), L < 20 nH, pulse length 100 to 1000 ns, and up to 1000 Hz prf.

DESCRIPTION: Compact, reliable solid state pulsed power switches can be an enabling technology for many Air Force applications such as radar drive circuits, power modulators for high peak power electrical systems for manned and unmanned air vehicles and narrow band high power microwave systems. Compact, high speed opening and closing switches are needed to reduce the size and weight and improve the reliability of pulse power modulators and pulse forming networks. Currently available vacuum based technology such as thyratrons, krytrons and spark gaps are large and require extensive peripheral equipment such as gases handling equipment, pumps and extensive electronics and/or triggering circuits. This topic is designed to examine the current state-of-the-art in solid state switches and develop a design that goes beyond the capabilities of what is currently available. Innovative designs (junction field effect transistor (JFET), insulated gate bipolar transistor (IGBT), emitter turn-off (ETO), heterojunction bipolar transistor (HBT), stacked arrays, ...) and advanced material utilization (GaAs, SiC, GaN, diamond, ...) should be explored. Methods for achieving the maximum performance that is possible are dependent on the fundamental limitations of the material of choice, and device design should be examined through modeling and simulation. The program should address technical challenges in materials development to improve performance, as well as, device design for compact size and weight, long lifetime, fast turn on or turn off time, high efficiency, triggering, and packaging.

PHASE I: Examine device design and material utilization through modeling and simulation. Perform feasibility experiments of materials and designs. Test initial switch design; a scaled design must verify the essential functionality of the concept. Define system requirements for a functional packaged switch.

PHASE II: Develop, fabricate and demonstrate a prototype, solid state pulsed power switch capable of switching 20-50 kV, and I > 5kA with low-jitter, fast rise times (20 ns or less), minimal inductance (<20 nH), modest pulse length (100 to 1000 ns), and up to 1000 Hz pulse repetition frequency. Develop a business and commercialization plan for the Phase II engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military application: Modulators for high peak power electrical systems for manned and unmanned air vehicles, military radar drive circuits, directed energy systems. Commercial application: Modulators for high peak power electrical systems for high speed rail traction, utility power distribution substations, power modulators for particle accelerators, uninterruptible power supplies.

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2. J. Casey, et al., “Solid-State Modulators for the International Linear Collider,” 2005 IEEE Pulsed Power Conference, Monterrey, CA, June 2005.

3. J. D. Sethian, et al., “ELECTRA: A Repetitively Pulsed, Electron Beam Pumped KrF Laser to Develop the Technologies for Fusion Energy,” 2005 IEEE Pulsed Power Conference, Monterrey, CA, June 2005.

4. H. O’Brien, et al., “Evaluation of Advanced Si and SiC Switching Components for Army Pulsed Power Applications,” IEEE Transactions on Magnetics, Vol. 43, No. 1, Pt. 2, Jan. 2007, pp. 259-264.

KEYWORDS: solid state switch,pulsed power,high power microwave,IGBT,JFET,GaAs,SiC,GaN,laser triggered switch,light activated switch

AF073-009 TITLE: High Average Intensity High Repetition Rate Short Pulsed Neutron Source

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

OBJECTIVE: Develop a high energy neutron source with a short pulse, high repetition rate, and time-average high intensity.

DESCRIPTION: Improved methods for the remote detection of concealed high explosives are of critical importance to the military for applications such as convoy protection and mine clearing. Present techniques are too short in range to be used at a safe distance in case the explosive detonates.

A neutron source with a pulse width of about 5 nanoseconds, a repetition rate of order 100 kHz, and a time-averaged intensity of at least 10^9 n/s would be valuable for intermediate (~10 m) to long range (~100 m) sensor applications of this nature. The emitted neutrons would interact with nuclei in the environment, which would emit gamma rays. Gamma rays received by sophisticated detectors under development (not a part of this solicitation) can theoretically identify the nuclei's species, direction, and (from time-of-flight) distance. Obtaining a detailed three dimensional elemental map of the environment is required for adequate background discrimination. This requires an intense short-pulse neutron source, ideally with only sufficient delay between firings to process the secondary signals. The stated parameters are intended to be suggestive of this requirement for real-time applications, but significantly greater time averaged intensity would given greater consideration.

High time-averaged intensity is needed to obtain sufficient statistics in a timely manner due to the rapid drop off in the signal with range for a given target. High repetition rate is needed due to the maximum number of neutrons interaction gammas that can typically be processed per shot. A short pulse width is needed due to the time-of-flight requirement. Existing devices are at least upgradeable to the minimum time-average intensity levels, but have much lower repetition rates and longer pulse widths than specified. Conversely, high repetition rate technologies with short pulses have much lower time-averaged intensities. Innovative approaches are sought to achieve all the desired parameters in a given system.

The size and weight of the ultimate commercial system envisioned is an important consideration for most applications. That is, it should be readily transportable on a modestly sized ground vehicle for field use.

Coordination with independently funded efforts addressing the detector issue is highly desirable. Such coordination will help optimize performance parameter goals, for example.

Detection of fissile materials using secondary neutron detectors is an additional potential application of the proposed source.

PHASE I: Investigate innovative approaches to achieving target intensity, repetition rate, and pulse width parameters. Deliver documented results quantifying these parameters and demonstrate the feasibility of the proposed approach. Deliver a Phase II Plan that includes a prototype design for further tests.

PHASE II: Finalization of the design and fabrication of the prototype device. Perform functional, reliability, etc. testing to demonstrate the desired application. Deliver a Phase II Final Technical Report and Marketing Plan.

DUAL USE COMMERCIALIZATION: Military application: Such a neutron source would be a great benefit for military detector systems wherever mapping of hazardous materials such as high explosives and/or fissiles is required, such as convoy protection. Commercial application: Such a neutron source would be great benefit for civilian concealed hazard material imaging systems at ports of entry, for example.

REFERENCES: 1. G. Viesti, et al, "The EXPLODET project: advanced nuclear techniques for humanitarian demining," Nucl. Instrum. and Methods in Phys. Research A 422, 918-921, 1999.

2. J. Csikai, ed., Handbook of Fast Neutron Generators, CRC Press, Boca Raton, Florida (1987).

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KEYWORDS: high energy neutron source, gamma, explosives, fissile, detector, intensity, high repetition, explosives detection, hazardous material detection

AF073-010 TITLE: <u>User Definable 4-D Common Operating Picture (COP)</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To create a 4-D common operating picture (COP) the elements of which are user selectable and are automatically correlated in time and space.

DESCRIPTION: In today's net centric warfighting environment, personnel in Air Operations Centers (AOCs) have access to an abundance of information about the operational environment. However, this information resides in multiple databases both in and outside the AOC. Users often must log on to several different systems to access all needed information. The information from these various sources is generally not correlated in time or space. In addition, current software depicts the 3-D operational environment in a 2-D display format. To facilitate tasks such as airspace management, mission planning and precisions targeting, a 3-D depiction of the operating environment is needed which can be played back or forward in time. The ability for a scenario or task to be played backward or forward in time is considered the 4-D aspect. Typical methods to visualize the warfighting environment include geospatial and temporal perspectives, but fail to link the two in a coherent way. Linking the two methods is risky because they are traditionally decoupled. Linking geospatial and temporal perspectives enables operators to move within the time dimension to see plans, the current situation, archived data, or to change resolution from tactical to theater/operational to global/strategic perspectives and continue to have data presented in a framework that remains context-relevant within the dynamic 4-D range. A refresh rate of no slower than 30 Hertz is required. An emphasis should be placed on developing a user definable/user selectable operational picture that links tactical to strategic, analyst to executor to planner (past/present/future). Predicting the future battlespace is difficult, but being able to display possible outcomes will enable the warfighter to better plan missions. The operational picture should supply temporal data, have metadata querying and meta-analysis. These desired features increase program risk. An innovative operator interface design is required that optimizes the 4-D visual presentation for user tasks. The tool(s) used to interact with the design should be appropriate for the interface. Presented information should be displayed in such a way that would enable the user to define/select his dataset in no more than three seconds. Metadata, including age and source of information, must be accessible and the information must be correlated in time (+/- 1/30 second) and space (+/- 1 display pixel). Situational information (task specific) must be accessed using no more than three applications and in less than five seconds without overload, such as information not needed for that situation (task) or without inducing fatigue effects (eye strain).

PHASE I: Identify and evaluate user definable/user selectable strategies that demonstrate how data from databases, text, text chat, voice communications, outside sources, etc, can be correlated and presented to users to create an easily understandable 4-D COP linking geospatial and temporal perspectives in a high level functional design. The results will be documented in a report.

PHASE II: Construct a working prototype that demonstrates how data from databases, text, text chat, voice communications, outside sources, etc., can be correlated and presented to users to create an easily understandable 4-D common operating picture. The 4-D COP will be user definable/user selectable and link geospatial and temporal perspectives. Software/hardware deliverable will be robust enough for laboratory testing.

DUAL USE COMMERCIALIZATION: Military application: Military applications include AOCs and other command and control environments. One example would be the ability to develop courses of action based on the known and the projected battlefield. First responders, control centers, and the Department of Homeland Security would also benefit. Commercial application: Applications include activities where information from multiple sources is needed to understand the operating environment. This technology could also be used for time-based analysis of collected data.

REFERENCES: 1. Phister, P., Plonisch, I. & Humiston, T. The Combined Aerospace Operations Center (CAOC) of the Future. 6th International Command and Control Research and Technology Symposium. U.S. Naval Academy, Annapolis, MD, (2001).

2. Vego, M.N. Operational Command and Control in the Information Age. Joint Force Quarterly, Autumn 2004. http://www.dtic.mil/doctrine/jel/jfq_pubs/1935.pdf

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KEYWORDS: common operating picture (COP), 4-D, air and space operations center (AOC), command and control (C2), net centric, user definable

AF073-011 TITLE: Participant Tracking in Immersive Training and Aiding Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Individual and simultaneous precision tracking of the location and face direction of multiple participants in large volume immersive simulation environments.

DESCRIPTION: Immersive simulation environments may be used to support personnel learning, training, and aiding functions. Visual and auditory information are the primary stimuli presented to participants in such environments, and such stimuli may be presented via transducers that are personally worn. Some environments may simulate the ground or interiors of buildings, in forward locations or in analysis/command/control locations. In all cases, participants must interpret large volumes of complex information and make decisions accordingly. Participants may move around in some environments, and specific content in the various stimuli presented to each participant may vary depending on their role, their location, and the direction in which they are facing. If a hand-held display (HHD) such as a simulated binocular or a head-mounted display (HMD) is used or worn by a participant, optimal decision making requires that the imagery displayed by that HHD or HMD be contextually appropriate at all times for the direction in which the HHD is aimed and/or the wearer of the HMD is facing. The same requirement holds true if spatial audio cues are presented to the participant. Multiple participants may train or operate at the same time in one environment. Individual tracking information is required to continuously determine the location and direction in which each participant, as well as any imaging devices they are holding, are facing in a multiparticipant simulation environment. Low latency and high angular accuracy of tracking is of particular importance for HHD and HMD imagery. If participants are walking in a simulated ground environment, no cables or other obvious physical manifestations used for tracking should be present that would not be present in the real world. Walls or other obstacles may be present in a ground environment such as a building, but such obstacles must not interrupt or interfere with individual tracking data.

The Air Force is seeking tools and concepts to create immersive simulation environments for learning, training and aiding applications spanning the gamut from tactical to strategic. For this topic the Air Force is specifically seeking unobtrusive means of wirelessly and simultaneously tracking the location and orientation of multiple individuals and simulated imaging devices they may carry in an environment measuring at least 25,000 cubic feet in volume projected onto a floor area of at least 2500 square feet. Such tracking information must be continuously updated in real time on a by-individual person and device basis, in any posture or orientation, in scenarios of at least one hour duration each, and must have positional accuracy, angular accuracy, and drift rate suitable for uninterrupted high-fidelity learning, training and aiding of participants either closely grouped or separated from one another. The conspicuity, weight, and volume of any equipment individually worn or attached for such tracking purposes must be minimal. Such tracking means must introduce no safety or health hazards to any users, and must be compatible with any other RF or optically-based data transferal or imaging systems in such environments.

PHASE I: Examine, compare, and document requirements on candidate tracker technologies. Define and document technical solution options, and design a tracker concept capable of meeting all requirements in “Description”

PHASE II: Prototype proposed Phase I design concept and demonstrate it for at least three individuals simultaneously using government-furnished HMDs. Durability, operating duration are considerations. Submit complete technical report documenting all work.

DUAL USE COMMERCIALIZATION: Military application: Any system needing realistic untethered high-resolution data transfer to/from dismounted trainees. Examples: USAF Joint Terminal Attack Control Trainer Simulator, US Army Dismounted Soldier Simulator. Commercial application: Entertainment and gaming industries, also education, training or maintenance applications which would benefit from continuous roaming access to high-resolution imagery or reference materials.

REFERENCES: 1. Lanzagorta, Rosenberg, Rosenblum and Kuo, (2000). “Rapid Prototyping of Virtual Environments,” IEEE Computing in Science and Engineering, Vol. 2, No. 3 (ISSN: 1521-9615), pp. 68-73, May/June 2000.
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Network, (2005). Iowa State University, Ames, Iowa. http://www.hci.iastate.edu/TRS/THESES/MS-Yifei-Wang-2005.doc

KEYWORDS: tracker, human performance, wireless, high resolution, simulator, immersive, high fidelity, sensory cues, visual display, auditory

AF073-012 TITLE: Terahertz Source and Spectrometer

TECHNOLOGY AREAS: Biomedical, Sensors, Weapons

OBJECTIVE: Develop a terahertz spectroscopy system consisting of a tunable terahertz source that can generate energy from 0.1 to 7 terahertz (THz) with 1 Watt (W) continuous wave (CW) output power and a terahertz spectrometer capable of better than 200MHz spectral resolution.

DESCRIPTION: The terahertz range of the electromagnetic spectrum lies between the infrared and radiofrequency regions of the spectrum. Recent technological advances have allowed for exploration of the possible applications within this region of the spectrum. The terahertz region has many potential applications including medical imaging and security (1-3). Terahertz spectroscopy can be used for detecting and identifying biological, chemical and explosive materials. The spectroscopic database in the terahertz range of the electromagnetic spectrum is currently being compiled by labs throughout the world. In order to ensure safe employment of terahertz sources for such applications, the spectroscopy of biological materials and the interaction of terahertz frequencies with biological materials need to be studied in greater depth. Data of terahertz interaction with skin currently exists only from 0.1 to 2 THz (4,5). The remaining portion of the terahertz spectrum (2 to 30 THz) remains unexplored. To enable to fielding of terahertz sources in many groundbreaking applications, it is necessary to further study the terahertz portion of the spectrum. A terahertz source and spectrometer would enable the biological research necessary to better understand the interaction of terahertz frequencies with biological tissue. Our requirements are for a tunable terahertz source capable of producing energy from 0.1 to 7 THz at power levels of 1 W, CW and reflectance spectrometer capable of better than 200MHz spectral resolution. The two items must be developed together and coupled as a system.

PHASE I: Determine the feasibility of designing a terahertz source that can generate 1 W, CW terahertz energy from 0.1 to 7 THz coupled with a spectrometer with spectral resolution of better than 200MHz. Breadboard a prototype version.

PHASE II: Develop, demonstrate, and validate an operational terahertz source/spectrometer system that was designed during Phase I.

DUAL USE COMMERCIALIZATION: Military application: Use by government to generate terahertz energy for medical imaging and security applications. This source could also be used in academia for basic scientific exploration of terahertz energy. Commercial application: Use by industry and academia, to generate terahertz energy for medical imaging and security applications. This source could be used in academia for basic scientific exploration of terahertz energy.

REFERENCES: 1. Dobroiu A, Otani C, Kawase K. Terahertz-wave sources and imaging applications. Measurement Science and Technology 17:R161-R174; 2006.

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KEYWORDS: terahertz, directed energy, radio frequency radiation, dosimetry, spectroscopy

AF073-013 TITLE: Integration of Psychophysiological and Performance Measures into an Adaptive Aiding System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a closed-loop, real-time prototype that integrates psychophysiological (i.e., EEG activity) and performance (i.e., reaction time) signals for adaptive automation in complex human systems

DESCRIPTION: The increased tempo of military operations, reduced manning and round the clock operations puts high levels of stress on Air Force personnel. Adaptive aiding or automation on demand can be used to reduce the cognitive demands on operators. This system would detect operator problems, look at the current mission situation and then provide the exact mitigation required to provide optimal performance. Procedures are needed to determine the momentary operator functional state (OFS) and in the context of the mission determine how to aid the operator to avoid errors and improve mission success.

Psychophysiological data have been shown to provide accurate and reliable estimates of OFS in operational environments in real time. Studies have shown that closed loop procedures using psychophysiological data significantly improve mission success. Additionally, models based upon operator performance have also resulted in improved mission success. Combining these two procedures (physiological and performance- based) should produce a synergistic effect that would provide even greater mission success. Further, by monitoring the development of the mission it will be possible to provide context-sensitive adaptive aiding. In other words, a system is needed that continuously monitors OFS using psychophysiological and performance data to detect overload and in the context of the mission evolution provide the most appropriate aiding. The operator's situation awareness (SA) of the mission can also be assessed with embedded nonintrusive SA probes.

The critical feature of such a procedure would be the ability to predict future mission demands and future status of the operator. Procedures that are reactive only to the current OFS may have limited impact on mission effectiveness. However, a procedure that can predict upcoming mission demands and also predict what the operator's capabilities will be at that time would greatly improve the warfighters effectiveness. While developed to demonstrate its utility with the Uninhabited Air Vehicle (UAV) task, the procedure should be designed so that it has universal applicability.

PHASE I: Identify and define salient psychophysiological measures, isolate critical performance measures, develop a task model, design SA measures, select classifier to integrate measures and develop mitigations which improve human performance.

PHASE II: Build, optimize, and test the psychophysiological and performance based adaptive aiding prototype demonstration in realistic UAV simulation.

DUAL USE COMMERCIALIZATION: Military application: This application will be useful for UAV operations by decreasing mission errors and improving mission success and allow one operator to control multiple Air Force systems. Commercial application: It will be useful in civilian situations that place high levels of stress on operators such as air traffic control, nuclear reactor operators, and process control operators.

REFERENCES: 1. Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Interface Division, Flight Psychophysiology Laboratory, http://www.hec.afrl.af.mil/Organization/HECP/fpl.asp

KEYWORDS: adaptive automation, operator functional state, human performance modeling, psychophysiology, situation awareness, human performance

AF073-014 TITLE: Rapidly Configurable Modular Litter System for use in Aeromedical Transport

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop technology concepts for an innovative patient litter system usable in military transport aircraft and the civil reserve fleet.

DESCRIPTION: The current patient litter is a canvass sheet 22 by 72 inches secured on poles. It is too narrow for many patients and cumbersome when loaded with critical patients plus medical equipment. Treatment items, supplies, and a vast array of medical equipment are haphazardly mounted to or around the litter or at locations scattered around the aircraft. The litter as a platform does not succinctly accommodate the large quantities of medical equipment such as ventilators, defibrillators, monitors, IV Pumps and suction devices. Separate pieces dangle in the aisles each with their plasma screens pointing in different directions. Each has a separate battery. Lighting is deficient, the patient microclimate temperature control is substandard and the background noise is prohibitive for voice communications. Urine and biological secretions are collected in bags hanging by hook off the litter creating clutter and spill hazards. Mounting the current litters in military transport aircraft requires first a skeleton of stanchions, power lines, oxygen lines, and emergency oxygen masks to be installed. This preconfiguration consumes precious manpower and time. Patient loading cannot begin until this stage is complete. Ground transport is also awkward. Each of the numerous pieces of equipment has to be powered in this phase by their own battery packs which results in a heavy, bulky, and awkward configuration. Medical oxygen must be provided by separate heavy carry along tanks. The litter loaded with the patient and equipment often weighs over 300 pounds. The canvass litter, as the basic platform for aeromedical patient transport, arose pre WWII, and all innovations since then including incorporation of modern medical equipment and upgrade to modern aircraft have been crudely adapted to this platform.

A Systems Engineering approach is required to develop an integrated self-contained Patient Transport Unit (PTU) with a focus on Human Systems Integration and greatly reduced logistics footprint. The numerous pieces of medical equipment should be merged and bundled into a minimal number of composite devices that are integrated as part the PTU, which would provide power to all from a single battery and from a single external power supply. The multiple plasma screens for each piece of equipment should be condensed to one user-friendly Multi-Function Display screen, integrated into the PTU, that would allow the care takers to quickly and easily access any of the patient information. The medical equipment should ultimately have the ability to record and telemeter the patient information throughout the patient's journey from the battlefield to state-side, and be integrated into the TRANSCOM Regulating and Command and Control Evacuation System (TRAC2ES).

The PTU should be light weight, durable, lockable to the aircraft bed and more airworthy than current systems. It should accommodate large and heavy patients and contain ergonomic features for efficient moving and improved comfort. It should be compatible with use in the field facilities, ground transport vehicles, staging facilities and receiving facilities so that the patient can stay on the same device all the way through the patient movement system. Supplies and treatment items should be kept in special compartments within each PTU. There should be collection chambers for biological fluids, provisions for microclimate control and provisions for avoidance of skin pressure ulcers. The modularity of the PTU will result in supporting the full range of patient complexity from very simple to very critical. Each unit should be stand-alone structurally such that no preconfiguration of the aircraft bay is required to permit rapid loading and unloading from aircraft and ground vehicles. It should be rigid to allow mounting of devices such as video cameras for telemedicine and hoods for infectious disease control. Each PTU should also be able to be easily integrated into a stable cluster of units for stacking and interlocking to the one below and those to the side allowing erection of structures with patients stacked up to three high. Each cluster would provide the ability to network and share power, oxygen and communications systems from a common source independent of the aircraft. The clusters should also enable the ability for a Remote Monitoring station for the entire cluster. This standalone, stackable, interlocking nature will permit use additional type of military and civil aircraft.

PHASE I: Propose design concepts to develop a light-weight modular litter assembly that can rapidly be secured within a variety of airframes. Investigate means of merging and integrating medical equipment and patient services into the system and interconnecting the configurations into clusters to share common resources.

PHASE II: Refine the design and identify specific medical equipment that can be integrated with the system. Demonstrate modularity of the system and ability to interconnect systems to network power, oxygen and communications systems. Fabricate a flight testable prototype that can be tested in US Air Force (USAF) or Civil Reserve Air Fleet (CRAF) aircraft.

DUAL USE COMMERCIALIZATION: Military application: Used for aeromedical transport in multiple aircraft including those that currently cannot be used for aeromedical transport. Commercial application: Civilian ground and aviation transport can use for ambulance and life flight. Agencies planning for large-scale disaster management such as Federal Emergency Management Agency (FEMA).

REFERENCES: 1. Loyd, Herb. Deficiencies of Current Aeromedical Evacuation Litter Systems., Biodynamics Database Web Site, http://www.biodyn.wpafb.af.mil/Study%20Reports/AE/Litter Deficiencies.pdf, February 2007.

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KEYWORDS: aeromedical evacuation, combat casualty care, military operational medicine, in-flight medical equipment, litter, NATO gurney, biomedical equipment, medical electronics

AF073-016 TITLE: Architecture Methodology Integration

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Provide increased agility to provide effective interoperable architectures with associated cost savings.

OBJECTIVE: Develop new architecture methodology constructs for information technology systems to provide effective translation of structured architectures into object oriented architectures.

DESCRIPTION: Object orientated architectures are based on the interactions of objects which have clearly defined responsibilities. This is established by combining data and behavior into single objects, as opposed to structural analysis architectures, where data and attributes are separated. Well written object orientated codes are modular in nature, and are much less expensive to maintain that structural analysis programs over the software lifecycle. Today almost all Air Force information systems are based on structural analysis architectures, and 70% of the software lifecycle costs are in maintenance. Savings of millions of dollars of maintenance costs per year can be realized by converting legacy structural analysis codes to object orientated architecture codes. Currently object orientated software code can be translated from structured analysis software code by using an assortment of converters, but the results are merely programs written in object oriented languages that still retains much of the structured analysis characteristics. The inability to accommodate this results in stove-piped architectures and costly inaccurate requirements-derived architectures. There is a clear need for examining the theoretical underpinnings of the two architecture methodologies and proposing new constructs that effectively bridge the gap between structured analyses and object oriented architectures. Given a theoretical basis for methodology integration, this effort should then consider approaches that allow for efficient design and fielding of the system architecture from captured user requirements contained in the operational architecture. Commercial applicability of the above is manifested in the need for similar technologies and approaches in the private sector.

PHASE I: Develop a theoretical basis for effective methodology integration. Propose, as needed, new architecture constructs to accommodate architecture integration.

PHASE II: Propose and demonstrate prototype tools in a realistic environment that implement the new constructs developed in Phase I. Proposed tools should address existing product-product limitations. Conduct testing to demonstrate the approach is scalable and adaptable to mission objectives.

DUAL USE COMMERCIALIZATION: Military application: Tools and approaches based on new theoretical constructs will be directly applicable to current and future Command and Control (C2) systems, such as the Combatant Commanders Integrated C2 System. Commercial application: This tool/toolset would also be used in a broad range of civilian applications which demand that architecture methodologies evolve and change or otherwise coexist with disparate methodologies.

REFERENCES: 1. M. Eriksson, K. Borg and J. Borsler, The Far Approach- Functional Analysis/Allocation and Requirements Flowdown Using Use Case Realizations, Proceedings of the 16th International Symposium of the International Council of Systems Engineering, Orlando, FL (Jul 2006).

2. DoD Architecture Framework Version 1.5 (http://www.defenselink.mil/cio-nii/docs/DoDAF_Volume_I.pdf), 23April 2007.

KEYWORDS: Operational Architecture, System Architecture, Object Oriented, Structured Analysis

AF073-017 TITLE: Distributed Multidimensional Analysis of Battlespace Weather

TECHNOLOGY AREAS: Information Systems, Battlespace

STATEMENT OF INTENT: Dramatically enhance AF Weather’s ability to support the warfighter

OBJECTIVE: Improve situational awareness by analyzing complex multidimensional relationships among weather and military operational data and thereby provide opportunities to quickly mitigate operational risk

DESCRIPTION: Weather can adversely impact military operations. Relating the state of the atmosphere, operational thresholds, and operational intentions is profoundly complex. Representing the state of the atmosphere alone has been extremely difficult. To adequately describe past, present, and future states, weather data is arranged in five dimensions (latitude, longitude, altitude, time, and measures (e.g., pressure, temperature, and wind vectors)). The Joint Meteorological and Oceanographic (METOC) Conceptual Data Model, an official subset of the DoD Enterprise Data Model was developed to format, store, and disseminate multidimensional weather data. Current military weather systems instantiate this data model in relational databases. Using relational schemas places the burden of joining tables on the application. This is highly undesirable now that modern architectures require separation of metadata from the business logic. Current dependencies on relational schemas and emphasis on disseminating raw data also slows everything down thereby hindering military decision-makers’ ability to keep up with the ever-increasing speed of military operations. Properly transformed and stored data would streamline data flows, increase storage efficiencies, and dramatically speed up near- and long-term weather forecasting and the application of those forecasts to operational risk management. There is clear need for better multidimensional representations that enable integration of metadata of various data sources as well as efficient fusion of many heterogeneous data sources. Computing multiple related groupings, aggregates by various hierarchies, and statistics are operations which do not scale well using non multidimensional storage techniques. Applications need to consume the data through the views of their choosing, which requires not only making all of the views available, but highly compressing the storage of those views. The Government is looking for revolutionary ways of dealing with the multidimensional complexities of weather forecast processes and weather-advice-in-air-battle-management applications. Figures of merit in assessing capability include scalability, speed of analysis, and ultimately, enhanced efficiencies in conducting military operations. With such new capabilities, military decision-makers will gain the situational awareness and virtual assistance necessary to keep up with the ever-growing information streams and services available to them.

PHASE I: Design revolutionary concept for relating highly dynamic complex multidimensional data to accomplish either 1) Continuous, rapid, distributed weather forecasting, or 2) Incorporation of weather affects within the air battle management process. Develop approaches for determining technical feasibility

PHASE II: Implement Phase I design using real-world and/or simulated data streams/sources. Demonstrate the efficacy of multidimensional analysis of weather data against relevant military operational data to glean situational awareness and discover opportunities to mitigate operational risk.

DUAL USE COMMERCIALIZATION: Military application: Weather forecasting applications by shortening forecasting cycles, and air battle planning by mitigating adverse impact of the weather (air task order production, efficient time-phased deployment). Commercial application: Weather forecasting, weather impact mitigation to supply chain management, retail category management.

REFERENCES: 1. Xiaoguang Tan, 2006: Data warehousing and its potential using in weather forecast, Institute of Urban Meteorology, CMA, Beijing, China, unpublished http://ams.confex.com/ams/pdfpapers/99796.pdf

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4. Sismanis, Y., A. Deligiannakis, N. Roussopoulos, Y. Kotidis, 2002: Dwarf: Shrinking the PetaCube, Proceedings of the 2002 Association for Computing Machinery (ACM) Special Interest Group on Management of Data (SIGMOD) International Conference on Management of Data, Madison, Wisconsin, June 3-6, 2002, pp. 464-475.

KEYWORDS: weather, multidimensional analysis, Data Warehouse

AF073-018 TITLE: Using Next Generation Processors

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: To better understand and utilize next generation computational resources for compute intensive systems.

OBJECTIVE: Develop a model that maps computationally intensive problems, broken down into their computing kernels to next generation multi-core processors.

DESCRIPTION: Multi-core processors represent the next generation of processors. Companies such as IBM, AMD, Intel, NVIDIA and ATI are introducing a variety of these multi-core processors. IBM has introduced the Cell processor, an eight core processor, while both AMD and Intel have been introducing multi-core architectures to their line of desktop and server processors. Finally, graphics processor manufacturers NVIDIA and ATI have recently opened up the numerous shader or “stream” processors, NVIDIA’s 8800GTS contains 128 processors and ATI’s R580 has 48, in their latest Graphics Processing Units for general computational use. These new multi-core processors offer a new paradigm in processing technology and are already showing promise for extremely high FLOPS count in a single processing package.

Unfortunately, the shift from a single core processor to a multi-core processor comes with new challenges. Each multi-core processor utilizes a different internal architecture that leads to different programming techniques and requires different strategies for optimizing problems to fully utilize the processor. The challenge then is to match the right problems with the right multi-core processor and the right optimization techniques. One possible way to tackle this problem is by categorizing the different multi-processor architectures, the optimization techniques available, and identifying the different categories of high performance problems. With this information, it would then be possible to select the optimal processor for each category of problem and apply the appropriate optimization to utilize the multi-core processor to its fullest.

Developing a tool that first maps computationally intensive problems, broken down into their computing kernels (FFTs, stencil computations, and matrix multiplication, etc.,) to next generation multi-core processors in order to identify the most appropriate next generation processor for each problem, and second assists the developer with optimizing code to run on these different processor architectures will allow scientists and engineers to easily make design and acquisition decisions based on the problem space in addition to simple FLOP counts.

PHASE I: Investigate parameters that distinguish computationally intensive problems. Identify & investigate processor characteristics that can be used to determine the suitability of a processor to the problem parameters. Identify optimization techniques for the processor characteristics, not the processors.

PHASE II: Identify which processor characteristics are observed for the different multi-core processor architectures. Develop an extendable wizard to help a developer select a multi-core processor based on the high performance problem type, through the use of the Phase I parameters, they are working with. Develop an Integrated Development Environment to alleviate optimization issues for developers.

DUAL USE COMMERCIALIZATION: Military application: A potential result is in applying huge processing power from affordable COTS hardware to rapidly accomplish complex tasks not previously attempted, such as airborne, combined "INTs" correlation/fusion Commercial application: A potential result is a tool that organizations will be able to use to optimize the utility of their computational resources and aide in building investment strategies for acquisition of resources.

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http://www.wired.com/gadgets/pcs/news/2006/11/72090?currentPage=all

KEYWORDS: multi-core processors, cell processors, stream processors, shader processors, high performance computing, scientific computing

AF073-019 TITLE: Airborne Network Routing Protocol Security

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: Develop solutions to secure Airborne Network routing protocols

OBJECTIVE: Develop innovative solutions to secure routing protocols within dynamic, ad hoc groups for airborne networking platforms in a tactical environment.

DESCRIPTION: Military entities define the concept of the Airborne Network (AN) as the sum total of all capabilities required for conducting airborne network-centric operations to shorten the kill chain and facilitate the synchronized flow of relevant information by extending the Global Information Grid (GIG) to the airborne domain. It is presently being determined what mix of routing protocols (Mobile Adhoc Network (MANET), Interior Gateway Protocol (IGP) and Exterior Gateway Protocol (EGP)) will enable end-to-end, global connectivity. Information exchanges in the AN will be localized to tactical subnets while others will cross airborne, space and terrestrial transit networks. These information exchanges may leave themselves open to attack by malicious parties. Each node in the topology needs to be confident that routing information that it is acquiring to support these information exchanges comes from reliable sources and is accurate to ensure mission/time critical data can reach its intended destination. Additionally, the dynamic and resource-constrained nature of AN operations will place a premium on rapid convergence of routing tables and efficient mobility solutions. The control plane exchanges that achieve this convergence and mobility-enabling has been susceptible to attacks in big pipe, stable terrestrial networks and will certainly be vulnerable in the AN environment.

To combat these threats, there is a distinct need for innovative solutions that can secure commonly used routing protocols for AN platforms. Many of the security protocols (e.g., Secure Origin Border Gateway protocol (soBGP) and Secure-Border Gateway Protocol (S-BGP) associated with these routing protocols are heavily certificate/(public-key infrastructure (PKI) based and may not function well in a dynamic, ad hoc, Size, Weight, And Power (SWAP)-constrained environment. There has been a sizeable amount of research in the areas of secure key distribution for sensor networks and securing MANET protocols, but the techniques explored in those research efforts have not yet been applied to commonly used routing protocols like Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP), or to the airborne network environment. It is not yet known if any of the techniques developed for specialized ground based wireless networks would be suitable solutions for securing routing protocols expected to be used for inter-networking across heterogeneous airborne networks, but they should certainly considered to be part of the trade space

In order to counter perceived threats to the AN control plane and due to the slow deployment of security protocols like S-BGP and soBGP, innovation is required to develop a range of security options available for implementation with existing common routing protocols.

PHASE I: 1) Develop alternative approaches to securing commonly used routing protocols (ex.BGP,OSPF) leveraging terrestrial techniques that are communications efficient without degrading routing convergence. 2) Perform an analysis to show effects of secure routing protocols on routing efficiency and overhead while addressing vulnerabilities.

PHASE II: 1) Develop, test and demonstrate secure routing protocols in a laboratory setting. 2) Conduct test and evaluation of protocol alternatives to show route convergence and relative computational and communications overhead. 3) Demonstrate the operation of secure protocols in conjunction with a security assessment that shows how expected vulnerabilities are countered.

DUAL USE COMMERCIALIZATION: Military application: Innovation in this area would address important security issues to enable networking across airborne platforms. Commercial application: AN security features are of interest in the commercial world to enable the next generation of IP-enabled commercial aircraft and the future Next Generation Air Transportation System (NGATS)

REFERENCES: 1. Fortifying BGP: No quick fix by Jim Duffy, Network World, Oct 6, 2003 http://www.networkworld.com/news/2003/1006bgp.html

2. Routing Security by Steven M. Bellovin, http://www.dtc.umn.edu/resources/routesec.pdf

3. Lightweight Key Management in Wireless Sensor Networks by Leveraging Initial Trust, Bruno Detertre et. al., http://icsd.i2r.a-star.edu.sg/SecureSensor/papers/sri-sdl-04-02.pdf

4. Routing Security in Wireless Ad Hoc Networks, Hongmei Deng, Wei Li, Dharma P. Agrawal, http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1039859

KEYWORDS: Security, Secure Routing, OSPF, BGP, S-BGP, soBGP

AF073-020 TITLE: Reservation-based Quality of Service (QoS) in an Airborne Network

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: Develop resource reservation QoS for Airborne Networks

OBJECTIVE: Design and develop protocols for providing Integrated Services-model (IntServ) Quality of Service (QoS) in an airborne network composed of heterogeneous network technologies.

DESCRIPTION: The Department of Defense (DoD) is engaged in initial efforts to develop and IP-based airborne network which interconnects mobile airborne platforms and provides interconnectivity with space and terrestrial networks. In general, the nodes of the airborne network will be interconnected by a heterogeneous mix of communications systems. Most of these communications systems provide their own QoS mechanism, primarily with what's known as Differentiated Services (DiffServ) QoS, where IP packets are marked to indicate different traffic classes/priorities, then queued and transmitted based on those classes/priorities on a hop-by-hop basis by routers in the network. In DiffServ QoS, there are no service guarantees, but higher priority traffic does get preferential treatment. Few of these communications systems make provisions for what's known as Integrated Services (IntServ) QoS, which attempts to actually reserve a specified bandwidth for an application flow between nodes. As an example, the Joint Tactical Radio System (JTRS) increment 1 architecture restricts use of IntServ QoS (via the Resource Reservation Protocol [RSVP]) to within a secure (classified) network, employing DiffServ QoS in the unclassified (encrypted) network backbone between secure networks. Furthermore, RSVP was not designed to support mobility and will not perform in an airborne network. Mobile RSVP provides all the features of RSVP, but only operates over a single (first/last) hop. It provides reserved bandwidth to a mobile node with changing access points to the terrestrial network. The future locations of the mobile node must be known and put into a mobility specification.

There are several issues involved with providing IntServ QoS in an airborne network, particularly with the methods traditionally used.

- Overhead control traffic associated with the signaling can compete with application data traffic on narrow-band legacy radio links.
- Although cross-layer integration may provide optimum performance in a homogeneous environment, the variety of Media Access Control (MAC) and other lower layer protocols that will be used in the airborne network suggests that the QoS mechanism should be independent of these lower layer protocols.
- The dynamic topology of an airborne network makes IntServ QoS with hard guarantees on bandwidth/delay extremely difficult to implement
- Depending on the location and use of encryption devices in the airborne network, providing end-to-end IntServ QoS is complicated by the encryption/decryption process.

Innovation is required to determine the approaches, protocols, and general technologies that can be applied in an airborne network to provide IntServ QoS. Possible alternatives to the traditional methods of implementing IntServ include use of network layer, in-band IntServ QoS signaling mechanisms that provide soft reservations. Operating at the network layer of the protocol stack allows operation over and between any number of underlying MAC and lower layer protocols. In-band signaling does not generate additional IP packets for making reservations. The signaling is carried in the packets carrying user traffic. In this way, in-band signaling keeps the control overhead to a minimum. The disadvantage of this method is that soft reservations may occasionally be downgraded or dropped as the network topology changes.

PHASE I: Investigate IntServ signaling protocol options suitable to a dynamic airborne network backbone. Present the pros and cons of various protocol options. Work with government sponsors to define scenarios for simulations. Analyze the performance of proposed IntServ QoS protocols via simulation.

PHASE II: Complete design and development of prototype systems that implement candidate solutions. Demonstrate within an emulated or actual experimental airborne network environment. Demo environment should be heterogeneous, representing multiple MAC layer technologies (e.g. Tactical Targeting Network Technology [TTNT], JTRS Wideband Networking Waveform [WNW], etc., or surrogates) and routing algorithms.

DUAL USE COMMERCIALIZATION: Military application: The capabilities developed under this effort could be implemented on military aircraft to provide improved quality of service for mission critical information flows. Commercial application: The capabilities could be modified to work over a commercial airline fleet for real-time weather reporting services. Router vendors may commercialize the selected protocol for 802.11 wireless systems.

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2. MIT's Technology Review Magazine, http://www.technologyreview.com/articles/05/05/issue/feature_emerging.asp?p=0.

3. Airborne Internet Consortium, http://www.airborneinternet.org/

KEYWORDS: Airborne Network, IntServ QoS, Network Modeling and Simulation, resource reservation

AF073-025 TITLE: Metadata & Information Tagging Technologies for Application Interoperability and Services

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Develop methods to support metadata and information tagging schemas to improve data interoperability

OBJECTIVE: Investigate, develop and demonstrate methods to support metadata and information tagging schemas to facilitate data interoperability and system application interaction through web based services.

DESCRIPTION: Web services are becoming a common mechanism to establish interoperability between systems and applications requiring data from a variety of sources. In general, these capabilities use open standards, such as Extensible Markup Language (XML) and Simple Object Access Protocol (SOAP) technologies to establish communication and interact with other web applications for the purpose of exchanging data and metadata. Web services can provide the means for different software applications to interact even when running on a variety of different platforms and/or operating system frameworks. This service is made possible through the use of XML. Services can also be combined in a way to achieve very complex operations. Combining the services of various application programs with others can provide sophisticated added-value services. SOAP is a lightweight XML-based protocol for promoting web service oriented communications and exchanging information in a distributed environment. SOAP uses three basic parts. An envelope is used to define the framework for describing the contents of a message and how to process it. Second, there are a set of rules for encoding application data types and third, a convention for remote procedure calls and responses. Initially these capabilities were more predominantly used for the exchange of data on large more secluded enterprise networks, but now web services are evolving to include more common implementations for supporting transactions for the public on the Internet. Web services technology is playing an important role in establishing net-centric operations for information gathering and data analysis by the intelligence analyst and the warfighter. Given the vast number of systems, applications and data sources available to an intelligence analyst, a critical problem is how to make these capabilities available within new or evolving network environments where new potential services are being added dynamically. These instances are especially true for deploying conditions where technologists are not available for implementing web services for the warfighter. What is needed is an innovative Web Interoperability & Services Environment (WISE) Toolbox for the warfighter. There are some initial instances of commercially available web services toolkits, but none have been directly tailored to meet the needs of the warfighter. This topic will investigate the design, development and demonstration of a WISE Toolbox to meet the needs of the warfighter. A toolbox shall be designed to allow analysts to readily establish, acquire and invoke web services for their systems and applications. This capability will facilitate federated searches for services and the delivery of new services. WISE will also feature functions for tagging and labeling intelligence information for a variety of different data types providing a quick and effective means for finding and assessing available data in a services oriented architecture. To the extent possible we would like to see the WISE tool box built using Open Source components thus maximizing the reusability of the toolbox.

PHASE I: Develop an approach for the design and development of a WISE Toolbox for the warfighter. The toolbox will be designed to allow analysts to readily establish, acquire and invoke web services for their systems and applications. Build a proof-of-concept to demonstrate the approach to the Government.

PHASE II: Build a complete WISE Toolbox for the warfighter. The toolbox will be developed to allow analysts to readily establish, acquire and invoke web services for their systems and applications. A representative demonstration of the entire WISE Toolbox will be accomplished in the Network Centric Enterprise Services Innovation, Integration and Interoperability Lab (NC) ESI3L in building 1607 Hanscom AFB.

DUAL USE COMMERCIALIZATION: Military application: The technology will be useful for military applications that use web services. Warfighters will be able to readily establish, acquire and invoke web services for their systems and applications. Commercial application: Commercially the toolbox will be useful for new and novice Internet users to expose their web services to the public. This toolbox will allow entrepreneurs to build web sites to market their product.

REFERENCES: 1. World Wide Web Consortium (W3C), "Web Services Activity Statement," http://www.w3.org/2002/ws/Activity.

2. World Wide Web Consortium (W3C), "SOAP Version 1.2 Part 0: Primer," http://www.w3.org/TR/2003/REC-soap12-part0-20030624/#L1153
KEYWORDS: Web Services, Extensible Markup Language, Simple Object Access Protocol

AF073-026 TITLE: Interface Design and Versioning Framework

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Provide a framework to design & version SOA interfaces.

OBJECTIVE: Provide a technical and governance framework to make the design and versioning of Service Oriented Architecture (SOA) interfaces more efficient and cost effective.

DESCRIPTION: A Service Oriented Architecture (SOA) is a collection of services that communicate with each other. A greater knowledge in designing SOA interfaces will significantly increase the success of much of the DOD's Information Technology (IT) modernization efforts. Because the design of truly usable interfaces that describe structures and behaviors is poorly understood, it is common that the wrong granularity or state management strategy can make usage and, in particular versioning, almost impossible. Practical strategies need to be validated early in the program life cycle.

Versioning is one of the critical aspects of making integration efforts successful. Without designs that make versioning manageable, both providers and consumers of interfaces run the risk of creating a mesh of virtually unchangeable relationships that are costly to fix later in the life cycle process.

The scope of this problem goes beyond web services to numerous options such as Representative State Transfer (REST) and Really Simple Syndication (RSS). The problem of designing and versioning interfaces also impacts security, Web Services Description Language (WSDL), Extensible Markup Language (XML) schema, workflow, governance and performance engineering.

This is further exacerbated in large integrations when System of Systems effects magnify these emergent behaviors. The result of this is that it is unlikely that NetCentric environments can be fully protected by pre-production testing, and therefore test methodologies will by necessity need to be extended to full production systems.

PHASE I: Analyze the impact of design decision points such as extensibility versus versioning, additional WSDL operations, adding XML schema types, issues of non-backwards compatible interfaces, namespace strategies and other areas of impact to the design process.

PHASE II: Provide methodologies and tools that make the design and versioning of Service Orientated Architecture (SOA) interfaces more efficient and cost effective.

DUAL USE COMMERCIALIZATION: Military application: This research is appropriate for any instance or node of a SOA. Commercial application: This research is appropriate for any instance or node of a SOA.

REFERENCES: 1. The Web Services-Interoperability Organization, 2006-04-10, Basic Profile Version 1.1, (http://www.ws-i.org/Profiles/BasicProfile-1.1.html) (2006).

2. Service Orientated Architecture SIG, (http://soa.omg.org/) (April 6, 2007).

3. Dan Harkley and Robert Orfali, Client/Server Programming with Java and CORBA, 2nd Edition, John Wiley and Sons (1998).

KEYWORDS: Service oriented architecture, versioning, interface design, versioning framework, representative state transfer, really simple syndication

AF073-027 TITLE: Variable Continuity of Operations/Service-Oriented Architecture (COOP/SOA) Services

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Provide programs with the ability to automatically track their computing resources and set automated policies for geographic disaster recovery.

OBJECTIVE: Achieve survivability through automatic IT infrastructure discovery, trending and automated policy-based relocation and recovery of failed IT infrastructure from one geographic location to another.

DESCRIPTION: Existing Continuity of Operations/Service-Oriented Architectures (COOPs/SOAs) solutions are complex, inflexible and costly as currently demonstrated by long delays between failure and full restoration of critical operations (ranging from hours to days). This is primarily due to the inability of existing techniques to separate applications from their platform and location. In addition there is little or no ability to dynamically allocate resoures independently of physical infrastructure and location.The enduring legacy of stove-piped systems has created an environment where strategies and techniques for COOP are rigid, esoteric, and brittle. As a result, much of the Air Force application portfolio is lacking this essential protection at the level required to meet our dynamic operational mission requirements. The solution design is usually viewed as a static one time, all-or-nothing investment decision; instead, a solution is sought that virtualizes the infrastructure. This capability would allow applications to seamlessly move, in response to failure or based on operational needs, to other sites across geographical boundaries independent of hardware. Relocation and recovery of failed processes (including data, executables, interfaces and management architecture) within a COOP/SOA framework must be policy-driven and not manually-driven. Recovery should be largely automatic - limiting or eliminating human intervention. Technical barriers include the virtualization of interfaces and automatic management of increasingly complex configuration management data.
We need a portfolio of business continuity services that are: less rigid, more affordable, easier to use, and are composed of shareable resources based upon real-time disaster recovery requirements.. Support for resource allocation should encompass Quality of Service (QoS) and Quality of Information Assurance (QoIA). Furthermore, the resources should not be logically affixed to any specific location or enterprise. They should be shared capabilities amortized over multiple applications in a SOA model. Tactically, these services need to be dynamically reused to support changing operational needs and priorities while in production. Strategically, these services should be evolvable to meet the needs of the application over its life-cycle as SOA services. A continuum of services that provides minimal operational continuity to real-time fail-over for transactions should offer intermediate options that exploit innovations such as virtualization of: operating systems, applications and data storage. Asymmetric fail-over for degraded operations and other shared innovative thinking would offer alternatives not currently available.

PHASE I: Design a COOP/SOA architecture that achieves survivability through automatic geographic relocation and recovery of failed processes that is managed by a policy engine.

PHASE II: Demonstrate a policy engine that can dynamically make re-assignment of COOP resources using this COOP/SOA management capability to meet real-time changes in priorities.

DUAL USE COMMERCIALIZATION: Military application: Dynamic COOP capabilities are a need common to all production environments and are independent of vendors and products. Commercial application: Roughly 3 out of 4 companies that lack business continuity measures do not survive emergencies. Dynamic COOP capabilities bring computers back to life and end users back to work.

REFERENCES: 1. ReferenceTitle: Leveraging the strengths of your extended enterprise to continue operations during and information warfare attack?
Journal: Computer Fraud & Security p.16-18
Publisher: Elsevier, July 2003

2. Reference Title: Business continuity and lean operations synergies and conflicts Author: Battler, John R. Corporate Source: JRB Process Development Services, Manahawkin, NJ 08050,United States
Conference Title: 05AIChE: 2005 AIChE Annual Meeting and Fall Showcase

3. MCI Expands Voice, Private IP Restoration TelecomWeb News Digest
August 15, 2005

KEYWORDS: Continuity of Operations, COOP, business continuity, fail-over, Service-oriented Architecture, SOA

AF073-029 TITLE: Proactive Determination of Networked Node Vulnerability

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Develop a proactive capability to scan network nodes for security vulnerabilities.

OBJECTIVE: Automate vulnerability scanning of network nodes and analyze the impact these vulnerabilities have on the network. Communicate this information to other nodes and users for appropriate responses.

DESCRIPTION: The number of known vulnerabilities found in common operating systems, network appliances and applications on our heterogeneous networks continues to grow as fast as fixes can be developed. To combat this threat, there are a large number of tools available for free and on the commercial market to detect specific sets of vulnerabilities on specific operating systems or types of devices. These tools are useful in detecting vulnerabilities on specific nodes, but lack an analysis of the risk to the overall system. Any non-trivial system has nodes relying on data and services provided by other nodes. These vulnerabilities and interdependencies greatly detract from the trustworthiness of networked computer systems and increase operational risk. Using a ‘best-of-breed’ set of tools, determine first the vulnerabilities exposed by a given machine on a network of multiple operating systems (which must at a minimum include multiple versions each of modern Unix, Linux, and Windows, and at least one network accessible and controllable device such as a network appliance, networked storage device or router). Such determination should be done via continuous passive network traffic sensing (“sniffing”) and manual input of known node configuration at a minimum. Create a representation of the nodes’ intercommunications leveraging this capability and update this representation in near-real-time. This will allow administrators and/or automated solutions to utilize this model of detected, possibly changing vulnerabilities and nodal interpendencies for the purpose of risk analysis. Examples of these multi-node risks include chains of vulnerabilities (a security weakness on one node leading to the compromise of others) and degradation in the accuracy of services or information provided, among others. Securely provide this representation in machine- and human-readable formats. This delivery is intended to enhance automated analysis & improvement of network security via adaptive configuration changes in response to the identified risks. Ideally, the proposed architecture would be general enough to be used in a variety of situations. These could range from the most obvious enterprise environment (a network operations center) for the analysis of a large and mostly transparent network, to a light-weight mobile platform for situational risk analysis in a mostly opaque and hostile environment. The primary research challenges involve: creating a best-of-breed set of scanning tools for heterogeneous node analysis, automated update of vulnerability profiles as visible through these scanning tools, system level risk analysis based on the vulnerabilities of member nodes, automated detection and comprehension of multi-platform chains of vulnerability/cascades of errors, and determination of ‘normal’ versus ‘abnormal’ behavior within the system.

PHASE I: Deliver and demonstrate an automated best-of-breed scanning capability to detect network nodes, vulnerabilities and interactions via passive network ‘sniffing’ and sporadic information input regarding system. Demonstration must output in near real time in one or more formats.

PHASE II: Take demo capability from Phase I and analyze that output with system risk analysis. Suggest remedial actions, indicating the degree of risk averted by the action as well as node(s) and communication(s)affected. Trivial cases are strongly discouraged.Recognition of ‘normal’ and ‘abnormal’ events events should be developed via both automated and human-centric methods – Complex Event Processing.

DUAL USE COMMERCIALIZATION: Military application: Determining vulnerabilities and risk prior to exploitation by an opponent to enhance network security. Improving detected vulnerabilities helps reduce system administration workloads Commercial application: Any networks processing non-public data (medical records, financial information, commercial R&D) would find such capabilities useful.

REFERENCES: 1. http://vulnerabilityassessment.co.uk/Penetration%20Test.html

2. http://nvd.nist.gov/nvd.cfm

3. http://www.cert.org

4. http://pavg.stanford.edu/cep

KEYWORDS: Sniffing, network scanning, vulnerability, vulnerability assessment, complex event processing

AF073-031 TITLE: Consolidating Entity Information from Heterogeneous Text Sources for Multi-INT Fusion

TECHNOLOGY AREAS: Information Systems

REQUIREMENT SUPPORTED: Information and Data Correlation and Fusion

OBJECTIVE: Research and develop technology for high-accuracy consolidation of entity information, extracted from various unstructured and semi-structured textual data sources, for multi-INT fusion.

DESCRIPTION: The goal of this effort is to research and develop innovative technology enabling high accuracy consolidation of entity information extracted from a variety of textual data sources, including both unstructured and semi-structured text. “Entities” refers to any real-world entities of interest to a given application domain. For example, in the military domain of multi-INT fusion, real-world entities of interest include people, facilities, locations, missions, Basic Encyclopedia Numbers (BENs), and organizations. Textual data sources that may contain information on these entities of interest include Human Intelligence (HUMINT), Initial Phase Interpretation Reports (IPIRS), Mission Reports (MISREPS), Bomb Damage Assessment Reports (BDAREPs), and Significant Activity Reports (SIGACTs). As another example, consider the legal domain. In the legal domain, real world entities of interest may include people (expert witnesses, judges, and lawyers), companies, and organizations. Textual data sources containing information on these real world entities may include trial case summaries, MEDLINE articles, professional-license records, and newspaper articles (Dozier and Jackson, 2005). “Consolidation of entity information” means pulling together all information extracted on a given real-world entity into a single record, also known as a cross-document entity profile. So, for example, to construct a person profile, we may extract and consolidate the person’s name, their birth date, address, phone number, name of employer, title, e-mail address, name of spouse, and so on.

The primary technical focus of this effort is to significantly advance the state-of-the-art of cross-document coreference resolution. Cross-document coreference resolution is a text extraction technology gap that needs to be addressed in order to determine, with high accuracy, which entity's information in one document should be consolidated with which other entities' information from other documents (i.e., which entities discussed in different texts actually refer to the same real-world entity).

Cross-document coreference resolution consists of two main sub-problems, cross-document name disambiguation and alias resolution. Cross-document name disambiguation determines whether the same name really refers to the same real-world entity (e.g., is "George H. W. Bush" in document #1 the same as "George Bush" in document #2? Can their information be merged?). Alias resolution, on the other hand, determines when different names really refer to the same real world entity (e.g., is there strong evidence that "Osama bin Laden" in document #1 and "Abu Abdallah" in document #2 are really the same person? Can their information be merged?).

Previous SBIR efforts have focused on within-document coreference resolution (enabling consolidation of entity information extracted within a single document). Other Government research programs, such as the Knowledge Discovery and Dissemination (KDD) Program, have made good headway in the area of cross-document coreference resolution, as have a number of excellent universities that specialize in natural language processing (NLP). However, cross-document coreference resolution is far from being a solved problem; it is still a major obstacle faced by real-world text exploitation applications today. Therefore, achieving high-accuracy cross-document coreference resolution is a key technology gap that must be addressed to effectively consolidate entity information extracted from a variety of document types, in support of multi-INT Fusion and other application domains.

PHASE I: Research and develop techniques for high-accuracy cross-document coreference resolution, and assess their feasibility. An unclassified corpus of at least two types of textual data will be made available as Government Furnished Information. Develop and demonstrate an initial prototype design.

PHASE II: Research and develop a prototype capability enabling high accuracy consolidation of entity information extracted from across a variety of textual data sources (preferably real-world BDAREPS, MISREPs, IPIRs and HUMINT), per the Phase 1 design. Demonstrate how this capability improves the accuracy of current approaches for cross-document merging of entity information.

MILITARY APPLICATION: Multi-INT fusion systems for Improvised Explosive Device (IED) predictive analysis will benefit from the addition of rich entity information, extracted and consolidated from a variety of text sources.

COMMERCIAL APPLICATION: Law Enforcement Criminal Investigations would be greatly aided by the ability to access all info on a given entity, extracted from numerous diverse text sources, and consolidated into a single record.

REFERENCES: 1. Bagga, Amit and Baldwin, Breck. Entity-Based Cross-Document Coreferencing Using the Vector Space Model. Proceedings of the 36th Annual Meeting of the Association of Computational Linguistics and 17th International Conference on Computational Linguistics, pp. 79-85, 1998.

2. Dozier, Christopher and Jackson, Peter. Mining Text for Expert Witnesses. IEEE Software, May/June 2005 (Vol. 22, No. 3), pp. 94-100.

3. Fleischman, Michael and Hovy, Eduard. Multi-Document Person Name Resolution. Proceedings of the Workshop on Reference Resolution and its Applications: Association of Computational Linguistics (ACL) 2004, pp. 9-16.

4. Heong, Chung and Allan, James. Cross-Document Coreference on a Large Scale Corpus. Proceedings of Human Language Technology/North American Chapter of Association for Computational Linguistics annual meeting (HLT/NAACL), pp. 9-16, 2004.

5. Agenda for Session I of the Knowledge Discovery and Dissemination (KDD) 2006 Conference, www.mitre.org/register/kdd/ (see link: "View Complete Agenda for Session I [PDF, 34KB]").

KEYWORDS: Cross-Document Coreference Resolution, Name Disambiguation, Name Discrimination, Name Resolution

AF073-033 TITLE: <u>Advanced Insider Threat Detection and Response</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this effort is to define, develop, and demonstrate innovative approaches to detecting and countering insider threats to Air Force cyber systems.

DESCRIPTION: Insiders pose an especially serious threat to AF cyber systems. By their nature, insiders are trusted to some degree, and thus may have physical and/or logical access to cyber infrastructure. As such, detecting malicious activity by such an entity is exceptionally difficult. The Federal Plan for Cyber Security and Information Assurance R&D [1] identifies insider cyber attacks as some of the most damaging attacks to critical national security infrastructure. The private sector, where financial institutions maintain critical financial records, and corporations that store priceless intellectual property have similar concerns. Unfortunately, current cyber security devices are focused on repelling threats from unauthorized entities on the outside. Current techniques that have been designed to address insider threat only address the most blatant violations of policy or the grossest deviations from accepted behavior. As such, there currently exists a great need across the Federal, military, and private sectors for a viable and robust means to detect, analyze, and counteract carefully-designed attacks from trusted entities on the inside. Many times, these trusted entities have detailed knowledge about the currently-installed host and network security systems, and can easily plan their activities to subvert these systems. [2-4]

Critical research categories for insider threat detection and response have been defined by the DoD's Enterprise-wide Solutions Steering Group (ESSG) Insider Threat Technology Advisory Group (TAG) [5] and include: 1) insider characterization and modeling; 2) preventative countermeasures; 3) prediction, monitoring and detection; and 4) responsive countermeasures. Within each of these research areas, there are a number of gaps relative to the state-of-the-art, as summarized below:

Table 1. Insider Threat Research Gaps. [5]

Need	Gap	Areas for Exploration
Insider Characterization and Modeling	Typology / taxonomy of insiders	Typology with respect to DoD and IC and significant assets
		Human characteristics, both individual and group; psychological profiling; examination of motivations and intentions
	Models of insider adversary behavior	Informal modeling
		Statistical modeling
	Validation of insider adversary behaviors and models	Empirical studies
		Experiments
		Simulations
Preventative countermeasures against the insider	Accountability for insider actions, particularly in heterogeneous environments	Multiple and coordinated forms of authentication across security domains or organizations
		Watermarking, fingerprinting, and other forms of marking data to provide a deterrent to or a detection of unauthorized actions (disclosure, modification)
	Access control mechanisms sensitive to insider threats	Differential access controls depending on roles, rights, privileges, access context, and history
Monitoring and detection of adversarial insider behavior	Effective modeling / profiling of adversarial insiders	Social network analysis
	Monitoring techniques for different classes of insiders	Monitoring and analysis of system administrators
		Application-based monitoring and analysis
		Correlation across multiple monitoring mechanisms
		Differential and adaptive monitoring
Reactive countermeasures for the insider adversary	Analysis capabilities	Tools for analyzing and correlating monitoring data and audit records
		Forensic tools on machines and storage devices

Evidence collection and preservation

Automated response capabilities   Dynamic determination of the need for, and implementation of, restricting access, initiating additional data collection or monitoring, compartmentalizing the organization’s network

Other high level requirements for such a system include the ability to fuse and correlate cross-layer information from multiple cyber sensors, the ability to compare activities with policy, rules, permissions, roles, accepted behaviors, etc., and the ability to locate, physically and logically, the source of insider activity. Finally, the solution must analyze the cyber sensory inputs, along with static information, in order to formulate appropriate responses and implement the same via cyber actuators.

PHASE I: Develop a prototype algorithm for detecting and countering insider threats to cyber systems. Design an implementing architecture that includes proposed cyber instrumentation (i.e., cyber sensors, cyber actuators). Perform a performance/feasibility analysis of the architecture/algorithm(s).

PHASE II: Implement the best approach from Phase I in an experimental hardware/software environment, representative of AF cyber infrastructure. Correlate Phase I analysis with experimental results. Analyze the prototype system with respect to performance, scalability, cost, security, and vulnerability.

DUAL USE COMMERCIALIZATION: Military application: All operators and users of military cyber infrastructure are potential insider threats. This effort is applicable to all cyber resources used by the Services and the Intelligence Community. Commercial application: All commercial networks and cyber infrastructures are subject to insider activity. This effort is fully applicable to all private, commercial, industry and civilian gov't infrastructures.

REFERENCES: 1. "Federal Plan for Cyber Security and Information Assurance Research and Development," National Science and Technology Council (NSTC) Cyber Security and Information Assurance (CSIA) Interagency Working Group (IWG), http://www.nitrd.gov/pubs/csia/csia_federal_plan.pdf, April 2006, esp. pp. 39-41.

2. Chinchani, R.; Iyer, A.; Ngo, H.Q.; Upadhyaya, S.; Towards a Theory of Insider Threat Assessment, 2005 International Conference on Dependable Systems and Networks, 28 June-1 July 2005, pp. 108 - 117.

3. Hui Wang; Shufen Liu; Xinjia Zhang; A Prediction Model of Insider Threat Based on Multi-agent, 1st International Symposium on Pervasive Computing and Applications, Aug. 2006, pp. 273 - 278.

4. Martinez-Moyano, I.J.; Conrad, S.H.; Rich, E.H.; Andersen, D.F.; Modeling the Emergence of Insider Threat Vulnerabilities, Proceedings of the Winter Simulation Conference, Dec. 2006, pp. 562 - 568.

5. Gabrielson, Bruce; Solving the Insider Threat Problem (ESSG IT TAG), University of Louisville Cyber Security Days, October 5, 2006.

KEYWORDS: Insider, threat, anomaly, intrusion, detection, network, modeling, assessment, response

AF073-034   TITLE: Passive and Active Mission Modeling

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a system that passively models an individual’s behavior to determine the relative importance of the resources that underly that behavior.

DESCRIPTION: More programs, such as effects-based operations and mission-driven network management, are becoming focused on leveraging “commander’s intent.” The term “commander” includes the lowest ranking person in-charge of a small team, to a General commanding forces in the field. The goal of integrating commander’s intent into systems is laudatory, but has the assumed requirement that those intentions be manually entered into the system. To capture intent, a user or business process team must first spend countless hours/days educating the system on the various facets (and varying degrees of importance of those facets) of their job. Few individuals have time to do this.

And even if they did, the job at-hand is often dynamic and therefore what was taught must now be unlearned as new priorities become apparent. If we are able to model and prioritize an individual's mission(s), we can then assign priorities to resources supporting that mission. As resources become impaired, an individual can understand the relative-to-them impact of that failure. This effort would look to passively examine a user's observable behavior (e.g., their keystrokes, their common networked applications, their focus on the screen, the areas where they spend the most time, etc.) and build a hierarchy of "how they do their job." Actively, perhaps once a week/month, the modeling system would present the user its best-guess on the user's mission model, enabling the user to adjust/remove/add-to those best-guess priorities. Mechanisms for creating process models could be used to make models for tasks, processes, groups, and/or organizations based upon the same collection and parsing of passively collected data.

PHASE I: Phase I end products shall be: proof of concept prototype & demonstration showing the feasibility of meaningful, passively-derived (actively adjusted) mission models; a technical report documenting the design and demonstration; and, a development plan for the Phase II effort.

PHASE II: The end product for Phase II shall be a fully functional technology application demonstrated in the user environment and a technical report documenting the design and development. Technical and human performance measures in a dynamic environment will be documented.

DUAL USE COMMERCIALIZATION: Military application: The capabilities developed under this effort could be used by any system which depends upon understanding of a user-level (also group, process, task, organization) business/mission model. Commercial application: Augment network security applications based on user-behavior. Augment mgmt apps in showing actual user info/system dependencies; id critical resources to best apply tech refresh dollars.

REFERENCES: 1. The Global Information Grid Vision; http://www.nsa.gov/ia/industry/gig.cfm

2.Electronics Systems Center Strategic Technical Plan v2.0, March 10, 2005, http://www.afc2isrc.af.mil/itf/documents/ESC%20Strategic%20Technical%20Plan%20v2.pdf

3. C2 Constellation http://www.dodccrp.org/events/2004_CCRTS/CD/papers/164.pdf

4. An Automatic Business Process Modeling Method Based on Markov Transition Matrix in BPM; authors: LI Yan, FENG Yu-qiang http://ieeexplore.ieee.org/iel5/4094461/4037319/04104865.pdf?tp=&isnumber=4037319&arnumber=4104865

5. Knowledge based decision making on higher level strategic concerns: system dynamics approach; authors: Yim, N-H; Kim, S-H; Kim, H-W; Kwahk, K-Y http://ieeexplore.ieee.org/iel5/6809/18271/00843280.pdf?arnumber=843280

KEYWORDS: intelligent agents, modeling and simulation, decision-making, business process modeling, behavior

AF073-035 TITLE: <u>Biomolecular Taggants for Covert Tracking and Watermarking</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: This program seeks biomolecular taggant technology to covertly mark, detect or track objects, persons or Chemical/Biological/Radiological/Nuclear/Explosive agents and report from standoff distance.

DESCRIPTION: This technology utilizes biological media such as synthetic DNA or proteins to provide complex, molecular scale detectors to covertly track adversaries, material assets and detect Chemical/Biological/Radiological/Nuclear/Explosive, CBRNE targets. Applications include the ability to mark an asset or person of interest with an amount of taggant material that is small enough that it is covert, and then track movement and contacts through transferred taggant material. Simple taggants can be used to covertly watermark secure documents and systems to verify authenticity. Complex taggant libraries will interact to provide information on networks of contacts. Binary taggants could show evidence of tampering. Taggants should be detectable from a distance either singly or in self-amplified aggregates using covert, easily detectable emission. Taggants may mark military base-scale areas and provide covert evidence of intrusion or they may mark molecular-scale areas indicating evidence of bio-molecular agents. Taggants operate by chemical means, enabling exquisite detection of biological and chemical agents and precursors. Chemical operation, rather than electrical operation, makes bio taggants intrinsically radiation hard and enables the use of bio taggants to track nuclear materials with low taggant degradation while carrying a complex information store in the tag. Opportunities for research include work on taggant delivery mechanisms, environmental hardening and encapsulation, large scale taggant libraries and interactions, complex taggant operations, remote activation, signal emission, signal amplification, signal detection, stand-off detection, small sample detection, reaction mechanisms for CBRNE agents, controlled degradation or deactivation, long term energy storage, active taggants for CBRNE neutralization, transferability, and red team activities such as decontamination and signal blocking. Programs are sought in near term applications such as tracking and watermarking as well as far term applications such as complex contact network tracking operations, long distance detection and CBRNE remediation. Research should include full taggant system development. Research that focuses on medical or biological research such as drug watermarking or genomics is not desired for this program.

PHASE I: Develop system design, plan for interface integration and identify key hurdles to development. Gather commercial market information and identify potential Phase III partners and military concepts of operations.

PHASE II: Develop and demonstrate a prototype system in a realistic working environment. Develop initial phase III engineering plan. Show plan to transition technology to a commercially viable market. Provide evidence of interest by potential commercial transition partners. Provide envisioned characteristics for planned DOD concepts of operations.

DUAL USE COMMERCIALIZATION: Military application: Applications could include watermarking and tracking of objects of interest, intrusion or tamper detection, and detection of CBRNE agents. Application suggestions / con-ops are welcome. Commercial application: Applications include tracking and tamper detection, watermarking materials and drugs for authentication and numerous medical applications requiring complex indication of biological materials.

REFERENCES: 1. Yan, H. et. al., "Directed nucleation assembly of DNA tile complexes for barcode-patterned lattices" PNAS, Jul 8 2003, V. 100, No. 14, p. 8103

2. Seeman, N. C., "DNA in a Material World", Nature, 2003, V. 421, p. 427

3. Shimanovsky, B., Feng, J., Potkonjak, M., "Hiding Data in DNA", Lecture Notes in Computer Science 2002, V. 2578, p. 373

4. GOOGLE "DNA Taggants" provides many commercial examples

KEYWORDS: DNA Taggants, Molecular Bar Codes, Molecular Watermark, Covert Tracking

AF073-037 TITLE: <u>Novel High Power Microwave (HPM) Hardening Materials for Aircraft, Ground, & Space Systems</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop and demonstrate conformal coating technology that provides broad band electromagnetic immunity (EMI) for sensitive electronics, systems, and shelters.

DESCRIPTION: With the emergence of readily available high power microwave (HPM) technology, the need for immunity from these systems is ever increasing (1,2). HPM devices produce high power bursts of microwave or RF radiation over distances ranging from a few meters upwards to 20 kilometers. The HPM microwave sources typically come in one of two varieties, narrow band and ultra-wide band. Narrow-band devices operate at a discrete frequency, tend to be very costly, and have a long range. Ultra-wide band devices by contrast are compact, operate at shorter distances, but emit over a very wide frequency range (such as 10MHz to 10GHz). These systems represent a much more difficult shielding problem. While many of the problems can be eliminated by going from copper wiring to fiber optic cables, there are always going to be areas containing electronics that will require novel shielding techniques. Here we are focused on development and demonstration of conformal wide-band shielding materials. These shielding materials must be compatible with traditional manufacturing processes, including prepreg composite manufacturing, conformal dip coating, spraying, or extrusion. Materials should exhibit a shielding effectiveness (SE) in excess of 80dB over the frequency range of 1MHz to 20GHz.

PHASE I: Develop and demonstrate a conformal shielding material with an SE greater than 60dB over 100MHz to 10GHz. Materials should exhibit durability in standard DoD operational environments (i.e., rain, snow, sand, and typical fluids).

PHASE II: Develop and demonstrate a conformal shielding material with an SE greater than 80dB over 1MHz to 20GHz. Technology demonstrated should be scaleable to manufacturing quantities. Materials should demonstrate durability in standard DoD operational environments (i.e., rain, snow, sand, and typical fluids). Specific testing guidance will be provided at the start of Phase II.

DUAL USE COMMERCIALIZATION: Military application: These materials will be useful in a variety of Electromagnetic Shielding applications and can significantly reduce weight of traditional metal enclosures and parasitic Al foils. Commercial application: These materials would be useful in myriad medical environments where stray EM radiation can interfere with equipment in use as well in commercial EMI shielding apps such as cell phones and computers.

REFERENCES: 1. www.de.afrl.af.mil/Factsheets/HPM.pdf: HPM Fact Sheet.

2. www.fas.org/man/crs/RL32544.pdf: High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments.

3. High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments, DTIC Document #ADA447874 http://handle.dtic.mil/100.2/ADA447874

4. High Power Microwaves: Strategic and Operational Implications for Warfare, Eileen M. Walling, Colonel, USAF, Occasional Paper No. 11, Center for Strategy and Technology, Air War College, Air University, Maxwell Air Force Base, Alabama www.globalsecurity.org/military/library/report/2000/occppr11.htm

5. HIGH POWER MICROWAVE EFFECTS ON CIVILIAN EQUIPMENT,Odd Harry Arnesen, et al. Norwegian Defence Research Establishment, Box 25, NO-2027 Kjeller, Norway. http://www.ursi.org/Proceedings/ProcGA05/pdf/E03.2(0528).pdf

KEYWORDS: HPM, microwave, high power microwave, aircraft, spacecraft, shelter, electromagnetic, hardening

AF073-038 TITLE: Surface Processing for Enhanced Environmental and Creep-Fatigue Resistance

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Establish innovative manufacturing techniques to enhance the temperature capability and environmental resistance of Ni-based superalloys.

DESCRIPTION: Today's most advanced propulsion systems are enabled by materials that can survive for significant periods of time at high temperatures in harsh environments under highly loaded conditions. Future long-term challenges of the USAF such as long-range strike (LRS), reusable access to space, and persistent strike will require even more capable and efficient propulsion systems. Delivering the future turbine, rocket, ramjet, and scramjet engines with the desired increased capability will be highly dependent on advances in materials technologies providing resistance to exposure at even higher temperatures for longer times under increasingly corrosive environments. One avenue being exploited to achieve improved performance is through local tailoring of microstructure. Approaches such as dual alloy [1] and dual microstructure heat treatment [2] have been conceived to strike a balance between fatigue resistance (at the bore) and creep resistance (at the rim) of turbine disks utilizing the best available Ni-base superalloys. However, recent tests have demonstrated that to reach the desired future capabilities creep-fatigue (also commonly referred to as "dwell fatigue") may be life limiting for the next generation of Ni-based superalloys. [3] One path to achieve increased materials capability is through development of advanced materials and alloys from which to fabricate an entire component. Some chemistries being investigated such as Pt and/or Cr additions to Ni-based superalloys [4] increase density and expense, and there is no guarantee that the resulting materials will have the full suite of properties required by the components. An alternative is to protect only select regions of a component, sites likely to experience the harshest conditions, with a protective skin of more environmentally resistant material. [5] This would essentially create a graded material, where the outer surface has the desired chemistry and microstructure to impart increased environmental and creep resistance, while the bulk of the component retains the chemistry and microstructure necessary to meet strength and fatigue lives. Toward this end, innovative manufacturing and processing methods need to be identified and developed, where local chemistry and microstructure can be controlled. Therefore, the challenge issued in this solicitation is to identify (1) alloy additions to Ni-based superalloys that increase their environmental resistance and (2) fabrication routes that can tailor local chemistries and microstructures in an effort to achieve a balance of environmental and creep-fatigue resistance at "hot spots" while preserving strength and fatigue properties in the bulk of the material/component. Partnering with an OEM is highly desirable as it increases the likelihood of the developed technology being transitioned, and an OEM will be instrumental in identifying envisioned components and the broader suite of properties for characterization in Phase II. Access to unique research equipment within AFRL/MLL will be considered if warranted. Please contact the topic author for information.

PHASE I: Based on the candidate chemistries and processing route identified in the proposal for achieving a graded chemistry/microstructure of interest, demonstrate feasibility on a small batch of material and characterize local microstructure and chemistry. Define and/or assess potential impact on creep-fatigue properties via coupon-level tests.

PHASE II: Demonstrate impact of graded chemistry/microstructure on a larger suite of properties—ideally those of interest for design of envisioned components (tensile, fatigue, creep, dwell fatigue, TMF, etc.). Demonstrate process on prototypical shape and show feasibility to scale to component size.

PHASE III, DUAL USE APPLICATIONS: Application of this technology would be in advanced military propulsion systems such as turbine engines, rocket engines, ramjets, and scramjets as they mature. Commercial benefits include improved materials for propulsion systems and land-based turbines for power generation.

REFERENCES: 1. Mourer, D.P., et al., "Dual Alloy Disk Development," Superalloys 1996, R.D. Kissinger, et al., Eds., TMS, 1996, pp. 637.

2. Gayda, J., "Dual Microstructure Heat Treatment of a Nickel-Base Disk Alloy Assessed," http://www.grc.nasa.gov/WWW/RT2001/5000/5120gayda.html.

3. Telesman, J., et al., "Microstructural Variables Controlling the Time-dependent Crack Growth in a P/M Superalloy," Superalloys 2004, K.A. Green, et al., Eds, TMS, 2004, pp. 215.

4. Corti, C.W., Coupland, D.R., and Selman, G.L., "Platinum-Enriched Superalloys", Platinum Metals Rev., 24, 1980, pp 2-11.

5. Advances in Net-Shape Powder Metallurgy, http://www.afrlhorizons.com/Briefs/Feb04/ML0318.html

KEYWORDS: creep fatigue, dwell fatigue, environmental resistance, graded microstructure, high-temperature behavior, Ni-base superalloys, turbine disk

AF073-039 TITLE: Development of Electrically Conductive Skins for Morphing Unmanned Air Vehicles (UAVs)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate conductive deformable materials to enable morphing unmanned aerial vehicles.

DESCRIPTION: Morphing unmanned aerial vehicles (UAVs) have the potential to significantly enhance the capability of multi-element missions that are enabled by disparate vehicle configurations. For example, UAVs that can quickly switch their structure from a long-endurance loitering configuration to a high-speed dash configuration allows a single asset to quickly adapt to the specific mission element of a combined hunter-killer mission. As a result, the morphing vehicle can achieve a better mission response than UAVs of either fixed configuration. The configuration change of current concept morphing vehicles requires skin materials to undergo large deformation while maintaining sufficient out of plane stiffness to endure aerodynamic loads. While many of the mechanical issues of morphing skins are being addressed with novel attachment of elastomers, application of shape memory polymers, use of novel reinforcement, and smart integration of actuating elements; the skins also need to maintain electrical conductivity in all configurations. Efforts to coat deformable skins with electrically conductive material typically results in materials that crack and debond from the deforming substrate. Filling the deformable skin with conducting particles typically compromises the reversible strain achieved and leads to a skin whose conductivity varies substantially with deformation. We seek novel concepts that will maintain electrical conductivity under the deformation associated with the reconfiguration of a morphing structure as well as the supporting reinforcement and coupling of the overall composite system.

PHASE I: Conceive and demonstrate a materials concept that can obtain a surface resistivity of less than 1 ohm per square, under reversible uniaxial deformations of at least 100 percent strain with less than a 20 percent variation in resistivity.

PHASE II: Apply to 6"x6"-reinforced plate not more than 1/8" thick showing <0.1" local deflection under subsonic aerodynamic loading conditions when the surface area is changed 100% from shearing/extension/bending. Calculate force required to achieve configuration change and develop appropriate electrical and mechanical connections to both electrical ground and securely attach skin to a substructure frame.

DUAL USE COMMERCIALIZATION: Military application: The technology will have use in charge dissipation in morphing UAV skins; seamless control surfaces; cable sheathing; rapidly-assembled space structures; or for applications requiring flexibility. Commercial application: The technology will enable flexible conductive gasket materials, electrostatic dissipating flexible hoses, large strain/low load sensing, and flexible electronics.

REFERENCES: 1. E. Livne and T. A. Weisshaar, "Aeroelasticity on Non-conventional Airplane Configurations – Past and Future," Journal of Aircraft, 40(6) 2003.

2. K. Kha and J. N. Kudva, "Morphing Aircraft Concepts, Classifications, and Challenges," Smart Structures and Materials 2004, Proceedings of SPIE Vol.5388 p. 213.

3. Wilson, J.R., Morphing UAVs change the shape of warfare. Aerospace America. pp. 28-29. 2004.

4. H. Koerner et al. "Deformation–morphology correlations in electrically conductive carbon nanotube-thermoplastic polyurethane nanocomposites," Polymer 46 (12) 2005.

KEYWORDS: morphing, skins, conductive, elastomers, shape memory polymers, composites, UAVs, adaptive

AF073-040 TITLE: Bearing Sensor Data Transmission for Engine Health Management

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate the capability to transmit bearing sensor data for real time monitoring of turbine engine roller bearing health.

DESCRIPTION: Roller bearings are a critical component for engine rotor rotation as well as the lift fan and rotorcraft drivetrains. One of the leading causes of turbine engine failures and the leading cause of Category A air system mishaps related to turbine engines is directly related to roller element bearing failure[1]. A trade study sponsored by the Air Force Research Lab (AFRL) has confirmed that significant financial and safety-related benefits can be achieved through a maturation and integration of Integrated System Health Management (ISHM) sensor technology into future Air Force (AF) systems [2]. Temperature and vibration measurements on bearing components provide an early warning of impending bearing failure and researchers at AFRL's Materials and Manufacturing Directorate (ML) have and continue to actively sponsor in-house and Small Business Innovation (SBIR) program development of micro-electro mechanical system (MEMS) and inductor-capacitor (LC) sensors that will detect temperature and vibration anomalies in bearing cage components. The sensor will be located on the bearing cage or race component and experience an oil wash within a temperature environment of 250 to 300ºC. In-house research has shown that temperature and vibration data can be acquired from an LC sensor with the stationary transceiver located less than an inch from the sensor. Successful transition of these sensors into actual AF systems will require the development of a data transmission capability measured in inches or feet rather than millimeters. This program seeks to develop the capability to efficiently transmit temperature and vibration data from a MEMS or LC sensor to a remote location where data processing and analysis can be performed. A very real potential exists that this capability could be integrated and used to assess turbine engine health prior to mission takeoff. However, despite whether the solution is a pre-flight or in-flight capability, successful integration and demonstration of this technology will require original equipment manufacturer (OEM) collaboration as well as collaboration with the manufacturer(s) of the bearing sensor. It is encouraged that the contractor maintains interactions with the AF Program Manager and the ML ISHM team. This will enable effective development and ensure the technology is operational within the engine environment and available for any future technology demonstration opportunities.

PHASE I: Develop the technology that will allow the transmission of temperature and vibration data from a bearing sensor operating at or near actual engine operating temperatures to a remotely located data collection unit. Demonstrate the data transmission capability at 300°C in a lab environment.

PHASE II: Fully develop and optimize data transmission technology and its integration with the bearing sensor. Demonstrate successful integration of the prototype technology in a simulated engine environment at 300°C for a period of 1,000 hours. It is desired that a prototype bearing sensor and data transmission system be delivered to the government for further evaluation and testing.

DUAL USE COMMERCIALIZATION: Military application: Bearing sensor data transmission ability joined with a bearing sensor would have pervasive military apps such as air- and land-based turbine engines on aircraft and tanks and power systems on ships. Commercial application: A bearing sensor data transmission capability combined with a bearing sensor would have pervasive commercial applications including land based power plants and commercial aircraft engines.

REFERENCES: 1. MacConnell, James H., "Integrated System Health Management (ISHM) Design Study: Summary Report," May 2006.

KEYWORDS: Bearing Sensor, Integrated Systems Health Management, Propulsion Health Management, Harsh Environment Sensors

AF073-041 TITLE: Advanced Ultra-Lightweight Hybrid/Composite Mirrors (ULHCMs)

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate advanced ultra-lightweight hybrid/composite mirrors (ULHCMs; with areal density <5kg/m2) for air and space applications. Technology should be scalable to a 1.2m mirror size.

DESCRIPTION: The DoD requires visible quality mirrors for applications including transformation communication systems, directed energy weapons, missile seeker telescopes, and reconnaissance/surveillance systems for both unmanned air vehicles and satellites. Mirrors for these applications range in size from 0.1m to 1.2m for monolithic configurations and up to 20m for segmented configurations. The reduction of the mirror weight will allow additional weight savings throughout the telescope and bench structures, which could drastically impact system designs and capabilities. Current state-of-the-art (SOA) glass mirror designs have areal densities (AD) in the 15 to 30 kg/m2 range, while monolithic SiC-based mirrors can reduce this to the 10 to 15 kg/m2 range. ULHCM concepts have the potential to reduce the areal densities to the 1 to 5 kg/m2 range. Unfortunately, these concepts have only been demonstrated at the coupon level (1- to 3-inch diameters) and additional work is needed to advance their readiness level. As shown in recent glass, SiC, and Be mirror programs, scalability, handleability, and stability will be major technology challenges. In this program, ULHCMs will be fabricated at various sizes to assess their potential as 1.2m mirror segments similar to that of the Advanced Mirror System Demonstrator (AMSD) program. Issues that will be addressed include: understanding/quantifying the advantages of replication versus polishing of ULHCMs, fabricating on-axis and off-axis aspheres, reducing time (schedule) to half that achieved in the AMSD program, reducing cost to half that achieved in the AMSD program, assessing mounting and actuation schemes, achieving suitable stiffness (natural frequency of part) and vibrational damping, achieving suitable surface figure and finish error, assessing thermal and environmental stability, as well as demonstrating repeatability and reliability.

PHASE I: Fabricate a 4- to 6-inch diameter, space qualifiable, low authority mirror with an areal density below 5 kg/m2. Quantify the material behavior, process control, optical performance, and mounting issues. Assess the potential for scale up from a processing and infrastructure point of view.

PHASE II: Conduct a processing science-type program and produce a space-qualifiable 20-inch (0.5 m), on-axis aspheric mirror. Include processing and lay-up trials as well as thermal and mechanical property evaluation. Fabricate a 0.5m mirror segment and deliver its performance assessment and all associated data at the end of the effort.

DUAL USE COMMERCIALIZATION: Military application: Large segmented mirrors for reconnaissance/surveillance type telescopes as well as laser beam deflectors for directed energy weapons and telecommunications. Commercial application: Large segmented mirrors for land and space-based telescope systems at university observatories and NASA systems. Small mirrors could be used for hobby-based astronomical telescopes.

REFERENCES: 1. David A. Williamson, Ed. “Advanced Materials and Processes for Large, Lightweight, Space-Based Mirrors," Proceedings of IEEE Aerospace Conference, Volume 2776, March 2003.

2. “Advanced Materials and Processes for Large, Lightweight, Space–Based Mirrors,” AMPTIAC Quarterly Vol 8, Number 1, 2004.

3. http://optics.nasa.gov/tech_days/tech_days_2004/index.html.

4. http://optics.nasa.gov/tech_days/tech_days_2005/index.html.

KEYWORDS: lightweight mirrors, hybrid materials, composite materials, optics

AF073-042 TITLE: Materials for Terahertz Detectors

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop materials that enable highly efficient and compact detectors of coherent electromagnetic radiation at terahertz (THz) frequencies.

DESCRIPTION: The THz portion of the frequency spectrum (0.1 to 30 THz) has attracted interest for various potential applications such as seeing-through-clothes and other visual barriers for urban warfare and hidden weapons discovery, checking personnel and packages for guns and explosives, and even communications. However, the spectral region has been underutilized because of the inadequacy of THz detectors that are in turn limited by materials. We seek novel materials development that enables and demonstrates significant improvement in the operation of these detection systems in terms of all or some of the following measures for both imaging and spectroscopy: higher temperature operation (room temperature is the goal), smaller component size and weight, higher detectivity, faster response time, and possibly coherent detection for low noise and background subtraction. Our primary interest is 0.1 to 3 THz for spectroscopy and 0.1 to 1.0 THz for imaging. No specific detection scheme enabled by the proposed material is identified herein or required, and the scheme may include nonlinear optical devices, photo-mixing, and Mach-Zehnder interferometers or similar guided-wave electro-optic devices among others.

PHASE I: The emphasis of the effort is to develop processing techniques for material(s) that enable significant improvement in the operation of THz systems. The materials shall also be characterized, and demonstrations shall be performed that show the potential for this improvement in system performance.

PHASE II: The contractor shall further develop the proposed material or relevant material processes as well as to fully demonstrate the materials properties and their usefulness for commercial and military applications. The material(s) will demonstrate state-of-the-art performance in a component or device. All manufacturing processes for commercialization of the material and/or product shall be developed.

DUAL USE COMMERCIALIZATION: Military application: This work is applicable to military security for detecting weapons and explosives hidden behind visual barriers. Commercial application: This work is applicable to airline and airport security, along with any business that needs such security measures for detecting hidden weapons and explosives.

REFERENCES: 1. J.E. Bjarnason and E.R. Brown. Appl. Phys. Lett., Vol. 87, 134105 (2005).

2. J. Federici et al. Appl. Phys. Lett., Vol. 83, p. 2477 (2003).

3. W. Shi, Y.J. Ding, N. Fernelius, and K. Vodopyanov. Optics Letters 27(16), 1454 (2002).

KEYWORDS: terahertz, detector, coherent

AF073-043 TITLE: Development of High-Definition (HD), Low-Light-Level Detector

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design and build a high-definition, low-light-level detector.

DESCRIPTION: Most Air Force reconnaissance and targeting systems contain color or black/white charge coupled devices (CCDs) for daytime imaging. These sensors typically function effectively from dawn to dusk, but cannot compete with other technologies for nighttime operation. This effort is designed to develop a new low-light-level detector that will extend the operational performance of current CCD detectors beyond dawn and dusk conditions. In addition, the new detector should have HD (1K by 1K). Together these advances will greatly improve the performance of visible/near-infrared camera systems.

PHASE I: Demonstrate the feasibility of a HD, low-light-level detector with improved performance compared to current state-of-the-art (SOTA) color and/or black/white CCDs.

PHASE II: Design and build HD, low-light-level detector with improved performance compared to current SOTA color and/or black/white CCDs. Incorporate this detector into a realistic optical system and demonstrate improved performance with prototype testing in a lab environment. It is desirable that a prototype detector be delivered to the govt for additional testing and evaluation in optical test beds.

DUAL USE COMMERCIALIZATION: Military application: There is a well-documented, critical military need for improved sensor performance at dusk and dawn as well as application for all DoD sensor systems currently incorporating color or black/white CCDs. Commercial application: Consumer demand for better indoor video camera performance. An HD, low-light-level detector would directly benefit the indoor performance of video cameras.

REFERENCES: 1. Atlas, Gene and Mark V. Wadsworth, “Hybrid imaging: a quantum leap in scientific imaging,” Proc. SPIE Vol. 5167, p. 121-126, 2003.

2. Janesick, James R., “Charge coupled CMOS and hybrid detector arrays,” Proc. SPIE Vol. 5167, p. 1-18, 2003.

KEYWORDS: CCD, CMOS, hybrid, low light level, high definition

AF073-044 TITLE: High Energy Density Storage for Solar Power Generation Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop affordable, long-life, high-energy density storage devices for solar power generating systems.

DESCRIPTION: The Air Force has a requirement to store energy generated from photovoltaic sources for autonomous portable ground power applications. Such systems should have high power density, low rate of self-discharge, and perform in extreme conditions. Lead acid batteries currently used offer low cost; however, the current systems have low energy density (<50Wh/kg), high intensive maintenance, and low cycle life (200 to 400 cycles) that hinder system performance. The purpose of this topic is to seek energy storage devices that have four times the energy density and cycle life as compared to the cost of lead acid batteries technologies.

PHASE I: Investigate feasibility of new materials/methods/processes to design and build a breadboard prototype demonstrating the fundamental components of the energy storage device to meet the objective. The contractor must verify the device has the potential to perform in the -20°C to 60°C temperature.

PHASE II: Develop Phase I technology to fabricate an energy storage system capable of integration with commercial photovoltaic power generation systems to provide 24kWh of electrical energy. The system will be verified under actual operating conditions such as operational temperatures and loads. It is desired the prototype be delivered to the government for further evaluation at the end of the contract.

DUAL USE COMMERCIALIZATION: Military application: Deployable shelters, special operations, aircraft, small UAVs, and electric vehicles (EVs). Commercial application: Remote locations, utility systems, building-integrated photovoltaic (BIPV), and hybrid electric vehicles (HEVs).

REFERENCES: 1. Rydh, Carl J. “Energy analysis of batteries in photovoltaic systems. Part I: Performance and energy requirements.” Energy Conversion & Management 46 (2005): 1957-1979.

2. Rydh, Carl J. “Energy analysis of batteries in photovoltaic systems. Part II: Energy return factors and overall battery efficiencies.” Energy Conversion & Management 46: 1980-2000.

3. Ludwig, Joerissen. “Possible use of vanadium redox-flow batteries for energy storage in small grids and standalone photovoltaic systems.” Journal of Power Sources 127 (2004):98-104.

KEYWORDS: Energy storage, energy density, batteries, energy conversion, photovoltaic, lead-acid, lithium-ion, electrochemical, self-discharge, capacitors, life cycle

AF073-045 TITLE: Carbon Nanofibers, Testing, and Fabrication

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Demonstrate new nano-tailored carbon-fiber forms suitable for eventual incorporation into composites for high-performance satellite components.

DESCRIPTION: Composites provide highly effective, multifunctional performance and are utilized on most current satellite systems. Future systems are expected to have an even greater percentage of composites. Continuous, aligned carbon-fibers are the dominant constituent for several key structural properties and also provide thermal and electrical conductivity paths as the polymeric matrix offers such low thermal/electrical properties. State-of-the-art high-performance carbon-fibers are based on polyacrylonitrile (PAN) or pitch precursors and are utilized in product forms of tows consisting of 3,000 to 12,000 fibers of diameters in the 7 to 10 micron range. Key properties such as modulus and tensile strength and electrical and thermal conductivity are related to the microstructure and are dependent upon the precursor and the fiber manufacturing process. For example, PAN-based fibers have disordered microstructures that translate to high tensile and compressive strengths. Pitch-based fibers have a more crystalline ordered microstructure that translates to high-tensile modulus and thermal conductivity. Users of advanced composites typically trade between the performances of existing PAN- and pitch-based fibers. Advanced satellites require superior stiffness, thermal management, and electrical management at very low weights and within small volumes. A fiber with a new balance of high-strength, high-modulus, and high-thermal and electrical conductivity could enable novel new satellite concepts, structures, and components. Several forms of nanocarbon are currently available such as single-wall carbon nanotubes (SWNT), multiwall carbon nanotubes (MWNT), and various types of carbon nanofibers. Continuous fibers based on carbon nanotubes may offer a new property trade space for high-performance composites. The Air Force seeks a process that can fabricate and supply fibers based on carbon nanotubes that offer new and application-specific combinations of strength, stiffness, and thermal and electrical conductivities unachievable with currently available carbon-fibers. Such fibers could be integrated into composites to provide tailorable and multifunctional materials for high-performance, multimission tactical spacecraft.

PHASE I: Demonstrate feasibility of producing nano-tailored carbon fibers. Address process stability and scale up. Characterize structural, thermal, and electrical properties. Develop structure-property relationships to guide optimization. Propose surface modification for good interface in composites.

PHASE II: Demonstrate the carbon nano-tailored fiber in product forms amendable to composite fabrication. Integrate within a polymeric matrix through processes that could be transitioned to production. Perform characterization of the final composite properties. Demonstrate enhancement of properties of importance to a proposed satellite component and validate the benefits of the new material

DUAL USE COMMERCIALIZATION: Military application: New multifunctional carbon fibers will have applications on military satellites and aerospace platforms. Commercial application: Applications for high-performance, multifunctional fibers with new properties range from commercial satellites to electronics.

REFERENCES: 1. J. W. Gillespie, "High-Performance Structural Fibers for Advanced Polymer Matrix Composites", The National Academies Press, Washington DC, 2005.

KEYWORDS: carbon nanotubes, carbon fibers, composite, multifunctional

AF073-046 TITLE: High Capacity, Lightweight , and Compact Thermal Energy Storage (TES) Technologies and Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop integrated TES technologies with goals of 1000 kJ/kg at 20 to 70°C and 180 MJ/m^3 that can store peak or transient heat loads representative of future high-power electronics or weapon systems.

DESCRIPTION: Cyclically and intermittently powered thermal systems are candidates for TES and transport technologies where the average thermal dissipation requirement is substantially lower than the peak requirement. Thermal management (TM) systems can then be reduced in size as a result of being able to store peak waste heat and dissipate it slowly. Depending on the specific application, cycle times may vary from relatively long (500 kW for an hour) or relatively short (900 kW for 20 seconds). A variety of phase change material (PCM) systems may be envisioned for such thermal storage; and depending on heat load to be stored and working temperature, include paraffin-based systems, molten salts, eutectic metals, and reversible chemical reactions. The TES system must be tailored towards specific requirements as the various platforms require quite different performance. For example, reversible chemical reactions hold promise for high-energy densities applicable to directed energy weapons (DEW) if they can be controlled and suitably large heats of reaction can be married with a low or nonvolatilizing reaction for use on military aircraft. PCMs with heats of reaction approaching the high latent heats associated with vaporization (water, 2200 KJ/Kg; ammonia, 1100 KJ/Kg), without substantial increase in volume, are also desirable for DEW systems. We seek novel TES technologies and integration approaches for managing transient heat loads representative of future weapon requirements, 1000 kJ/kg at 20°C for laser applications and 1000 kJ/kg at 70°C for high-power microwave applications, with volumetric goal of at least 180 MJ/m^3 and bulk thermal conductivity of 100 W/mK if applicable.

PHASE I: Develop a feasibility study for proposed innovation to include analysis, design, and experimental approach for TES concept demonstration. Address a specific weapon's TM need, including operating temperatures, energy magnitudes, interfaces, and weight requirements.

PHASE II: One or more of the systems identified in Phase I will be designed and built at a breadboard level of technical readiness to demonstrate proof of concept. Strong relationships with suitable aerospace primes should be demonstrated for potential enhancement and Phase III-type opportunities.

DUAL USE COMMERCIALIZATION: Military application: Perform integration and packaging of the high-capacity TES system into high-power, solid-state laser or high-power, microwave TM systems. Commercial application: There are several commercial requirements for improved TM, both in the aerospace and nonaerospace markets, including actuator cooling and hybrid automotive applications.

REFERENCES: 1. Du, J., Chow, L.C., and Leland, Q., "Optimization of High Heat Flux Thermal Energy Storage with Phases Change Materials", ASME IMECE, 5-11 Nov 2005.

2. Wierschke, K.W., Franke, M.E., Watts, R., and Ponnappan, R., "Heat Dissipation With Pitch Based Carbon Foams and Phase Change Materials," 38th AIAA Thermophysics Conf., Toronto, Ontario, 6-9 June 2005.

3. Baxi, C.B. and Knowles, T., "Thermal Energy Storage for Solid-State Laser Weapon Systems," Journal of Directed Energy, Vol. 1, pp. 293-308, Winter 2006.

4. Park, C., Kim, K.J., Gottschlich, J., and Leland, Q., “High Performance Heat Storage and Dissipation Technology,” ASME International Mechanical Engineering Conference & Exposition, Orlando, FL, 2005.

KEYWORDS: integrated thermal management, phase change materials, PCM, thermal energy storage, TES, thermal management, TM

AF073-047 TITLE: Stand-Off Detection of Functionalized Nanoparticles

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a system for remote monitoring of the presence and behavior of functionalized nanoparticles in the environment.

DESCRIPTION: Metal and metal oxide nanoparticles exhibit specific opto-electronic and physical properties that can be exploited for environmental monitoring. The material’s optical properties can be enhanced by incorporation of phosphorescent and fluorescent molecules. The interaction of the particles with selected targets can be directed by grafting ligand molecules onto particle surfaces. For example, functionalizing the particle with an antibody could allow selective binding to a bacterial cell surface. That conceptual approach is clearly adaptable to a broad range of recognition elements; specific ligands may be developed for most conceivable chemical, biological, or explosive (CBE) agents.

A system is needed in order to exploit the selective binding and distinct signatures of functionalized nanoparticles. In the present topic, a separate approach will be used to disperse functionalized nanoparticles within a defined area or upon a surface. The system developed will interrogate the dispersed particles, then monitor resulting spectral signal from particles. Changes in response due to interactions with selected chemical or biological targets must be detectable by system. In order to allow covert monitoring, the system should detect and monitor signature in the near-IR-to-microwave spectral regions.

PHASE I: Demonstrate the feasibility of the proposed monitoring system. Identify the approach and assemble lab instrumentation to demonstrate the detection of response from functionalized nanoparticles.

PHASE II: Develop a commercial prototype system for interrogation, activation, and detection of functionalized nanparticles at over 100 meter distance. Document system requirements such as power, weight, space, etc. Demonstrate system performance in field conditions. It is desired that the prototype system be delivered to the AF at the end of Phase II for further testing and evaluation.

DUAL USE COMMERCIALIZATION: Military application: Covert monitoring of operations area and materiel for presence of selected CBE. Commercial application: Design of optical materials, surveillance for contraband trafficking, homeland security/counter-terrorism monitoring.

REFERENCES: 1. Huang, Genin Gary, Wang, Chien-Tsung, Tang, Hsin-Ta, Huang, Yih-Shiaw, Yang, Jyisy, “ZnO Nanoparticle-Modified Infrared Internal Reflection Elements for Selective Detection of Volatile Organic Compounds,” Analytical Chemistry, 2006.

2. Kouassi, Gilles K., Irudayaraj, Joseph, “Magnetic and Gold-Coated Magnetic Nanoparticles as a DNA Sensor,” Analytical Chemistry, 2006.

3. “Testing and Evaluation of Standoff Chemical Agent Detectors,” Committee on Testing and Evaluation of Standoff Chemical Agent Detectors, National Research Council, 2003.

KEYWORDS: surface plasmon resonance, stand-off detection, microwave

AF073-048 TITLE: Temperature-Tolerant Processor for Reliable Control

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

STATEMENT OF INTENT: Improve the capability of engine full authority digital engine controls (FADECs) and aerospace controls

OBJECTIVE: Significantly improve the capability of engine controls and aerospace electronics to remove heat and withstand harsh environments. The focus is on achieving high-temperature conditions.

DESCRIPTION: Aerospace engine controls and electronic systems are designed to operate with wide environmental temperature excursions, from -67 to >275°F. They may also experience sustained extreme temperature and duty cycles that increase stress. Operating life, mission completion, and reliability of controls are significantly affected under these conditions. However, current trends are not favoring designs that cope with this environment. Increasing use and quantity of commercial components, coupled with projected rise in semiconductor power density in control electronics will likely reduce actual mission capability margins of aerospace systems. Current state-of-the-art microprocessor controllers operate with core power densities of 24 W/cm². Fabrication advances, resulting in increased transistor density and speed, are expected to enable power densities up to 200 W/cm² in the future. Semiconductor switches for power control are also expected to achieve these high power densities as well. Allowable temperature rise in controls and electronic enclosures in harsh environments is maintained using air or liquid cooling. Current state-of-the-art military engine controls use fuel cooling. However, current trends are projected to result in higher thermal loading of fuel-cooled electronics that will limit future advanced mission applications. The ability to effectively operate aerospace controls in a harsh temperature environment, greater than 275°F. without a fuel cooling loop is desired. It is also desired to develop a cost-effective conceptual design that maintains current state-of-the-art reliability. Appropriate technical approaches may include hybrid techniques that take advantage of advanced device technology, commercial components, circuit design and health/condition monitoring algorithms. Potential high-temperature electronic devices include silicon carbide (SiC), silicon on insulator (SOI), gallium arsenide (GaAs), and carbon nanotubes (CNTs) fabrication materials. The use of circuit design to reduce the effects of leakage current, processor errors, and component variability as temperature increases may be employed. The use of analog, discreet, or integrated circuits are appropriate. The use of condition monitoring and prognostic techniques may be employed to gain temperature tolerance. Prognostics may be used to manage power usage, reduce temperature concentrations, and tailor electrical stress to achieve design life.

PHASE I: Design a conceptual engine controller employing a hybrid approach using advanced device technology, temperature-tolerant circuit design, and electronics prognostics.

PHASE II: Develop and test prototype electronic control hardware employing a temperature-tolerant design. The design should be applicable to the harsh military engine and vehicle environment and accommodate planned advanced system architectures.

DUAL USE COMMERCIALIZATION: Military application: Applications include advanced engine and flight controls, unmanned aerial vehicles, and directed energy systems, military control units, actuators, and more-electric systems. Commercial application: Projected applications for the developed control technology include commercial aircraft, ground-based power generation, oil industry, and harsh industrial processing applications.

REFERENCES: 1. Jacob M. Li, “Packaging Design & Manufacture of High Temperature Electronics Module for 225ºC Applications utilizing Hybrid Microelectronics Technology”, Vectron International 267 Lowell Road Hudson, NH, 03051

2. Ovidiu Vermesan, Lars-Cyril Blystad, Roy Bahr, Magnus Hjelstuen, Lionel Beneteau, Benoit Froelich “A BiCMOS Ultrasound Front End Signal Processor for High Temperature Applications”, Proceedings of ESSCIRC, Grenoble, France, 2005

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KEYWORDS: controls, silicon carbide electronics, electronic circuits, prognostics, digital engine controller, temperature mitigation, robust circuit design

AF073-049 TITLE: Full Authority Digital Engine Control (FADEC) Cooling

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: Improve FADEC performance in hot ambient installation environment

OBJECTIVE: Develop innovative methods to cool an aircraft FADEC to make it independent of the fuel cooling system.

DESCRIPTION: The FADEC is a critical system in which the thermal management system determines a maximum allowable fuel temperature that is used to cool electronics. The FADEC could produce heat loads in excess of 300 W at 0.3 W/cm² and must operate in environmental temperatures up to 340 °F. The FADEC needs to be maintained at a temperature lower than 145 °F. The heat load needs to be transported to a sink typically located 2m away at an ambient temperature 120 °F.

Integration of loop heat pipe technology with the FADEC could alleviate the problem of increasing fuel temperature and completely isolating it from the fuel cooling system. Loop heat pipes are two-phase thermal transport devices that operate passively. They use the latent heat of vaporization to transport heat from one location to another and consist of an evaporator, compensation chamber, wick, liquid and vapor transport lines, and condenser. Integration of the loop heat pipe or other approach must be accomplished without a significant increase in weight to the aircraft (as low as 2 to 3 kg).

PHASE I: Develop a model of a thermal management system that will be capable of acquiring and rejecting heat loads generated by the FADEC. Complete analytical modeling of the system, such as a loop heat pipe, along with the integration of the loop heat pipe with the FADEC and heat sink is expected.

PHASE II: Build a full-scale loop heat pipe or other prototype approach capable of rejecting the required thermal loads to the heat sink. Testing should be conducted to verify proper operation of the loop heat pipe for the environmental characteristics of the FADEC.

DUAL USE COMMERCIALIZATION: Military application: This loop heat pipe has a direct application to cooling the FADEC on current and future fighter aircraft platforms. Commercial application: This loop heat pipe could satisfy cooling requirements for the FADEC on commercial aircraft engines as well as other miscellaneous cooling requirements.

REFERENCES: 1. Maidanik, Jury et al., "Heat Transfer Apparatus," U.S. Patent #4515209.

2. Maidanik, Jury, "Review: Loop Heat Pipes," <i>Applied Thermal Engineering</i>, Vol. 25, pp. 635–657, 2005.

3. Baldassarre, Gregg et al., "Loop Heat Pipes for Avionics Thermal Control," SAE Paper #961318, 1996.

4. Hashemi, Ab et al., "Aircraft skin cooling system for thermal management of onboard high power electronic equipment," Proceedings of the 1996 31st ASME National Heat Transfer Conference.

KEYWORDS: full authority digital engine control, FADEC, loop heat pipe, LHP, fuel cooling, thermal management

AF073-050 TITLE: Advanced Heat Exchanger (HEX) Scaling Methodologies for High-Performance Aircraft

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: Improve scaling methodologies for aircraft advanced HEXs.

OBJECTIVE: Develop characterization and scaling methodologies for aircraft advanced HEXs and corresponding modeling tool that incorporates these scaling methodologies.

DESCRIPTION: Current and future advanced high-performance aircraft are experiencing higher heat loads over legacy systems that are driving the need for improved heat sink capability to coolants. A primary mechanism to transfer excess heat to on board coolants (fuel, air, and oil) is through HEXs. Current systems are volume and weight constrained, so there is further need for HEXs that can provide improved heat transfer capability without increased size or weight over state-of-the-art products. Several HEX manufacturers have developed processes and designs to increase heat transfer per surface area and increased surface area within specific volumes. In addition, composite and other new materials that offer improved thermal conductivity, higher temperature strength capability, and unique manufacturability also have a direct impact in the development of new HEX designs. However, analytical approaches to characterize new HEX designs are immature and currently highly empirical, thus making the ability to optimize these advanced heat transfer devices improbable without comprehensive characterization efforts. The Air Force is seeking novel approaches for accurately characterizing and scaling new HEX designs, along with a modeling tool to facilitate timely trade studies of several concepts, all to help accelerate the typical concept initiation to development to hardware fabrication timeframes. To ensure accuracy of the characterizations and scaling laws, the development and verification of the most promising approaches is desired that takes into account installation effects, materials, manufacturing and costs. Also desired is the conceptualization and development of a robust easy to use modeling tool that accurately captures the characterization methods, scaling rules, and production influences of new HEXs. This tool is to be transitional to industry and the government. The focus of the Phase I effort will be to develop characterization methodologies and scaling laws for advanced HEXs, along with a modeling approach that takes into account installation effects, materials, manufacturing configurations, and cost. These will be used to investigate potential candidate technologies and heat transfer mechanisms that can lead to improvements in HEX volumetric efficiency over current technology.

PHASE I: Develop characterization methodologies and scaling laws for advanced HEXs suitable for use in high performance aircraft. Incorporate these methodologies into an easy to use, robust modeling approach that takes into account installation effects, materials, manufacturing configurations, and cost; all while having the capability of interfacing with other application tools.

PHASE II: Develop and validate the modeling approach from Phase I. Demonstrate the model by applying it to evaluate several potential candidate technologies and heat transfer mechanisms that can lead to improvements in HEX volumetric efficiency. Bench-level or laboratory experiment testing on at least one advanced HEX concept to verify the results is encouraged.

DUAL USE COMMERCIALIZATION: Military application: Smaller and lighter heat exchangers will increase cooling capabilities and enhance the performance of the warfighter. Commercial application: More-electric commercial aircraft, experiencing increased heat loads, will benefit from the smaller and lighter HEXs.

REFERENCES: 1. Smith, Eric M., Thermal Design of Heat Exchangers: A Numerical Approach: Direct Sizing and Stepwise Rating, New York, NY: John Wiley and Sons, 1997.

2. Hewitt, Geoff F. and Pugh, Simon J., "Approximate Design and Costing Methods for Heat Exchangers," <i>Heat Transfer Engineering</i>, Vol. 28 No. 2, February 2007, pp. 76-86.

3. Kuppan, T., Heat exchanger design handbook, New York: Marcel Dekker, 2000.

KEYWORDS: heat exchanger, heat transfer, scaling laws, materials, heat sink, high-temperature materials, modeling tools

AF073-051 TITLE: Test Method for Inducing Steep Thermal Gradients in Thin-Walled Structures

TECHNOLOGY AREAS: Air Platform, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: To develop affordable turbine airfoil thermomechanical fatigue (TMF) test capability

OBJECTIVE: Develop an economically viable test methodology to generate known thermal gradients in thin-walled structures.

DESCRIPTION: Thermomechanical fatigue (TMF) is a leading failure mode for the hot-section components of modern gas turbine engines. To improve the safety, reliability, and affordability of modern fleets, methodologies must be developed that allow more accurate modeling of TMF damage. Further, emerging technologies and vehicle concepts will pose a much more challenging environment in the future. The success of these programs depends on the ability to predict TMF capability. To this end, science and technology (S&T) programs are underway to develop a first-principles-based approach to modeling TMF behavior. This Small Business Innovation Research (SBIR) topic is needed to develop test capabilities to support these S&T programs and provide critical calibration and validation data.

Since TMF is most commonly experienced by high-pressure turbine airfoils, the Air Force is particularly interested in understanding the behavior of components under severe local thermal gradients. Turbine airfoils are subject to thermal loads that induce temperature gradients of several hundred degrees Fahrenheit through-wall thicknesses less than one-tenth of an inch. The ability to experimentally replicate these conditions will provide valuable data for a first-principles-based material model. To date, there are no economically feasible experimental techniques to simulate the dramatic through-wall gradients experienced by turbine airfoils.

A testing methodology is needed to generate severe thermal gradients in thin-walled structures. The approach should provide thermal gradients that simulate the conditions experienced by high-pressure turbine airfoils in modern gas turbine engines. Further, the approach should provide for experimental testing that is substantially less expensive than pressurized burner or full-engine testing. The testing method should support the following:

• Surface temperature generation up to 2000°F
• Capability to generate steep thermal gradients of several hundred degrees Fahrenheit through specimen walls less than 0.1 inch in thickness
• Automatic cycling and transient capability (up to 160°F/s)
• Representative turbine airfoil materials and geometry, including thermal barrier coatings (TBCs) and/or metallic coated specimens
• Compressive and tensile loading capability up to 5000 lb.
• Small feature testing capability (e.g., specimens with film cooling holes)

Since the intended purpose of the technology is to simulate the conditions within a modern gas turbine engine, it is strongly recommended that the development team include an engine original equipment manufacturer (OEM) as an active participant. OEM participation will allow for necessary guidance in the development of the test methodology for transition into a first-principles model for incorporation into standard design practices.

PHASE I: Determine the technical feasibility and detailed design of an economical test methodology to generate steep thermal gradients in thin-walled specimens which are simulative of turbine airfoils and representative of conditions experienced in modern gas turbine engines.

PHASE II: Develop, demonstrate, and validate a prototype test rig to generate steep thermal gradients in thin-walled specimens simulative of high-pressure turbine airfoils under conditions experienced in modern gas turbine engines.

DUAL USE COMMERCIALIZATION: Military application: TMF is evident in military gas turbine engines. This testing methodology will provide valuable data to improve the TMF capability for high-performance turbine engines. Commercial application: Development of successful test capability will provide lucrative turbine simulation testing business opportunities and provide valuable data to improve the TMF capability of all gas turbine engines.

REFERENCES: 1. M. Bartsch and B.Baufeld, "Effect of controlled temperature gradients in thermal-mechanical fatigue," Proceedings of the Fifth International Conference on Low Cycle Fatigue (LCF 5), Eds. P.D. Portella, H. Sehitoglu, K. Hatanaka, Deutscher Verband fur Materialforschung und prufung e.V., Berlin, 2004, pp. 183-188.

2. L. Jacobsson, C. Persson, and S. Melin, "Experimental methods for thermomechanical fatigue in gas turbine materials," Proceedings of ECF15, Stockholm 2004.

3. T. Brendel, E. Affeldt, J. Hammer , and C. Rummel, "Temperature gradients in TMF specimens Measurement and influence on TMF life," HT-TMF Conference, Berlin, September 2005. Also to be published <i>International Journal of Fatigue</i>; http://www.mtu.de/channel/files/pdf/temperature_gradients_in_tmf.pdf.

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KEYWORDS: thermomechanical fatigue, TMF, TMF testing, temperature gradient testing, turbine airfoil testing, inducing thermal gradients, temperature difference testing

AF073-052 TITLE: Full-Field Temperature and Strain Measurement Capability for Turbine Engine Applications

TECHNOLOGY AREAS: Air Platform, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop accurate, full-field temperature and strain measurement capabilities for turbine airfoils under modern gas turbine engine conditions.

OBJECTIVE: Develop methods to accurately measure full-field temperatures and strains associated with thermomechanical fatigue (TMF) behavior of turbine airfoils in turbine engine applications.

DESCRIPTION: TMF is a leading failure mode for the hot-section components of modern gas turbine engines. To improve the safety, reliability, and affordability of modern fleets, methodologies must be developed that allow for more accurate modeling of TMF behavior. Further, emerging technologies and vehicle concepts will pose a much more challenging environment in the future. The success of these programs depends on the ability to predict TMF damage and associated reductions in airfoil durability. To this end, science and technology (S&T) programs are under way to develop first-principles-based approaches to modeling of TMF behavior. This Small Business Innovation Research (SBIR) topic is needed to develop accurate and robust full-field temperature and strain measurement capabilities to support these S&T programs and provide critical calibration and validation data.

Since TMF is most commonly experienced by high-pressure turbine airfoils, the Air Force is particularly interested in understanding the behavior of these components under severe thermal and mechanical loads. Often, these components show evidence of TMF emanating from small features, e.g., film cooling holes. To calibrate and validate a first-principles-based approach for TMF modeling, the ability to accurately measure local temperatures, absolute strain, and strain rate are of utmost importance.

Therefore, methodologies are required which allow for measuring both ceramic-coated and uncoated specimens, simulating turbine airfoils, subject to thermal and mechanical loading conditions similar to those experienced by high-pressure turbine airfoils in modern gas turbine engines. Measurement specification requirements will include the capability to accurately measure local temperatures to within +/- 2 ºF within an area of 0.002 square inches, absolute strain to 0.01 percent (0.0001 inch/inch) over a range of at least 0.6 percent (0.006 inch/inch), and strain rate of 0.00001/s to 0.01/s. It will also be necessary to develop the capability to separate total strain into its free thermal and mechanical components. These capabilities must not only be of high accuracy, but must also be robust enough to withstand and operate for long periods of time during high temperature (up to 2000 ºF at the surface), rapid thermal transient (up to 160 ºF/s), and high mechanical stress (up to 5000 lb compressive and tensile loading) experimental testing.

Since the intended purpose of the technology is to measure the thermal and loading conditions within a modern gas turbine engine, it is strongly recommended that the development team include an engine original equipment manufacturer (OEM) as an active participant. OEM participation will allow for necessary guidance in the development of measurement technology for incorporation into standard developmental testing and design practices.

PHASE I: Determine technical feasibility to accurately measure full-field temperature and strain in thin-walled specimens, simulative of turbine airfoils, under conditions experienced in modern gas turbine engines.

PHASE II: Develop, demonstrate, and validate prototype device(s) to accurately measure full-field temperature and strain in thin-walled test specimens, simulative of high-pressure turbine airfoils, under conditions experienced in modern gas turbine engines.

DUAL USE COMMERCIALIZATION: Military application: TMF is evident in military gas turbine engines, increasing cost and reducing readiness. This test methodology will provide valuable data to improve the TMF capability of military gas turbine engines. Commercial application: TMF is evident in all gas turbine engines. Success in this endeavor will provide lucrative instrumentation business and contribute to improvement in the TMF capability of all turbine engines.

REFERENCES: 1. P. Hahner, K. Rau, and T. Beck, "Issues of Dynamic Temperature Measurement and Control in Thermo-Mechanical Fatigue Testing," http://www.npl.co.uk/tman/meetings/15_mar_06/presentations/haehner.pdf.

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KEYWORDS: thermomechanical fatigue, TMF, turbine airfoils, turbine engine hot section, full-field temperature measurement, full-field strain measurement, temperature gradient measurement, strain rate measurement

AF073-053 TITLE: Spall Propagation-Resistant Hybrid Bearings for High-Performance Turbine Engines

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: Improve spall propagation-resistant turbine engine mainshaft bearings

OBJECTIVE: Develop spall propagation-resistant turbine engine mainshaft bearings to provide increased reliability, safety, and performance margin of aircraft propulsion systems.

DESCRIPTION: Turbine engine mainshaft bearing loads continue to increase as engine flowpath components become more efficient and engine performance reaches unprecedented levels in near term, high-performance aircraft systems. In some of the more modern high-performance engines, bearing loads and resulting contact stresses already exceed the capability of M50 steel material used today, posing a significant life, reliability, and safety issue in these advanced propulsion systems. To address this, significant progress has been made in developing bearing materials and surface treatments that resist surface fatigue initiation and damage caused by hard contaminants by inducing residual compressive surface stresses on bearing races and through the use of hard materials such as ceramic Si3N4 rolling elements (hybrid bearings) and case carburized Pyrowear 675TM races. However, limited effort has been devoted to understanding and optimizing the fatigue propagation characteristics of these advanced bearings once initiation has occurred. This stage of the fatigue life history of an aircraft engine bearing is critical due to potentially catastrophic outcome that may result if a rapid spall propagation rate is encountered. Therefore, the objectives of this effort are 1) advance the understanding of spall propagation mechanisms of advanced materials such Pyrowear 675 TM to help identify the key controlling properties (i.e., microstructure, near-surface fracture toughness, etc.) and/or dynamic operating conditions that control spall propagation rates (the use and/or development of computer modeling and simulation (M&S) tools is highly encouraged for this part of the effort), 2) develop a suitable material/surface heat treatment strategy (i.e., nitriding, carbo-nitriding, etc.), that optimizes spall propagation-resistance without significantly compromising other desirable properties such as fatigue initiation life, wear resistance, and debris damage tolerance, and 3) demonstrate overall performance through subscale and full-scale bearing hardware at simulated engine conditions. To assist in meeting these objectives, interaction with major engine companies and bearing companies is highly recommended.

PHASE I: Research spall propagation mechanisms through literature review, bench top/subscale experimentation, and M&S. Develop conceptual spall propagation-resistant heat treat process on a single relevant bearing material or multiple relevant bearing materials.

PHASE II: Demonstrate enhanced spall propagation-resistance of selected concept under representative engine bearing dynamic conditions of loads, speeds, and temperatures.

DUAL USE COMMERCIALIZATION: Military application: Application to many military high-performance aircraft turbine engines. Commercial application: Commercial aircraft would benefit from improved reliability and safety margin.

REFERENCES: 1. Salehizadeh, H. and Saka, N., "Crack propagation in rolling line contacts," <i>J. of Tribology</i>, Trans ASME Vol. 114 Issue 4 (1992) pp. 690-697.

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KEYWORDS: aircraft, turbine engines, rolling element bearings, fatigue life, spall propagation, carburized bearing steels

AF073-054 TITLE: <u>Conjugate Heat Transfer Analysis Capability for Gas Turbine Component Design</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: Provide conjugate heat transfer analysis capability.

OBJECTIVE: To provide a conjugate heat transfer analysis capability that is suitable for use within the design cycle of turbine components.

DESCRIPTION: For future gas turbines, it is desirable both to increase performance and to reduce operating costs. While turbine performance increases are achievable through increases in turbine inlet temperature, this often results in decreased turbine durability. Since designers currently rely primarily on an experience-based approach, there is a durability margin that is built into the design of turbine components (e.g., blades and vanes). Consequently, component life estimates can be either overpredicted or underpredicted. If part life is greater than predicted, then turbine components are using more than the optimum amount of cooling, and the performance of the overall system is consequently reduced. However, if part life is less than predicted, then the system requires more frequent inspection coupled with possible repairs and/or part replacements. This inevitably results in increased life-cycle costs as well as reduced readiness of the armed forces. Further, turbine components are subjected to exceptionally harsh thermal environments, and present durability design and analysis capabilities used at original equipment manfacturers (OEMs) are not sufficient to allow for accurate predictions of component life in systems now under development. Consequently, major Air Force engine programs may be subject to durability problems, including burning, thermomechanical fatigue, and creep of turbine components. Conjugate heat transfer analysis, whereby the convective heat transfer to the components as well as conduction of heat through the parts are determined simultaneously, has shown great promise for the improvement of turbine durability design systems. However, conjugate heat transfer capabilities have at present been demonstrated only in bench level research projects. So, what is required is a validated conjugate heat transfer analysis capability that is suitable for inclusion in an industry-standard turbine durability design system.

PHASE I: Develop a conjugate heat transfer analysis capability and apply it to the design of a turbine component for experimental validation. Deliverables are the code, the test geometry and its predicted performance, and a detailed plan for experimental validation.

PHASE II: Validate the performance of the components designed in Phase I against experimental data. Further, the code must be production worthy for inclusion in an industry-standard turbine durability design system. The investigators will be required to interface with engineers at one or more gas turbine manufacturers to ensure the quality, robustness, and suitability of the code for use at the OEM.

DUAL USE COMMERCIALIZATION: Military application: The code would be used by the OEM to design airfoils for advanced demonstrator engines, and be adopted as standard work, thereby resulting in hardware for the Warfighter. Commercial application: A standard work design tool will affect all subsequent commercial hardware developed by the OEM.

REFERENCES: 1. Kusterer, K., Hagedorn, T., Bohn, D., Sugimoto, T., and Tanaka, R., "Improvement of a Film-Cooled Blade by Application of the Conjugate Calculation Technique," ASME Paper No. GT2005-68555, 2005.

2. Black, D.L., Meredith, K.V., and Smith, C.E., "LES Simulations Predicting Heat Transfer and Wall Temperatures on Turbine Inlet Guide Vanes at High Fuel-Air Ratios," ISABE Paper No. 2005-1201, 2005.

3. Bohn, D., Tummers. C., and Moritz, N., "Influence of Convex Curvature on Heat Transfer and Thermal Load of Full Coverage Cooled Multi-Layer Plates," ISABE Paper No. 2005-1072, 2005.

4. Fedrizzi, R. and Arts, T., "Investigation of the Conjugate Convective-Conductive Thermal Behavior of a Rib-Roughened Internal Cooling Channel," ASME Paper No. GT2004-53046, 2004.

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KEYWORDS: turbine, durability, conjugate heat transfer, lifing, thermomechanical fatigue, film cooling, internal cooling, physics-based design

AF073-055 TITLE: Improved Damping Modeling for Afterburners

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: Improved damping modeling robustness for afterburners.

OBJECTIVE: Develop robust models that can accurately predict acoustic damping over a wide range of augmentor conditions.

DESCRIPTION: Combustion instability, or screech, occurs in the afterburner of high-performance gas turbine engines. Screech is due to the coupling of the wave propagation of the combustion chamber with fluctuations in the heat release of the combustion process. This coupling can produce large pressure fluctuations that can be severe enough to damage engine hardware. Historically, screech has been mitigated by adding damping to the combustion system. The current damping technology employed by original equipment manufacturers (OEMs) for afterburners was borrowed from technologies developed by the rocket propulsion community in the 1960s. In the 1970s, Helmholtz resonators, realized by the use of perforated liners, were applied to the afterburners and tuned to damp the screech modes exhibited by the afterburner system of the time. These modes were typically in the 1 to 2 kHz range.

A single Helmholtz resonator is a side chamber that has a neck attached to a cavity. The resultant damping system is a band reject filter which damps pressure fluctuations around the resonant frequency of the resonator. In addition to being a tuned damper, Helmholtz resonators act as acoustic high-pass filters damping the pressure fluctuations at and above the resonant frequency. The perforation in an augmentor liner acts as the necks (ports) of multiple Helmholtz resonators which collectively share a common cavity volume.

Models for resonators were developed assuming that the flow through the resonator neck was uniform and the volume of the cavity was such that its acoustic frequencies were significantly higher than the frequency of the resonator system. These assumptions allow for the resonator to be modeled using lumped parameters.

The reality of modern augmentors violates the assumptions that predicated the lumped parameter models. The screech liner acts as a damper, but cooling air is also fed through the system to cool the liner. This flow can change the resonant frequency and damping effectiveness of the liner. Afterburners operate with moderate subsonic velocities. The velocity or grazing flow past the neck of the resonator port is appreciable and can also affect the resonant frequency and liner effectiveness. Finally, individual Helmholtz resonators in an augmentor liner do not have their own small cavity; their shared cavity volume can have its own dynamics, and those dynamics could act in a detrimental way to the system damping. Previously, empirical fudge factors, such as effective neck lengths or effective cavity volumes were employed to correct the predicted damping effectiveness of the resonator. In current afterburner systems, inlet conditions, such as temperature, vitiation level, operating pressure, velocity/Mach number, and turbulence levels are the most severe than ever experienced. The local conditions in today's augmentors greatly deviate from the global parameters used to calibrate existing models. Because of this, improved models that capture the local physical phenomena are required.

Desired are improved damping models. Models developed should take advantage of computational fluid dynamics (CFD) codes as well as reduced order thermoacoustics models.

PHASE I: Develop a detailed design of experiments methodology that identifies key parameters and hierarchy for damping model improvement, and perform a baseline prediction of the state-of-the-art augmentor liner technology with existing model.

PHASE II: Conduct physical experiments to ascertain key physical data and develop a physics-based damping model from derived understanding and experimental data. Demonstrate 50 percent improvement in model prediction of damping effectiveness over baseline at current augmentor conditions.

DUAL USE COMMERCIALIZATION: Military application: Models generated in the Phase II effort can be validated for sector rig and engine conditions and transitioned to military gas turbine OEMs for incorporation into existing augmentor design systems. Commercial application: Combustion instability is also prevalent in commercial gas turbine, land based power generation and commercial boiler industries.

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KEYWORDS: afterburner, damping, combustion instability, screech, Helmholtz resonator, acoustics, mean flow

AF073-056 TITLE: Advanced Heat Exchanger Materials

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: To improve heat exchanger applications, including return fuel-to-air heat exchangers through novel heat transfer materials.

DESCRIPTION: Advanced aircraft engines such as those used on tactical platforms use several types of heat exchangers to transfer heat energies from air-to-air, fuel-to-air and oil-to-oil or fuel. Currently, there are separate AFRL-funded heat exchanger and materials development efforts for tactical aircraft applications. AFRL/PRP’s investment directly addresses return fuel/air cooler (RFAC) heat exchanger applications that could potentially improve heat exchanger performance in fighter aircraft using conventional metals (i.e. aluminum and nickel).

Application of new/advanced materials--such as carbon, metal, or hybrids--instead of conventional materials, could potentially enhance heat transfer capabilities/performance and reduce heat exchanger weight/volume. Current goals for the new heat exchanger design include Tmax = 300 °F, heat transfer greater than 4500 BTU/min in 300 cubic inches of heat exchanger core volume, max pressure drop of 0.95 psid (JP-8 fuel) and 0.19 psid (ram air), and flow rate of 70 lb/min (JP-8 fuel) and 90 lb/min (ram air). Any material must be able to be integrated into emerging heat exchanger designs and still enhance mechanical and physical performance.

PHASE I: Identify novel heat transfer materials and surface morphologies that enhance the performance of liquid fuel-to-air heat exchangers and their application to aircraft systems through subscale experiments and analytical techniques. Demonstrate critical proof-of-concept fabrications and critical material characteristics at the subscale level to allow confidence in scale up and fabrication of the full scale core concept, including compatibility with JP-8.

PHASE II: Develop and demonstrate the new material concepts investigated in Phase I through fabrication of a RFAC heat exchanger module that can be used to characterize thermal performance enhancement for fuel-to-air heat exchanger applications. The full-scale prototype [4500BTU min=79kW] of the RFAC heat exchanger module shall include an integrated core and manifold.

DUAL USE COMMERCIALIZATION: Military application: RFAC heat exchanger that is form-fit-function ready for advanced fighter aircraft to improve thermal management system performance. Commercial application: More efficient heat exchanger in the commercial aircraft sector.

REFERENCES: 1. Watts, R., "Advancement in Compact Lightweight Carbon Aircraft Heat Exchangers," 2005 Spring SAMPE, Long Beach, CA.

2. Newland, S., "Applications for High Thermal Conductivity Graphite Heat Sinks for Fighter Aircraft," 2004 ICES, Colorado Springs, CO, 2005.

KEYWORDS: heat transfer, fuel cooling, heat exchanger, metallic, foams, carbon, hybrid

AF073-057 TITLE: High-Speed Thermal Sensing System for On-Engine Monitoring of Ceramic Coatings

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop real-time, on-engine thermal sensing of static and rotating turbomachinery

DESCRIPTION: High cycle temperatures are driving engine designers toward the application of more advanced thermal protection systems. At the same time, the need to verify the ability of those systems to conserve component durability life is also pushing the development of advanced sensors for determining local temperatures and heat transfer rates (condition monitoring), and to track defect/damage progression (health monitoring) for the hot engine flowpath structures. What is needed, then, is the ability to perform high-resolution, real-time, full-surface scans of rotating turbine blades, where the combined thermomechanical stresses are severe, as are the consequences of failure.

While most of the current sensing systems (e.g., thin-film thermocouples) are limited to point measurements, a number of optical methods (e.g., multicolor optical pyrometry) can potentially be adapted to provide full-surface scans of rotating parts. The main limiting factors appear to be the resolution and response time of the infrared (IR) imaging systems (pyrometers, cameras, optical fibers, etc.) and the partial translucence of most ceramic thermal protective coatings in the near to mid-IR range, which precludes the use of existing engine IR imaging systems that have successfully operated in that frequency range. And, as is the case for any instrumentation that is to be installed onto an operating engine, the environmental conditions that are typically found there can present significant design challenges, in the form of high temperatures and vibration levels which can damage the optical hardware, and contaminants (e.g., reactive chemical species and soot) which can seriously reduce the system's ability to see inside the engine flowpath. Lastly, the installation of such an optical system must not be allowed to compromise engine performance, durability, or data acquisition systems.

The objective of this program is to develop and demonstrate a robust thermal sensing system which has the suitable speed and temporal/spatial resolution in the mid- to far-IR range, is capable of operating at advanced engine conditions with minimal losses, and can be interfaced with existing data processing equipment at an engine test site. This thermal sensing system must be able to measure relative surface temperatures to within +/-25 °F, and to correct for changes in the surface emissivity due to the accumulation of contaminants (such as soot, dirt, and unreacted hydrocarbons) which are commonly found in the engine flowpath. The ability to measure absolute surface temperatures to within +/-25 °F and heat transfer rates is also desirable, but not required. Since the intended purpose of the technology is to monitor the conditions inside an operating engine, it is strongly recommended that the development team include an engine original equipment manufacturer (OEM) as an active participant, to guide the development of a practical engine sensing system and to provide a transition path for eventual demonstration of the technology.

PHASE I: Demonstrate the technical feasibility of developing a high-speed, high-resolution thermal sensing system that will operate in the mid- to far-IR range, and can be used to measure surface temperature distributions. Develop a plan for producing and demonstrating a prototype optical system in Phase II.

PHASE II: Produce a prototype optical system and demonstrate its capabilities on an advanced durability demonstrator engine, or on some comparable system such as a test rig that can replicate near-engine operating conditions and flowpath contaminants.

DUAL USE COMMERCIALIZATION: Military application: Real-time, on-engine monitoring of coated hot section components to verify performance and structural integrity, for military aircraft, marine, and ground-based propulsion systems. Commercial application: Real-time, on-engine monitoring of hot section components to verify performance and structural integrity, in commercial aircraft, marine, and ground-based propulsion and power generation systems.

REFERENCES: 1. Kavusi, S. and Gamal, A.E., "Folded multiple-capture: an architecture for high dynamic range disturbance-tolerant focal plane array," Proceedings of the SPIE - The International Society for Optical Engineering Conference, Proc. SPIE - Int. Soc. Opt. Eng. (USA), Vol. 5406, No. 1, pp. 351-360 2004.

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KEYWORDS: infrared imaging, turbines, cameras, camera shutters, optical devices, gas turbines engines, high speed imaging, thermal scanning, thermography, optical pyrometry, engine monitoring, sensors, thermal barrier coatings, optical properties, ceramic coatings

AF073-058 TITLE: Hypersonic Propulsion

TECHNOLOGY AREAS: Air Platform, Space Platforms, Weapons

OBJECTIVE: Develop technologies that improve high-speed (>Mach 4), air-breathing propulsion and extend the use of these systems to weapon, space access, and high-speed atmospheric applications.

DESCRIPTION: Hydrocarbon fueled supersonic combustion ramjets (scramjets) are expected to operate at conditions above Mach 4. Most recent design and test experience with scramjet engines is at relatively small scale, with engine air flows at 10 lb/s or less. Scramjet technologies for Air Force applications will need to scale up to larger systems, operate effectively over a broad range of Mach numbers with minimal variable geometry features, maintain thermal balance using only the on-board fuel as a heat sink, and integrate with other propulsion cycles without significant loss of integrated system performance.
This topic is aimed at technologies that address one or more of the following critical path issues:
1) Extend scramjet operability to lower Mach numbers: Reduce scramjet starting Mach number to Mach 3.5 while maintaining performance at higher Mach numbers within the same flowpath.
2) Scale to larger systems: Develop flameholding and fuel injection techniques that are scalable for engines 10 to 100 times the air flow capacity of current 10 lb/s designs.
3) Enhance scramjet operation in combination with other propulsion cycles:Mitigate performance losses at off-design operating conditions and during engine cycle transitions.
4) Improve cold start capability: Enable reliable cold start of the scramjet using liquid fuel at ambient conditions
The expected payoffs are to broaden the operating range of the hydrocarbon-fueled scramjet, make it more effective in combination with other propulsion cycles, and develop the analytical tools required to significantly increase the engine scale over current technology. Considerations that might be explored include nonintrusive combustion enhancement technology, scalable and fluid-phase tolerant injectors, fluidic controls, and drag reduction techniques.

PHASE I: Design innovative concepts and analyses on one or more critical path issues listed in the Description. Perform detailed numerical analyses or subscale testing of the concepts. Modeling and simulation can be used to demonstrate feasibility as well as guide critical experiments in subsequent phases.

PHASE II: Provide engineering systems analyses on one or more of the critical path issues in developing larger and broader operating range scramjets. Fabricate and evaluate prototypical devices or hardware to confirm predictions at an acceptable scale. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

DUAL USE COMMERCIALIZATION: Military application: New and innovative high-speed propulsion technologies are equally applicable to military and commercial space launch applications. Commercial application: Engine scaling over two orders of magnitude is useful for access to space. It allows physical testing at smaller scales to reduce cost while maintaining confidence of applicability to larger systems.

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KEYWORDS: hypersonic, scramjet, propulsion, high speed, space access, cruise missile

AF073-059 TITLE: Measurement Techniques for High-Pressure, Liquid-Fueled Combustors with High Soot Loading

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms

OBJECTIVE: Develop optical spectroscopic techniques for quantitative in-situ temperature and concentration measurements in high-pressure, liquid-fueled combustors with high soot loading.

DESCRIPTION: The demand for high-performance combustors--as stand-alone power plants and as part of combined cycles incorporating gas turbines and supersonic combustion ramjet engines -- is inspiring revolutionary designs for which validated combustor models or scaling laws are unavailable. Growing concern over the environmental impact of combustion emissions has driven increased regulation in recent years, and in response gas-turbine engine manufacturers are designing dual-use combustors that deliver increased performance and extremely low emissions. In light of these needs, it is critically important that we understand the formation processes for major and minor species (H_2O, CO_2, CO, OH, CH, NO, H, and O) in realistic combustor environments over a wide range of pressures and temperatures. Current state-of-the-art measurements of temperature and species concentrations in high-pressure combustors based on linear or nonlinear spectroscopic techniques are limited or complicated by soot luminescence (typical of complex JP fuels), quenching-induced calibration uncertainties, line-broadening effects, and nonresonant background contributions. Recent developments in laser technology have enabled advanced spectroscopic techniques that might alleviate many of these difficulties. Methods for acquiring temperature and multiple species concentrations simultaneously enable corrections for quenching or line broadening. Time-resolved fluorescence techniques have been used to measure species concentrations simultaneously with or independent of fluorescence lifetimes to avoid uncertainties in the quenching environment. Ultrafast nonlinear techniques have been used to adjust the temporal overlap of pump-probe beams to avoid laser-induced breakdown and various interfering signals. These techniques show great promise for application in high-pressure, liquid-fueled combustors with high soot loading. Due to the highly transient, inhomogeneous nature of practical combustion systems, emphasis is placed on measurements with high temporal and spatial resoutions of 1 microsecond and 250 microns, respectively, or better. This topic seeks spectroscopic means for measuring temperature and quantifying concentrations in high-performance combustors for pressures ranging from 1 to 20 atmospheres.

PHASE I: Develop spectroscopic techniques for measuring temperature and species concentrations at elevated pressure. Evaluate the dependence of the measurements on pressure and soot loading for hydrocarbon fuels and demonstrate feasibility for quantitative use in practical combustion systems.

PHASE II: Complete the experimental and theoretical development of spectroscopic techniques and perform measurements in a government furnished (GF) high-pressure, liquid-fueled combustor with high soot loading. Deliver prototype device hardened for application in a test-cell environment with a practical user interface.

DUAL USE COMMERCIALIZATION: Military application: This technology will yield significant payoffs in gas turbine-based and hypersonic combustion applications, including military aviation as well as land- and sea-based power generation. Commercial application: This technology will yield significant payoffs in various commercial combustion applications, including aviation as well as land- and sea-based power generation.

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KEYWORDS: combustor, high pressure, liquid fuel, soot, lasers, diagnostics, spectroscopy

AF073-060 TITLE: Computational Fluid Dynamics Enhancements for Scramjet Flow Simulations

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Develop and demonstrate methods for improving the accuracy and computational turnaround time for scramjet simulations.

DESCRIPTION: The Air Force Research Laboratory's Robust Scramjet program goals are to improve the operating characteristics of hydrocarbon scramjet engines and to scale current technology to significantly larger engine sizes. One issue, for future large scale systems, is that complete full scale engines will be too large for ground testing before flight. Therefore, a means of applying subscale and component ground test results to obtain accurate predictions of full scale propulsion system operation in flight is needed. Computational fluid dynamics (CFD) simulations are important for reaching a practical vehicle design. Enhancements to modeling and/or simulation capability for hypersonic aeropropulsion systems are required.

The modeling enhancements could include both physical model improvements and obtaining calibration data for the physical models. Areas for modeling enhancement include turbulence modeling, kinetics modeling and multiphase flow modeling. For turbulence modeling, improvements in hybrid Reynolds averaged Navier-Stokes/large eddy simulation (hybrid RANS/LES) methods and variable Schmidt number methods are desired. For kinetics modeling, improved computational speed and accuracy for high temperature hydrocarbon combustion are desired, possibly including soot production models. Modeling for soot radiation in scramjet environments is also desired. For multiphase flow, interface surface and homogeneous droplet distribution models as well as nucleation, condensation, and vaporization model improvements are desired. Models for supercritical flow in heated channels would also be useful.

Required enhancements to high speed aeropropulsion simulation capability mainly focuses on decreasing the time and effort required for a simulation, coupling multiple domains and CFD linked design optimization. Better grid generation and adaptation methods for complex geometries with high speed flow could reduce time and effort required for a simulation. A close coupling of the grid generator with standard computer-aided design (CAD) file formats could reduce the time for complex geometry grid generation. Also, a discretization error estimating tool for evaluating grid and solution quality could improve the accuracy of simulations. This could also extend to a grid adaptation tool. Decreasing the simulation time through dynamic load balancing and optimization of inter-CPU communications are possibilities for reducing computation time.

Multidomain methods for improvement include coupling of fluid and structural simulations with heat transfer and structural deflections, coupling regions of hypersonic and transonic flows, and coupling structured, unstructured or overset solution domains.

Efficient methods for design optimization using CFD could be developed. Currently, a reasonable guess at a CFD flow solution can be obtained less than half the time of a converged solution. Coupling CFD with an optimization method that allows inaccurate intermediate results could reduce the time required for design optimization.

PHASE I: Develop and demonstrate methods for improving CFD simulation accuracy or utility for scramjet design and analysis. Quantify the magnitude of the improvements and define any restrictions or limitations on application of the methodology.

PHASE II: Develop software modules implementing the methods. Incorporate the software modules into computational tools used by AFRL in scramjet design and analysis.

DUAL USE COMMERCIALIZATION: Military application: Military applications include scramjet propulsion systems for hypersonic air vehicles. Commercial application: Reduced time, risk and cost for developing hypersonic propulsion capability for access to space using hydrocarbon fuels. Software modules could be licensed, sold or leased to analysis tools providers.

REFERENCES: 1. Peroomian, O., “Convergence Acceleration for Unified-Grid Formulation using Preconditioned Implicit Relaxation,” AIAA 1998-0116, 1998.

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KEYWORDS: hypersonic, scramjet, chemical kinetics, supersonic combustion, liquid hydrocarbon fuels, modeling, simulation, turbulence

AF073-061 TITLE: Longer Length Carbon Nanotubes (CNTs) for Electric Power Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop material processing/fabrication techniques for long-length bundled carbon nanotubes (CNTs) showing improvement over copper conductor and determine the mechanical, electrical, and thermal properties of the resulting “composite” wire.

DESCRIPTION: CNTs have recently been demonstrated to possess a variety of potentially useful mechanical, thermal, and electrical properties. A CNT is essentially a graphitic sheet rolled over forming a single cylinder made only of carbon atoms [1]. The CNT is basically a single molecule made up of a hexagonal array of covalently bonded carbon atoms. There are two types: single wall carbon nanotubes (SWNT) which consist of one cylinder, and multiwall carbon nanotubes (MWNT) which consists of several concentric graphene cylinders. The initially determined properties of the CNTs may be particularly relevant to power applications of commercial and military interest [2]. However, the length of the CNTs are severely restricted (needing to be meters long) and properties are often specified in terms of a single CNT fiber, which is not applicable to power applications. The intent of this Small Business Innovation Research (SBIR) topic is to explore methods of making longer lengths (several centimeters or more) of nanotubes, with favorable electrically conductive power properties. These CNTs should either be fabricated as a grouping of aligned CNTs or single nanotubes that can be readily bundled together. Only as a collection/group of nanotubes similar to multistranded copper wire and of appropriate length and properties void of defects, can the potential for CNT power applications be realized. Further, there is an interest in developing an appropriate experimental evaluation criteria for CNT characterization and quality control such as electrical, mechanical, thermal, and chemical properties relevant to high current carrying power applications. Essentially, the focus of the program should be:
1) growing longer CNT bundles with significant advantages over copper conductor.
2) verifying the properties, purity, and quality of the bundles.

PHASE I: Assess and develop enabling technology approaches for efficient fabrication of nanotubes exceeding current length and bundling benchmarks. Obtain preliminary electrical and relevant test data on the material samples that validate fabrication techniques and identify additional developmental effort.

PHASE II: Optimize fabrication techniques developed in Phase I and demonstrate the capability to fabricate CNT bundles in lengths greater than current benchmarks and into forms that can be readily integrated into various electric power system applications. Perform extensive evaluations on the fabricated bundles to determine mechanical, electrical, and thermal properties. Deliver bundled CNTs to AFRL/PRPG.

DUAL USE COMMERCIALIZATION: Military application: Military and commercial applications, using longer length bundled CNTs, include armature windings of compact, lightweight generators, gyrotron magnets, and electrical power conversion components. Commercial application: Additional commercial applications include utility power cables.

REFERENCES: 1. S. Iijima, Nature 354, 56 (1991).

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KEYWORDS: carbon nanotube, CNT, single-walled carbon nanotube, SWNT, multiwalled carbon nanotube, MWNT, nanomaterials, chirality controlled

AF073-063 TITLE: Generation of Multiple-Input Multiple-Output Radar Waveforms

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: The generation of orthogonal waveforms for use in multiple-input multiple-output (MIMO) radar applications.

OBJECTIVE: Identify and develop techniques to produce a high number (100+) of orthogonal waveforms with optimal rejection for use in MIMO radar applications.

DESCRIPTION: MIMO radar technology is based on the transmission of orthogonal waveforms from each element or subarray. These transmitted signals are collected at the receive array, properly correlated using matched filters, and then coherently recombined to form the desired beams. This technology has been proposed as potentially improving radar system performance by providing greater angular accuracy, better target identification, and more degrees of freedom than conventional beamforming. To fully utilize MIMO capability, the generation of orthogonal waveforms and the corresponding receiver technology must provide a high level of rejection between signals.

The small business will investigate issues pertaining to simultaneously generating and coherently processing a large number (100+) of transmitted and received waveforms each of 25 kHz bandwidth and all at a carrier frequency of 5

MHz. Such issues may include the autocorrelation sidelobe levels, waveform cross correlation, output signal-to-noise ratio (SNR) and the matched filters' signal rejection properties.

PHASE I: Identify architectural design requirements for signal generation and matched filtering and develop simulations predicting the performance of the proposed system architecture.

PHASE II: Optimize, build, and deliver prototype signal generators and matched filters as designed and proved feasible in Phase I. Delivered prototype should consist of enough channels to demonstrate a high level of rejection between waveforms.

DUAL USE COMMERCIALIZATION: Military application: MIMO technologies will provide a significant performance increase to many military applications, such as high-resolution radar, unmanned air vehicle (UAV) swarms, and high-security communications. Commercial application: High capacity, low-interference waveform generation is a key technology in data transmission techniques for both the cell phone and wireless networking industries.

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KEYWORDS: waveforms, orthogonal waveforms, MIMO radar

AF073-064 TITLE: Wideband, Dual-Polarized, High-Frequency (HF) Element

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: Develop improved antenna radiating element for next generation over-the-horizon radar

OBJECTIVE: Develop/demonstrate a low cost, dual-polarized, high-frequency (HF), phased array antenna radiating element for next generation over-the-horizon radar (OTHR).

DESCRIPTION: The OTHR can provide wide area surveillance both in theater and within the continental United States (CONUS); thus, it can be used for detection of launch events and detection and tracking of low flying difficult targets, including drug traffickers. OTHRs are especially attractive because they can provide surveillance and detection services with an order of magnitude lower cost per square mile than any other type of radar. The existing OTHRs have co-located transmit and receive array antennas. Because of their large size and high cost, the receive arrays have no scan capability in elevation and can receive only linearly polarized HF waves.

Significant improvements over the current OTHR capability can be achieved through the use of directional arrays electronically scanning the beam in both azimuth and elevation, digital beamforming, and dual polarized radiators. Dual polarization, the primary focus of this topic, will enable reception of, not only the vertically polarized signals, but the horizontally polarized components that are generated by Faraday rotation during the propagation of HF waves through the ionosphere. A suitable design of a wideband dual polarized HF radiator could improve the signal-to-noise ratio (SNR) by as much as 3 dB, resulting in a higher probability of detection for OTHR. The contractor shall investigate novel designs for an OTHR radiating element that is capable of receiving dual-polarized HF waves in the frequency band of 6 to 28 MHz. The contractor shall demonstrate the performance of the new element design by fabricating and testing a small 2D array of these elements, with a scan volume of 360 degrees in azimuth and 0 to 30 degrees in elevation.

PHASE I: Investigate and analyze several dual-polarized element configurations suitable for operation from 6 to 28 MHz in a 2-D phased array for OTHR. Perform a design trade off study in terms of performance, cost and mechanical design, including realistic ground effects.

PHASE II: Select the most promising element configuration in Phase I and perform detailed numerical electromagnetic simulations. Refine the design trade offs, including fabrication and reliability. Fabricate a small 2D array and demonstrate the dual-polarized array characteristics, such as input impedance, polarization, and radiation patterns, over the above given scan volume and frequency range.

DUAL USE COMMERCIALIZATION: Military application: Dual-polarized radiators for HF OTHR will also be applicable to military ground-to-ground communication systems. Commercial application: There is increasing demand for wideband radiators for commercial applications, such as radio broadcast and sensor applications. Specifically, there is a strong market for radio propagation at HF.

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KEYWORDS: wideband radiators, dual polarized element, over-the horizon radar(OTHR), high-frequency (HF) antenna

AF073-065 TITLE: Tunable Filters for the Joint Tactical Radio System (JTRS)

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Reduce the board space required by filters in mulit-function radios

OBJECTIVE: Demonstrate new technologies to reduce the size, cost, and power of tunable filters for co-site mitigation and channel selection in wide-bandwidth radios.

DESCRIPTION: The Joint Tactical Radio System (JTRS) requires high-performance tunable filters for co-site mitigation and channel selection. Current tunable filter implementations require a large amount of board space driving the size and performance of the system. New technologies (including, but not limited to radio frequency (RF) micro-electromechanical systems, or MEMS, and ferroelectric thin films) offer the potential to provide high-quality (high-Q) tunable components in a compact, highly integrated form factor. By increasing the tuning range and quality factor of the reactive components, the number of tuning elements required for front end filters can be reduced while filter performance is maintained or improved. As a result, both the board space and part count required by the radio systems filters can be reduced. The high-Q of these new components is essential to ensure that RF performance meets the challenging linearity, isolation, and loss requirements of JTRS. This topic aims to demonstrate the design and suitability of new technologies for insertion into JTRS with particular emphasis on reducing the size required by the channel selection filters.

PHASE I: Design/simulate tunable filters that are suitable for JTRS in terms of board size, RF performance, cost, mass, lifetime, and reliability.

PHASE II: Produce tunable filter prototypes based on the Phase I effort. Demonstrate filter performance and JTRS suitability in the lab.

DUAL USE COMMERCIALIZATION: Military application: Components with low loss and wide tuning ranges are critical for next generation wideband radios, electronic warfare, and multi-function antenna systems. Commercial application: Wireless data transmission is growing exponentially, but the available spectrum is limited. Components enabling more flexible radios to improve the efficiency of spectrum utilization are critical.

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3. J.R. MacLeod, T. Nesimoglu, M.A. Beach, and P.A. Warr, "Enabling technologies for software defined radio transceivers," in Proc. of MILCOM 2002, vol. 1, October 2002, pp. 354-358.

KEYWORDS: tunable filters, MEMS variable capacitors, MEMS transmission line

AF073-066 TITLE: Low-profile, Wideband Antennas for the Joint Tactical Radio System (JTRS)

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: Develop low-profile, wideband JTRS antenna suitable for aerodynamic platforms.

OBJECTIVE: Develop an aerodynamic, wideband, low-profile antenna to enable flexible use of JTRS for aircraft.

DESCRIPTION: The Joint Tactical Radio System (JTRS) operates over a frequency band from 2 to 2000 megahertz. The purpose of this effort is to design, fabricate, and demonstrate a prototype of a wideband antenna that is operational over selected portions of this frequency range. In addition, the design should address the following technical objectives: (1) Minimize the voltage-standing-wave ratio (VSWR) with a target VSWR of 2.0, (2) Maximize the radiation efficiency, (3) Exhibit an omni directional radiation pattern in the azimuth plane, and (4) Exhibit an elevation pattern that is equivalent to that of a quarter-wavelength monopole for line of sight waveforms. In addition to the above criteria, the antenna should be low profile for improved aerodynamics. In particular, aircraft platforms typically mount antennas a distance of one-quarter wavelength above the ground plane to provide maximum broadside gain by constructively adding the primary and reflected antenna signals. If the distance is less than one-quarter wavelength, the primary and reflected signals will partially or completely cancel each other, thus limiting the bandwidth of the antenna. This effort should investigate and demonstrate novel approaches to overcoming the bandwidth limitations associated with wideband, low-profile antennas including, but not limited to, the use of magnetically conducting ground planes.

PHASE I: Modeling and simulation are encouraged to guide the design of a wideband, low-profile antenna, which meets the desired technical objectives. Innovative approaches to overcoming bandwidth limitations should be investigated in this phase. Results should be summarized in a final report.

PHASE II: Based on Phase I findings, select one or more candidate designs. For each design, fabricate and demonstrate a prototype antenna. Several iterations may be necessary to produce a prototype design that meets the desired performance objectives. Results should be summarized in a final report, and the final prototype will be delivered to AFRL for further testing.

DUAL USE COMMERCIALIZATION: Military application: A wideband antenna will enhance the channel flexibility offered by JTRS. Commercial application: Many commercial companies have an increasing need for RF/antenna components to support channel flexibility while retaining isolation to increase spectrum usage.

REFERENCES: 1. R. M. Walser, "Metamaterials: An Introduction", pp. 295 – 316 in: Introduction to Complex Media for optics and Electromagnetics, edited by W. Weiglhofer and A. Lahktakia, SPIE Press, 2003.

2. The Joint tactical radio and the Navy RF distribution system challenge. Adams, R.C., Moeller, K; Korckway, J.W.: MIOCOM 2002. Proceedings, vol. 1, 7-10 October 2002, pp. 359-362.

KEYWORDS: wideband antennas, low-profile antennas, JTRS, magnetically conducting ground plane, metamaterials, conformal antennas

AF073-067 TITLE: Efficient Radar Search Modes for Deep Space (DS) Surveillance

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: Develop advanced space object tracking capabilities

OBJECTIVE: Develop advanced techniques to perform ground based radar space surveillance and tracking. Identify capability to locate/track unknown objects with and without cueing.

DESCRIPTION: The Space Control Joint Capabilities Document (JCD) defines the warfighter's need for space situational awareness (SSA) in the near-earth and deep space orbital regimes employing the Integrated Global Space Surveillance (IGSS) network. Capability shortfalls exist in each of these regimes; however, addressing improvements in detection and tracking of small objects in highly elliptical orbit, medium Earth orbit, and geosynchronous Earth orbit represents the greatest technology challenge. The purpose of this SBIR is to establish and demonstrate an improved capability for conducting deep space searches by developing and deploying new signal and data processing technology for existing space surveillance radars. The effort will first identify practical solution bounds for erecting leak proof search volumes for both elliptical and circular deep space orbital regimes, including the geosynchronous belt. The resulting solution space will then be characterized in terms of applicable radar measurements, and a solution approach will be proposed for conducting searches and detecting and tracking unknown space objects within these orbital regimes. The solution will also provide flexibility to adapt the search volume for varying altitude bands, object sizes, probabilities of detection (Pd) and be tailored to the existing radar frequencies and be applicable to new surveillance radars that could be developed in different bands to improve detection/tracking accuracy.

PHASE I: Conduct a feasibility study of the proposed concept and identify:
- solution space for ground based SSA applications
- signal and data processing improvements
- imaximum search volume (low earth orbit to geosynchronous orbit and horizon to horizon line-of-sight)
- minimum resolvable target size and tracking capabilities/limitations
- benefits of high quality or guided cueing vs non-cued operations

PHASE II: Provide a concept demonstration of the most promising improved data and signal processing techniques from Phase I.
- Implement processing improvements needed for new detection and tracking capabilities
- Use existing radar surveillance station configurations to demonstrate improved capabilities.
- Quantify the maximum surveillance volume which can be covered for a variety of notional target sizes

DUAL USE COMMERCIALIZATION: Military application: Improved identification/tracking of new space objects. Enhances SSA for new and existing space objects. Commercial application: Enhances university and NASA capabilities for space object tracking.

REFERENCES: 1. Lt Col David Vallado and Col Salvatore Alfano, "A Future Look at Space Surveillance Operations", AAS/AIAA Space Flight Mechanics Meeting, Breckenridge, CO, AAS Publication Office, P.O. Box 28130, San Diego, CA 92128, Feb 7 – 10, 1999.

2. United States General Accounting Office Report to Congressional Requesters, "Space Surveillance, DoD and NASA Need Consolidated Requirements and a Coordinated Plan", GAO/NSIAD-98-42.

3. "United States Quadrennial Defense Review Report – V. Creating the U.S. Military of the 21st Century, Enhance the Capability and Survivability of Space Systems", http://www.pdgs.org.ar/Archivo/usa-cap5.htm#e-2

KEYWORDS: radars, space surveillance, signal processing, characterization

AF073-068 TITLE: Three-Dimensional (3-D) Synthetic Aperture Radar (SAR) Image Formation and Exploitation

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: Develop image processing and exploitation techniques for sparse-aperture 3-D SAR data

OBJECTIVE: Develop, implement, test, and analyze image processing and exploitation techniques for sparse-aperture 3-D SAR data.

DESCRIPTION: The production of high quality 3-D imagery is a critical need for future surveillance applications. Such imagery will be useful for high confidence vehicle identification, building and terrain modeling, and change detection. Traditional 3-D SAR processing requires the collection of a two-dimensional (2-D) aperture. A staring, circular SAR sensor that collects data with full 360° azimuth coverage can collect an elevation aperture by slightly varying the flight path from pass to pass. However, the resulting elevation aperture is sparsely sampled, resulting in a poor point spread function. Exploitation of the resulting images will be difficult due to the increased image artifacts.

In this research, we seek to develop and implement innovative image formation and exploitation algorithms suited for 3-D SAR applications. The sensor of interest is a staring, circular SAR sensor that collects 5 to 10 elevation apertures with full 360° azimuth coverage. Targets of interest include vehicles, both military and civilian, as well as buildings and terrain. Data-driven approaches for the coherent aligning of multiple passes without the use of fiducial markers are desired.

PHASE I: Investigate the technical feasibility of innovative algorithms which improve 3-D image quality. Produce a Phase II plan to extend the algorithm development and evaluation. The plan will identify the algorithm development environment, specify test plans, and identify data sets for testing.

PHASE II: Execute the plan developed under Phase I. Demonstrate the utility of the algorithms on measured radar data in the application of high confidence vehicle identification, building and terrain modeling, or change detection.

DUAL USE COMMERCIALIZATION: Military application: Both active and passive imaging is applicable within the Departments of Homeland Defense and Justice in the identification and fingerprinting of civilian vehicles. Commercial application: 3-D imaging techniques developed here have application in diverse fields such as 3-D acoustics, medical tomography, geosciences, and remote sensing.

REFERENCES: 1. Ishimaru, A., Chan, T., and Kuga, Y., "An Imaging Technique Using Confocal Synthetic Aperture Radar," IEEE Transactions on Geoscience and Remote Sensing, vol. 36. No. 5, September 1998.

2. Bryant, M., Gostin, L., and Soumekh, M., "3-D E-CSAR Imaging of a T-72 Tank and Synthesis of its SAR Reconstructions," IEEE Transactions on Aerospace and Electronic Systems, vol. 39, No. 1, January 2003.

3. Aleksoff, C. "3-D ISAR Enhanced Opto-Electric Processing," In Radar Processing, Technology, and Applications, William J. Miceli, Editor, Proceedings of SPIE, vol. 2845, pp. 196-204, November 1996.

4. Soumekh, M. "Reconnaissance with Slant Plane Circular SAR Imaging," IEEE Transactions on Image Processing, vol. 5, No. 8, August 1996.

5. "A challenge problem for 2D/3D imaging of targets from a volumetric data set in an urban environment", C. Casteel, L. Gorham, M. Minardi, S. Scarborough, K. Naidu, and U. Majumder, *Algorithms for Synthetic Aperture Radar Imagery XIV (Proc. SPIE 6568)* , SPIE Defense and Security Symposium, 2007, Orlando, FL.

KEYWORDS: persistent-sensing, staring-RF, 3-D image reconstruction, data driven autofocus, 3-Dvisualization, terrain modeling, building modeling, change detection

AF073-069 TITLE: <u>Feature-Aided Tracking, Detection, and Identification of Moving Targets Using Synthetic Aperture Radar (SAR)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: Develop exploitation algorithms for targeting moving targets

OBJECTIVE: Research, develop, and provide real-time implementations of exploitation algorithms for detecting, tracking, locating, and identifying moving targets in persistent radio frequency sensor applications.

DESCRIPTION: The Air Force is developing a novel persistent, staring mode radar that will enable detection, identification, and long-duration tracking of targets in a dense, high-clutter environment. Realizing the potential of this new radar system requires a new approach to signature exploitation and a new class of algorithms. Until recently, radar has been used in two classical modes to track and identify targets. Ground moving target indication (GMTI) mode is used to track movers but typically suffers from low cross-range location accuracy and an inability to perform target identification. Synthetic aperture radar (SAR) mode has historically used higher range resolution waveforms to provide accurate maps of the stationary scene as well as identification quality information for stationary targets.

Moving target approaches for conventional SAR include multiple-phase centers with displaced phase center and monopulse-type processing to reduce stationary ground clutter and improve cross-range accuracy; multiple-pass change detection to reject stationary clutter and detect movers in a single-phase center; persistent staring-mode SAR; GMTI-type processing to detect moving targets in SAR mode data over a sequence of coherent processing intervals that are shorter than a conventional SAR aperture; autofocus-based and shear-averaging-based methods for moving target detection (MTI); SAR-MTI mode detection and focusing of moving targets via a using a bank of velocity-matched filters; and detection and imaging of targets with linear velocity via keystone remapping and higher order focusing.

An interesting characteristic of many of the above approaches is that they blur the distinction between SAR and GMTI. In this research, we seek to develop and implement innovative processing techniques that hybridize SAR and GMTI modes to detect, identify, track, and locate moving targets. The proposed approaches should provide high location accuracy in range and cross-range to help minimize tracking ambiguities. These techniques should apply to single-platform RF sensor data with one or more along-track, overlapping-beam channels. The air platform may be assumed to fly multiple passes against the area of interest. Targets may include moving military and civilian vehicles or pedestrians. Real-time implementations should have adequate throughput and limited latency to process the radar data as it is collected either on board or on the ground as accessed via a very high-speed data link.

Innovative research is needed in which the following is accomplished: a. Design a RF processing system to detect, identify, and track moving targets in persistent, staring-mode radar, and b. Develop a system performance model (SPM) and perform trades and feasibility studies to support the design. During Phase I, a. Develop a top-level system design for the processing architecture, b. Demonstrate non-real-time components as needed to prove concepts, explore performance, and support Phase II developments, c. produce Phase II system development plan (SDP) that provides system component specifications, identifies hardware and software development environment, specifies test plans, and identifies developmental and test data sets; and analyzes the design using (at least one operational scenario) which proves the design's quantifiable operational utility if successfully implemented.

PHASE I: Design RF processing system and develop automatic target recognition (ATR) algorithms which detect, identify, and track targets in a persistent, staring-mode radar. Document processing architecture's top-level system design and demonstrate non real-time components to support Phase II SDP.

PHASE II: Execute Phase II SDP to implement a prototype real-time RF processing system to detect, track, and identify moving targets. Demonstrate and measure system performance. Use Phase II SDP that has system component specifications, identifies hardware and software development environment, specifies test plans, and identifies developmental and test data sets.

DUAL USE COMMERCIALIZATION: Military application: Airborne technology to track/identify specific vehicles, and individuals across broad urban areas for both safety and security. Supports long-term planning and modeling. Commercial application: Local law enforcement agencies greatly benefit from all-weather, standoff tracking of specific vehicles and individuals in urban conditions. Airborne traffic monitoring assists in traffic control.

REFERENCES: 1. M. Minardi, and E. Zelnio, “Comparison of SAR based GMTI and standard GMTI in a dense target environment”, Algorithms for Synthetic Aperture Radar Imagery XIII, E. Zelnio, editor, Proc. SPIE, 2006.

2. J.R., Fienup, "Detecting moving targets in SAR imagery by focusing," IEEE Trans Aero and Electron Sys., vol. 37, no. 3, pp. 794-809, July 2001.

3. J.K., Jao, "Theory of Synthetic Aperture Radar Imaging of a Moving Target," IEEE Trans Geosci and Remote Sensing, vol. 39, no. 9, pp. 1984-1992, September 2001.

4. R.P. Perry, R. C. DiPietro, and R.J. Fante, "SAR Imaging of Moving Targets," IEEE Trans. Aero and Electron, Systems, vol. 35, no. 1, January 1999.

5. P.K. Sanyal, D. M. Zasada and R.P. Perry, “Detecting Moving Targets in SAR via Keystoning and Multiple Phase Center Interferometry,” Algorithms for Synthetic Aperture Radar Imagery XIII, E. Zelnio, editor, Proc. SPIE, 2006.

KEYWORDS: synthetic aperture radar (SAR), feature-aided tracking, moving-target imaging, persistent-staring RF sensing, space-time-adaptive processing, GMTI, change detection, real-time (R-T)

AF073-070 TITLE: Waveforms Optimization Algorithms for Electronic Warfare Countermeasures Development

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: Develop systematic method for ECM technique generation.

OBJECTIVE: Utilize algorithms to dynamically derive potentially effective jamming waveforms and improve resource allocation to investigate, evaluate, and assess electronic countermeasure technique effectiveness.

DESCRIPTION: Continuous developments in radar technology have improved detection capabilities as well as electronic counter-countermeasures (ECCM). The development and optimization of electronic counter measures (ECM) techniques to go against these improved radars are often time consuming and non trivial. Vast resources are allocated to investigate, evaluate, develop, and assess these radar systems’ capabilities and vulnerabilities. The present process of developing jamming waveforms and ECM techniques is based upon exploitation data and circuit analysis of threat hardware. From this information a basic waveform is derived and then modified by trial and error. This method may offer a good solution but it may not offer the optimal solution. The use of stochastic algorithm will offer an innovative computational method beyond the typical conventional approach in the development of jamming waveforms in radar and electronic warfare applications.

PHASE I: Conduct proof of concept of an empirical method. Investigate implementation process, coupled with design variable randomness, to derive an optimal solution. The algorithm will derive an optimal jamming waveform beyond the conventional trial-and-error process.

PHASE II: Develop hardware model to demonstrate the ECM development process and assess its effectiveness. The algorithm will derive starting parameters with a desired goal to evaluate against the initial desired function. The method the algorithm uses to obtain the system performance from a given set of design variables in the environment where an optimized solution converges will be documented.

DUAL USE COMMERCIALIZATION: Military application: The utility of algorithm offers an innovative computational method beyond the typical conventional approach in the development of jamming waveform and techniques for military application. Commercial application: The algorithm, when developed, could be used as a tool or a process which helps to derive an optimal function within the design variables and constraints in engineering process.

REFERENCES: 1. L. Mathelin and M.Y. Hussaini, "A stochastic collocation algorithm for uncertainty analysis", NASA/CR-2003-212153.

2. P.D. West and B.J. Slocumb, "ECM modeling for assessment of target tracking algorithms"; Proc. of the Twenty-Ninth Southeastern Symposium on System Theory, March 1997.

KEYWORDS: algorithm, electronic countermeasure (ECM), radar, electronic warfare, jamming waveform, technique, optimization, vulnerability, design variable, constraints, converge

AF073-071 TITLE: Nonlinear Signal Processing for Advanced Digital Receive Systems

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: Develop real-time non-linear signal processing

OBJECTIVE: Develop real-time nonlinear signal processing (NLSP) techniques to enhance the performance of digital receive systems.

DESCRIPTION: Modern radar and digital communication receive systems require ever increasing requirements for additional bandwidth while simultaneously achieving state-of-the-art dynamic range performance. These needs have been met in the past by improving the performance of individual circuits and components that make up the receive (and transmit) chain. While performance requirements have continued to increase, the ability to get more performance out of required receiver components (low noise amplifiers, mixers, analog to digital converters, etc.) have not been able to keep up due to fundamental physical limitations.

The main performance limitations in receivers are due to inherent nonlinearities in microwave and RF components. Intermodulation distortion in amplifiers and mixers are major factors that limit the dynamic range in modern receivers. Third order (and higher) mixer products produced by mixers is also a major factor that limits receiver bandwidth and dynamic range. Spurious products produced within Analog to Digital Converters (ADCs) limit their Spurious Free Dynamic Range (SFDR) which effectively reduces their resolution (i.e. dynamic range). Given that more performance cannot be squeezed out of "front-end" RF components, the goal of this topic is to increase performance of modern digital receivers by adding processing at the "back-end". The objective of this topic is to develop innovative non-linear signal processing (NLSP) techniques that can be used to simultaneously increase both bandwidth and dynamic range leading to greatly improved performance with little to no increase in a digital receivers size, weight, or power consumption.

The goal of this effort is to develop and demonstrate innovative NLSP techniques that can demonstrate a 50 to 100% increase in bandwidth while simultaneously showing an increase in dynamic range of 20-30dB in real time and can be implemented in real time in a Field Programmable Gate Array (FPGA). The offeror will work with the

Government to pick a candidate receiver architecture appropriate to this effort in order to demonstrate their technique(s).

PHASE I: 1) Identify candidate digital receiver hardware (Low Noise Amplifiers, mixers, filters, ADCs, etc.), 2) Develop innovative digital receiver “calibration” methodology that supports NLSP real time implementation, and 3) Verify approach through detailed software simulation.

PHASE II: 1) Design, build, test, and deliver a digital receiver incorporating real time NLSP correction techniques.

DUAL USE COMMERCIALIZATION: Military application: The NLSP techniques demonstrated are applicable to military radar and communication systems. Both single-channel and multi-channel systems could be significantly impacted by this technology Commercial application: Improved bandwidth and dynamic range receivers will enhance the capabilities of future radar and communication systems while reducing the size, weight, power consumption, and cost of commercial system

REFERENCES: 1. Pitas, I., Venetsanopoulos, A.N., Nonlinear Digital Filters, Principles and Applications, Kluwer Academic Publishers, Boston, MA, 1990.

2. L.C. Howard and D. Rabideau, "Correlation of Nonlinear Distortion in Digital Phased Array: Measurement and Mitigation", IEEE MTT-S Digest, 2002, pp. 49-52.

3. D.J. Rabideau and L.C. Howard, "Mitigation of Digital Array Nonlinearities", Proc. 2001 IEEE Radar Conference, pp. 175-180.

4. White, L.B., Feng, R., and Angus, M, "Spurious Free Dynamic Range for a Digitizing Array", IEEE Trans on Signal Processing, vol. 51, Issue 12, Dec 2003, pp. 3036-3042.

5. Eduri, U., Malobetti, F., "On-line Digital Correction of the Harmonic Distortion in Analog-to-Digital Converters", Proc. of the IEEE ICECS, Sept 2, 2001, pp. 837-840.

KEYWORDS: nonlinear signal processing, digital receive arrays, phased-array antennas, digital filters, analog-to-digital converters, digital receivers

AF073-072 TITLE: Materials/Techniques for Small/Dense Global Positioning System (GPS) Antenna Arrays

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

STATEMENT OF INTENT: The Topic intends to reduce size and density of antenna arrays for GPS receivers thus reducing penalties in antenna efficiency and offering opportunities for using dual or wide bandwidth for the warfighters.

OBJECTIVE: Research the applicability of new materials and design techniques to develop small and/or dense anti jam antenna arrays for GPS for use in military airborne GPS systems.

DESCRIPTION: Due to severe space limitations, GPS multi-element adaptive arrays need to be reduced in size for many military systems such as tactical aircraft, helicopters, submarines, and missiles. Other platforms require more antenna elements in the same physical aperture to increase antijam protection of a controlled radiation pattern antenna (CRPA), resulting in a denser array. Compact, lightweight antenna arrays are also needed for hand-held GPS anti jam receivers.

In recent years, the development of new materials offers hope for building innovative miniaturized GPS antennas that can meet the size, efficiency, bandwidth, and satellite coverage required by GPS. The proposed antenna must make use of new materials or surfaces such as metamaterials to achieve a smaller and/or more dense array than currently possible using conventional materials. For instance, magnetic metamaterials are a new class of engineered composite materials containing either ferromagnetic thin films, ferrite inclusions, or miniaturized resonant circuit elements distributed either periodically or randomly in a host dielectric medium. The permittivity and permeability of these new materials offers the antenna designer additional design parameters for controlling the scaling factor and intrinsic impedance, thereby potentially offering significant reduction in antenna size while minimizing the penalty in antenna efficiency, bandwidth and impedance matching. In addition, antenna elements are being developed by industry with compact size and dual or wide bandwidths needed for wireless applications.

The required GPS receive-only array design shall operate over the GPS frequency bands L1 +/- 12 MHz and L2 +/- 12 MHz. A small array would have a 3.5-inch diameter footprint with as many elements as possible and minimum height. A dense array would contain a minimum of 11 antenna elements in a CRPA 14-inch diameter footprint with minimum height. Right-hand circular polarization (RHCP) omnidirectional coverage over the upper hemisphere down to +5º elevation angle is required. Each element must have a separate RF output port so that the elements can be adaptively weighted for pattern control, nulling, etc. Design priorities are to maximize omni RHCP gain coverage especially at low elevation angles and maximize the number of elements (to maximize the degrees of freedom for nulling and pattern control); minimize diameter, height, and weight; and minimize mutual coupling between elements. Low cross polarization (LHCP) is not required. Low-noise amplifiers are not required in the antenna but can be included if desired.

Performance characteristics such as Voltage Standing Wave Ratio (VSWR) are of interest.

PHASE I: Demonstrate application of the new material and proof of concept of the antenna design using computer modeling tools, or fabrication of a laboratory model antenna system with limited measured data.

PHASE II: Validate the proposed antenna and material design approaches through development, fabrication and test of a prototype article that functionally meets the design objectives. Quantify the electrical radio frequency performance to include gain, radiation patterns of each element, mutual coupling, and VSWR. Demonstrate that the mechanical design approach is suitable for airborne applications

DUAL USE COMMERCIALIZATION: Military application: Produce flight-worthy antenna arrays. The arrays shall be tested to correct environmental conditions. A flight-worthy prototype of each array shall be delivered to the government. Commercial application: Commercialization applications may include small arrays for spatial diversity systems in wireless systems.

REFERENCES: 1. S.R. Best, “Advances in Electrically Small Antennas”, Wiley & Sons, August 2007.

2. N. Engheta and R.W. Ziolkowski (Editors), “Electromagnetic Metamaterials: Physics and Engineering Explorations,” Wiley-IEEE Press, 2006.

KEYWORDS: GPS, global positioning system, adaptive array, airborne antenna, anti jam array, small antenna, space-time adaptive processing, STAP, adaptive beam forming, metamaterials

AF073-073 TITLE: Digital Beamforming (DBF) for Satellite Operations (SATOPS) Support

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This effort will develop innovative, receive-only DBF concepts, architectures and techniques that can be incorporated into phased-array antennas to support satellite tracking, telemetry and interference control operations for the warfighter.

OBJECTIVE: Develop/demonstrate novel, cost-effective DBF concepts for application to large multi-beam conformal phased array antennas in support of satellite tracking and adaptive pattern control.

DESCRIPTION: Compared to analog beamforming, DBF for receive beams offers Rx [1] significant improvement in adaptive pattern control for antijamming or interference control, high-resolution direction finding for tracking, antenna auto calibration, ultra low sidelobes, closely spaced multiple beams, and flexible antenna resource management. Recent advancement in digital technology, data processors, and component fabrication techniques for wireless communication has increased the processing capabilities and drastically reduced the cost of DBF systems. Thus, DBF becomes an attractive approach to enhance the capability of phased-arrays for robust operability. This effort will develop innovative, receive-only DBF concepts, architectures and techniques that can be incorporated into phased-array antennas to support satellite tracking, telemetry and interference control operations. All hardware and software thus developed should be modular and scalable with open interfaces that are applicable to a wide range of frequency bands, forms (including conformal arrays), sizes, and operation modes of phased array antennas for multiple space mission systems.

PHASE I: Investigate several candidate DBF architectures for general application to conformal phased array antennas including cost. Select an optimal architecture that can be incorporated into a multi-beam geodesic dome phased array antenna (GDPAA) [2, 3, 4] as a demonstration example.

PHASE II: For the DBF concept selected in Phase I, perform a detailed numerical simulation, and refine the design tradeoffs including fabrication, implementation, and operational issues. Construct and build a 4 by 4 array of horn antennas, each simulating a subarray of an actual GDPAA prototype, and demonstrate four simultaneous multiple Rx beams in the digital domain and in real time.

DUAL USE COMMERCIALIZATION: Military application: The DBF will be directly applicable to the GDPAA acquisition program for integration into the Air Force control and communication network. Commercial application: This technology is also applicable to mobile commercial satellite communication systems that use using phased-array antennas and gateway ground stations.

REFERENCES: 1. J. Litva and T. Lo, Digital Beamforming in Wireless Communications, Artech House, July 2006.

2. B. Tomasic, J. Turtle and S. Liu, "The geodesic Sphere Phased Array Antenna for Satellite Communication and Air/Space Surveillance – Part I," AFRL in-House Technical Report, AFRL-SN-HS-TR-2004-031, June 2004.

3. B. Tomasic, J. Turtle and S. Liu, "Spherical Arrays - Design considerations," 18th International Conference on Applied Electromagnetics and Communications, Dubrovnik, Croatia, October 2005.

4. B. Tomasic, J. Turtle, S. Liu, R. Schmier, S. Bharj and P. Oleski, "The Geodesic Dome Phased Array Antenna for Satellite Control and Communication - Subarray Design, Development and Demonstration," IEEE International Symposium on Phased Array Systems and Technology 2003, Boston, October 2003.

KEYWORDS: digital beamforming, multibeam phased-array antennas, adaptive pattern control in conformal phased array antennas, satellite operations

AF073-074 TITLE: <u>Multi Channel Radio Frequency Application-Specific Integrated Circuit (RFASIC) for Handheld GPS Receiver Anti Jam Enhancement</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

STATEMENT OF INTENT: Warfighter needs jam-proof GPS receivers based on extremely low power RF ASIC

OBJECTIVE: Design, develop, fabricate, and test a low-power multi channel RFASIC that will enable the integration of digital anti jam processing in global positioning system (GPS) handheld receivers.

DESCRIPTION: The size, cost, and power required for RF circuitry to support anti jam processing have generally been too large for practical, cost-effective implementation in GPS handheld receivers. Increased capabilities for both the military and civil sectors to meet evolving GPS threats, both intentional and unintentional, and GPS modernization requirements need to be accommodated without increasing the size and cost of current GPS handheld receivers. An anti jam solution for handhelds that is both fully integrated with the handheld unit and transparent to the user is required to meet the military Navy Warfare Center (Navwar) requirements for the dismounted soldier and many civil emergency response, transportation, and commerce applications. What is required is to leverage the advances in RF microelectronics for development of a low power highly integrated RFASIC suitable for integration within a handheld receiver. This will be one of the technology enablers for a complete integrated anti-jam solution for handheld receivers. The basic design goals for the RFASIC are that it will receive the GPS modernization signals in the L1 and L2 frequency bands, provide multi channel downconversion of the L-band signals to intermediate frequency (IF) suitable for sampling and digitizing, and provide for the analog-to-digital conversion of the IF signal for subsequent anti-jam processing. The RFASIC will require high dynamic range, channel-to-channel amplitude and phase matching, and isolation not currently found in current low-cost GPS handheld receivers.

The major technical capabilities objectives for the RF ASIC are as follows:

1. C/A, P(Y)-code, and M code capability
2. At least 2 channels each of L1 and L2 RF processing and downconversion
3. At least 8-bit analog-to-digital conversion on each channel
4. 1 dB compression point sufficient to support input signal power of at least -30 dBm simultaneously in the L1 and L2 bands
5. L1-to-L2 and L2-to-L1 isolation greater than 30 dB
6. Maximum 5 dB noise figure over the specified temperature range
7. Channel-to-channel matching sufficient to support a cancellation ratio of at least 30 dB against broadband noise in a 24 MHz 1 dB bandwidth
8. Maximum input Voltage Standing Wave Ratio (VSWR) of 2.0:1 over the specified temperature range
9. Input impedance of 50 ohms nominal
10. Power consumption ¡Ü 0.5 watts
11. Size, input power voltage, and environmental requirements consistent with military handheld receiver designs such as the defense advanced GPS receiver (DAGR).

PHASE I: Perform tradeoff studies and modeling and simulation as required considering power consumption, size, cost, RF performance, and environmental requirements to identify the most appropriate commercially viable RFASIC process technology for this application.

PHASE II: Design the required RFASIC macrocells and other layout features, including ASIC masks and process parameters. Fabricate, characterize and test RF building blocks and develop test breadboards as required to evaluate performance of critical or risky circuit design features.

DUAL USE COMMERCIALIZATION: Military application: Integrate RF building blocks into a final ASIC design. Fabricate a pre-production wafer. Develop an evaluation board that will allow the ASIC to be tested against a jamming and GPS environment. Commercial application: Commercial applications will be substantially based on military applications.

REFERENCES: 1. High Performance RF-to-Digital Translators for GPS Anti-Jam Applications, D. Moulin, P. T. Capozza, T. M. Hopkinson, J. Psilos, M. N. Solomon, ION GPS 1998, Nashville, TN - September 1998

2. Military/Civilian Mixed-Mode Global Positioning System (GPS) Receiver (MMGR), Peczalski, A.; Kriz, J.; Carlson, S.G.; Sampson, S.J., Aerospace Conference, 2004. Proceedings 2004 IEEE, Volume 4, Issue , 6-13 March 2004 Page(s): 2697 - 2703 Vol.4

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KEYWORDS: GPS, handheld receiver, anti jam, RF, ASIC

AF073-075 TITLE: <u>Agile Optics and Optical Systems for Autonomous Aerial Surveillance Cameras</u>

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

OBJECTIVE: Develop new concepts for compact lightweight optics for monitoring broad areas from small unmanned aerial vehicles (UAVs) while maintaining high resolution required for target discrimination tasks.

DESCRIPTION: To effectively operate in urban areas, the military must be able to achieve and maintain persistent awareness of suspicious activity before it becomes a threat. Continuous monitoring of large, complex regions such as cities is difficult. Small UAVs can provide improved viewing perspective for monitoring broad areas, but the sensor technology for such platforms has been largely limited to conventional imaging cameras that are unable to effectively monitor broad areas with sufficient spatial resolution for adequate discrimination performance.

The focus of this effort is to explore agile optical component and prototype design concepts that can adapt to changing sensing functions during the course of a mission. Examples of changing functions include line of sight stabilization, field of view control, adaptable area coverage, optical zoom (variable resolution), and rapid revisit slewing without mechanical gimbals. The emphasis of this topic is on novel optical devices and techniques that may include such technologies as variable index materials, deformable optical methods and materials, and field of view switching/steering. While compact integrated optical prototype design and component-level development is the goal of this topic, novel imaging architectures are also of interest.

[Proposals should address operation on an airborne platform with limited payload capacity typical of small-class UAVs, such as Dragon Eye, Raven or Pointer. The threshold objective is for a full sensor package weight including the optics of less than 450g with an ultimate goal of less than 100g.] The technology should provide optical performance necessary for detecting, locating, tracking moving objects (sizes from vehicles to personnel), and imaging of at fine resolution (< 1 ft). Spectral bands of interest are visible (0.4 to 0.7 microns), near infrared (0.7 to 1.0 microns), short wave infrared (1.0 to 1.7 microns), mid wave (3.0 to 5.0 microns) and long wave thermal infrared (8.0 to 12.0 microns) with emphasis on day/night operation.

PHASE I: Establish optical design and provide technical analysis that supports the proposed design and quantify expected performance. Investigate component-level optical device concepts. Perform initial component prototype development and experiments to validate concepts.

PHASE II: Construct and test a prototype imaging sensor to demonstrate and evaluate the optical design concept. Identify and reduce the risk of component technologies needed to perfect the design and demonstrate the approaches needed for commercialization of a flight-capable instrument.

DUAL USE COMMERCIALIZATION: Military application: Potential applications include compact imaging systems for persistent area surveillance and reconnaissance over urban environments from small UAVs for military and counter terrorism missions. Commercial application: Potential commercial applications include compact imaging systems for emergency and national disaster monitoring from small UAVs, compact law enforcement monitoring systems and novel consumer cameras.

REFERENCES: 1. M. Sandrock, et al, “A widely tunable refractive index in a nanolayered photonic material,” Applied Physics Letters, vol. 18, no. 18, 3621-3623, 2004.

2. M. Neifeld and J. Ke, “Optical Architectures for Compressive Imaging,” Frontiers in Optics 2006, Paper FWN2, Rochester, NY, October 2006.

3. J. Kostrzewa, et al, “An Infrared Microsensor Payload for Miniature Unmanned Aerial Vehicles,” Proc. SPIE, V. 5090, 265-274, 2003.

4. Lance Cpl. M. Hacker, “Dragon Eye provides quick, reliable intel,” Marine Corps News, Story Identification #2005120103142, 2005. (http://www.globalsecurity.org/military/library/news/2005/01/mil-050120-usmc01.htm)

5. AeroVironment Small UAVs Website, “Unmanned Aircraft Systems (UAS).” (http://www.avsuav.com/UAS.asp)

KEYWORDS: optics, agile, adaptable, deformable, steering, stabilization, UAV, persistent, surveillance, monitoring

AF073-076 TITLE: Exploitation of Large-Format (ELF) Electro-Optic (EO) Data

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

OBJECTIVE: Develop an automatic target recognition (ATR) algorithm suite for EO technologies to exploit panchromatic and large format (LF) imagery (hyperspectral, video, etc.).

DESCRIPTION: Recent advancements in the use of visible and EO sensors employed for the purpose of supporting the intelligence, surveillance, and reconnaissance (ISR) mission calls for the development robust sensor exploitation (SE) technologies. Image exploitation workstations need ATR capabilities (detection, discrimination, classification, and identification (ID)) to aid analysts and targeting platforms to reduce the volume of data and increase targeting performance. Developing these ATR capabilities would allow the DoD community take advantage of the ever-increasing presence of exploitable imagery obtained through multiple layered sensing platforms ranging from high altitude surveillance (satellite, Global Hawk, etc.) to low and ground level surveillance (security cameras, street cameras, small unmanned air vehicles (UAVs), etc.). The new ATR algorithm suite would provide cues from upstream LF, wide-area, low resolution image source (i.e., panchromatic satellite imagery), and pass information such as geo-location to a close-in, high resolution, EO sensor/platform (i.e., Reaper video) to accomplish tracking, and ID ATR capabilities and facilitate targeting. Existing and emerging SE capabilities depend upon quality imagery to develop sensor specific target signatures to ensure robust algorithm performance and provide performance bounds for the operators. Also, to maximize the performance of SE technologies, different state-of-the-art (SOA) techniques in signal and image processing as well as methods to enhance image registration quality are needed to improve the usefulness of low quality LF data.

PHASE I: Develop innovative algorithms suite to cue potential target areas from LF imagery ISR assets to reduce downstream data volume, reduce false alarm rates, and improve ID of a broad range of targets. Investigate LF imagery for quality, quantity, and availability, to determine feasibility for ATR.

PHASE II: Mature algorithms to ingest cued areas and automatically track/ID targets from exploited LF data. Research image/signal processing techniques used to enhance the usability of low-quality/resolution image data. Analyze and determine possible transition partners. Develop a set of test and evaluation criteria for the algorithm. Demonstrate the algorithm suite's tech readiness and capability.

DUAL USE COMMERCIALIZATION: Military application: Detection, discrimination, classification, and ID technologies will be directly applicable to all tactical, strategic, and reconnaissance DoD systems employing LF ISR system. Commercial application: Commercial mapping companies have the same problems with disparate formats and large databases. They would benefit from the application of this technology.

REFERENCES: 1. Y. Bar-Shalom (ed.), Multitarget-Multisensor Tracking:Applications and Advances, vol. 2, Artech House, Norwood, MA, 1992.

2. A. Koltunov, J. Koltunov, and E. Ben-Dor, "Adaptive Recognition Under Static and Dynamic Environment Assumptions," in Algorithms and Techniques for Multispectral, Hyperspectral, and Ultraspectral Imagery IX, Proc. SPIE 5093, Aerosense-2003 Symposium (Orlando, FL), April 21 - 25, 2003

KEYWORDS: ATR, sensing, targeting

AF073-077 TITLE: <u>Enhancing Trust via End-node Security in SensorWeb Decision Support Systems</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative security solutions extending to the end-nodes of collaborative sensor networks to improve trust in decision support systems.

DESCRIPTION: The commercial and defense sectors are increasingly using sensor webs and sensor grids for daily operations. Within the defense establishment, the global information grid (GIG) will provide the global connectivity for net-centric operations to get the right information in the right format to the warfighter at the right time. The migration to net-centric operations has highlighted the need for increased security and trust management.

The goal of security is to reduce the likelihood of successful exploitation of our information systems by reducing the accessibility of critical intellectual property (IP), the susceptibility of the software or data protection to exploitation, and the threat capability effectiveness. Next-generation layered sensor webs [1] and distributed decision support systems will necessitate advanced secure communication and protection that extend to the end-nodes of the network to ensure trustworthy operation. New and innovative research is needed in developing IP-centric security solutions that extend to sensor elements that may be forward deployed into hostile territory, where compromises are likely to occur. For decision makers to trust the data gathered, synthesized, and communicated by each sensor element or set of elements, software protection and anti-tamper technologies must be integrated with multi-spectral (electro-optic/infrared/radar/acoustic) sensors, and provide seamless operation in a heterogeneous network environment. The goal of this topic is to conduct research and development related to extending trust to the end-nodes of a sensor web. The researcher should consider development of situational aware autonomous trusted sensor systems that: (1) have characteristics of self-awareness, self-protection, and self-healing; (2) allow remote forensic interrogation and assessment of sensor elements to ensure trustworthiness; and (3) integrate software anti-tamper technology with sensor nodes to reduce threat accessibility, sensor system susceptibility, and threat capability effectiveness. Proposed solutions should also allow secure collaboration between sensor nodes (i.e., machine-to-machine collaboration), as well as between sensor systems and decision makers (i.e., machine-to-human collaboration). Collaborative secure sensor webs could be created from heterogeneous sensor and human resources for autonomic decision support.

PHASE I: 1. Develop innovative concepts for incorporating robust security solutions into the end-nodes of a sensor web.
2. Provide design and architecture documents that describe the concept and demonstrate feasibility of the key enabling concepts.

PHASE II: 1. Design, develop, and demonstrate a prototype that implements the Phase I concepts for integrated software protection/anti-tamper technology with electro-optic/infrared/radar/acoustic sensors and secure collaboration.
2. Provide test and evaluation results demonstrating the ability to defend against exploitation from attackers who have obtained both logical and physical access to sensors.

DUAL USE COMMERCIALIZATION: Military application: Sensors are ubiquitous devices with many military/commercial applications. Technology that extends trust to the end-nodes of a sensor network can be applied to intra and inter-theatre sensor systems. Commercial application: Trusted sensor systems and networks can also be applied to financial, health care, homeland security, and other commercial systems.

REFERENCES: 1. Sensor Web, Wiki, http://en.wikipedia.org/wiki/Sensor_Web

2. http://www.research.ibm.com/autonomic

3. Dr. Mikhail J. Atallah, Eric D. Bryant, and Dr. Martin R. Stytz, "A Survey of Anti-Tamper Technologies," http://www.stsc.hill.af.mil/crossTalk/2004/11/0411Atallah.pdf

KEYWORDS: sensor web, global information grid, software protection, anti tamper, autonomic, trusted computing, sensor grid

AF073-078 TITLE: <u>Technology Enablers for Layered Sensing</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop and demonstrate key technological enablers for effective layered sensing to optimally employ Intelligence, Surveillance, Reconnaissance (ISR) sensors and platforms.

DESCRIPTION: Over the last several decades, the U.S. military has developed a wide variety of new sensor and platform types along with much of the infrastructure necessary to exploit the resultant data. Taken together, these assets form a "layered sensing" architecture. Bringing together the pieces of this architecture to form a working system, effective in a highly dynamic battlespace has yet to be achieved. Lost opportunities during recent military operations have demonstrated this; Our ability to acquire, process, analyze, and propagate actionable data with sufficient speed and accuracy remains inadequate. This is due to critical shortfalls in several automation technologies that, once addressed, could enable an integrated and synchronized ISR enterprise with tailored operations.

This effort seeks key advancements in three enabling technology areas: (1) Sensor Resource Management to provide automated routing, mode management, and sensor cross-cueing to optimize the use of available resources. Current technology has been unable to rapidly produce solutions which can fully and effectively leverage all sensors, while scaling up to the combinatorics of the problem.
(2) Geolocation/Georegistration methods and algorithms to accurately fix objects/events in time and space through knowledge of platform and sensor position, velocity and time. Current technology has not been able to effectively accommodate dissimilar phenomonologies, nor adequately deal with diverse platform error sources and arbitrary imaging geometries while rapidly producing solutions. (3) Intelligent Bandwidth Compression to provide maximum benefit from available communication networks. Current technology has not proven robust and adaptable enough to deal with network faults, surge in communication demand, and to consider military context, as well as numerous other challenges presented by real operations. Proposals should address at least one of these areas.

Some of the desired attributes of an operationally effective layered sensing system include (1) fully leveraging phenomenological diversity (as an example, fusion of radar and electro-optic systems) (2) timely and self-organizing operation to enable getting the best possible information to the right place at the right time, (3) All-weather, all condition operation, (4) intrinsic integration into ground operations, and (5) an ability to support the most challenging battlefield sensing tasks such as extremely high-confidence identification (ID), urban operations, and camouflaged, concealed, and deception (CC&D) targets.

PHASE I: Identify a representative military surveillance and targeting mission and the sensory assets utilized. Model system components/controls to facilitate concept validation. Develop and demonstrate algorithmic methods using simulations. Analyze test results and determine technical feasibility.

PHASE II: Improve fidelity of 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.

DUAL USE COMMERCIALIZATION: Military application: The U.S. military has developed new sensor and platform types and the infrastructure needed to exploit the resultant data. Our ability to disperse actionable data to the field remains inadequate. Commercial application: Diverse sensing applications (e.g., surveillance, manufacturing, and traffic control) have experienced rapid growth. Technology would be applicable to law enforcement and commerical security systems.

REFERENCES: 1. D. Hall and Llinas, J (Eds.), Handbook of Multisensor Data Fusion, CRC Press, 2001.

2. Y. Bar-Shalom (ed.), Multitarget-Multisensor Tracking:Applications and Advances, vol. 2, Artech House, Norwood, MA, 1992.

3. C. Papadimitriou, Steiglitz, K, Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, Englewood Cliffs, NJ, 1982.

4. T. Ibaraki, Katoh, N., Resource Allocation Problems: Algorithmic Approaches, The MIT Press, Cambridge, MA, 1988.

KEYWORDS: layered sensing, persistent surveillance, sensor resource management, georegistration/geolocation, intelligent bandwidth compression

AF073-079 TITLE: Reconfigurable Subaperturing for Endo-clutter Processing

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop and demonstrate an innovative approach for dynamically configuring an array antenna's subaperture architecture for enhanced endo-clutter processing.

DESCRIPTION: Conduct research to define, develop, and demonstrate a dynamically alterable array subaperture architecture. This effort will investigate the potential for enhanced endo-clutter processing with a capability to dynamically reconfigure subaperture architecture so as to maintain optimal target detection and clutter-plus-interference rejection performance while operating in complex signal environments. Knowledge-based processing has significantly improved moving detectable velocity in radar systems, however knowledge-based space-time adaptive processing (STAP) has a limitation in that the optimal result in a localized maxima is due to a fixed subaperturing scheme. Rather than hardwiring an array antenna in a fixed design, it is desirable to have subaperture configurations that are adaptable to changes in mission, scenario, and environment. Indeed, the subapertures can be overdesigned to compensate for changing mission requirements; however, this results in exponential increase in processor requirements. Radar system operations can be significantly impacted by the number of subapertures employed as well as their size, configuration, and degree-of-overlap. This topic is aimed at the development of a radar aperture in which subapertures can be reconfigured on the fly based on sensing of targets and environments. For instance, a target can be passing through a benign clutter area where, for example, six subapertures configured azimuthally are adequate to meet moving detectable velocity (MDV) requirements, and then the target enters an area where discretes exist. This situation could easily be resolved maintaining the target MDV by increasing the number of subapertures (and STAP channels). The larger number of subapertures would only be maintained for the time period that the target is in close proximity to the discretes so that a fixed processor throughput would result in only a small increase in processing latency until the subapertures were again reduced to the more benign clutter environment. It is expected that changes in any implemented subaperturing scheme would be impacted by measured signal-to-interference-plus-noise ratios (SINR), signal processing requirements, array time-energy management restriction and operational priorities, as well as physical hardware constraints.

PHASE I: Conduct research to define a dynamically alterable array subaperture architecture. Deliverables shall include 1) Phase I Design Research Plan, 2) Technical Report of Phase I Research Results, 3) Phase II Implementation Plan, to include Preliminary Design of a prototype device for Phase II testing.

PHASE II: Develop a subaperture architecture design for demonstrating the ability to dynamically alter and control subaperture reconfiguration as a function of changes in measured SINR. Finalize design of the prototype device and perform Phase II testing: 1) Technical Report of the demonstration results and 2) Marketing Plan for Phase III dual use applications.

DUAL USE COMMERCIALIZATION: Military application: Potential military applications of this design concept would include ground surveillance from military aircraft radar. Commercial application: Potential commercial applications include commercial aircraft radar, and commercial wireless broadcast systems.

REFERENCES: 1. Van Trees, Harry L., "Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory", Wiley and Sons Inc., New York, 2002.

2. Melvin, William L. "A STAP Overview." IEEE A&E Systems Magazine, vol. 19.1, 2004, pp. 19-35.

3. Sensors Directorate. http://www.wpafb.af.mil/afrl/sn/

KEYWORDS: endo-clutter, reconfigurable subapertures, STAP, SINR, moving detectable velocity (MDV)

AF073-080 TITLE: Managing Uncertainty in Anticipatory Exploitation

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics

OBJECTIVE: Anticipation of target behavior will impact the ability to manage resources, detect anomalous behavior, and prosecute targets. The effort will develop techniques to account for/manage uncertainties.

DESCRIPTION: Anticipation of target behavior will have enormous impact on the Air Force's ability to manage sensor and other resources, detect anomalous behavior, command operations tempo, and prosecute targets. Anticipation relies on behavior models, which contain errors and known uncertainty, as well as automated exploitation, which contains errors and may contain representations of uncertainty. This effort develops anticipation techniques that account for and manage these uncertainties as they anticipate target behavior. The effort develops a prototype anticipation algorithm that explicitly models/measures uncertainty in its input (behavior models and exploitation) and propagates this uncertainty to its output.

This effort will begin with development of a model of traffic through an intersection that depends on a variety of parameters including factors that are known (e.g. time of day), estimable (e.g. weather), and unknown (e.g. special events). Civilian vehicle traffic, observed through the developers choice of sensor will be tracked, and reliability will be measured, both with and without access to the traffic model. Observations and conclusions will drive ways in which the tracking algorithms employ the model and contend with its uncertainty or errors. Experimentation is encouraged and will drive further development. Next step will be to expand the traffic model to a larger area, and employ techniques learned in the smaller scenario, to drive sensor management with the traffic model to optimize the tracker's ability to continuously track civilian vehicles of interest.

PHASE I: Develop an algorithm/system, potentially including a traffic model tracker and sensor manager, to automatically anticipate/monitor moving ground vehicle behavior. Uncertainty in input will be propagated through the system. Prototype will contain all algorithm and model components needed for validation.

PHASE II: Effort will refine and expand the behavior model and anticipation algorithm to improve performance and more accurately capture uncertainties. The anticipation algorithm will drive sensor management to maintain track on the selected vehicles.

DUAL USE COMMERCIALIZATION: Military application: Unmanned aerial vehicle tracking of ground targets for an extended period in urban environments. Commercial application: Traffic monitoring and law enforcement

REFERENCES: 1. "Knowledge-Base Application to Ground Moving Target Detection," AFRL-SN-RS-TR-2001-185 (ADA 395956), 2001.

2. A. Koltunov, J. Koltunov, and E. Ben-Dor, "Adaptive Recognition Under Static and Dynamic Environment Assumptions," in Algorithms and Techniques for Multispectral, Hyperspectral, and Ultraspectral Imagery IX, Proc. SPIE 5093, Aerosense-2003 Symposium (Orlando, FL), April 21 - 25, 2003.

3. Y. Bar-Shalom, and X. Li, Estimation and Tracking: Principles, Techniques and Software, Artech House, Boston, MA, 1993. Reprinted by YBS Publishing, 1998.

KEYWORDS: Managing uncertainty, sensor management, multiple target tracking, feature aided tracking, behavior modeling

AF073-081 TITLE: Anticipating Emergent Threat Propensity using Human/Machine Perceptual Sensing

TECHNOLOGY AREAS: Sensors, Electronics, Human Systems

OBJECTIVE: Research and develop integrated perceptual sensing technologies that help focus Command and Control (C2) operators' attention on salient cues that anticipate emergent threats.

DESCRIPTION: The evolution of Intelligence, Surveillance and Reconnaissance (ISR) technologies and their integration into network centric operations has resulted in information overload for the warfighter. In the commercial sector, a similar increase in distributed, sensor-rich applications has sparked an explosion of available data to decision makers. C2ISR operators themselves are faced with increasing data on the floor from sensing and information systems while searching across the electromagnetic, cyberspace, and intelligence spectrums for stealthy adversaries. Currently, no integrating system or architecture exists that focuses these sensing systems on the operators' most critical information needs because the strategic intent of commanders is not well coupled to the human-computer-sensing subsystems that assist in carrying out that intent. For significant data reduction without harm to decision support, perceptive sensing capabilities are required. Such acute attention-focusing systems would integrate the commander's strategic intent with tactics and with the current context of operation, including an understanding of the behavioral, cultural, environmental, and economic contexts of the theater of operations.

The overarching purpose of this topic is that Commander's intent should be combined with situation and context information to produce relevant maps of the propensity for emergent threats. This combination of intent cues with context may require some novel interplay of humans in the loop with algorithms from the social, sensor and information sciences. To select the appropriate algorithms the research team should consider using an interdisciplinary, hybrid human/machine approach exploiting a critical path subset of the following competencies: reinforcement learning; Bayesian; Markov decision processes; artificial neural networks; cognitive modeling of perception; naturalistic decision making; judgment and decision making; knowledge elicitation and presentation; human computer interaction; collaborative knowledge management; integrated theories of information including perception, cognition and human action; information fusion; cross-domain knowledge synthesis for prediction; the theory of situation awareness; other decision sciences; multi-source pattern and behavior recognition; persistent and layered multi-sensor intelligence, surveillance, and reconnaissance (ISR); dynamic sensor management; distributed multi-source sensor fusion; and vigilant sensing control and processing.

The research team should consider combining only those competencies that are needed to create a novel affective/perceptive sensing system that feels out the environment for propensity of emergent threat activities to focus decision makers' attention within the battlespace. Perception provides judgment and feedback about operations in a theater that may be relevant, salient, and key to an operator's interest, which distinguishes it from merely sensing everything in the battle space.

The researcher should consider methodologies that address standard interdisciplinary research protocols such as those of a synthetic task environment including 1) analyzing the job environment; 2) constructing a laboratory prototype; 3) creating functional scenarios; 4) benchmarking the prototype with real operators; and 5) challenging and assessing the science and technology. Researchers should consider representing the battlespace as a layered sensor grid including ground, air, space, and cyberspace. 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. The research team should consider describing their functional architecture compliant with DoDAF Systems View 1.

PHASE I: Phase I activity shall include: Design man/machine architecture combining sensing, information, and cognitive technologies to aid perception of emerging threats; exploit strategic intent, cultural context, and layered sensors; storyboard a proof-of-principle prototype exploiting the architecture.

PHASE II: The researcher shall develop/demo a prototype implementing the Phase I architecture and technologies to show ability for anticipation and shaping of emergent threat situations; a linkage of two or more levels of strategic/tactical intent; a fusing of two or more sensing layers from ground to space; and a use of broader salient context information. The researcher shall detail the Phase III plan.

DUAL USE COMMERCIALIZATION: Military application: The desired product is a human-in-the-loop sensing system to aid decision makers in Command, Control, Intelligence, Surveillance and Reconnaissance (C2ISR) in the perception of emerging threats. Commercial application: This system would benefit any application reducing information overload from complex and dynamic contexts employing diverse sensor inputs (e.g., mobile robots sensing chem/bio threats (ref 5)).

REFERENCES: 1. M. Talbert and G. Seetharaman, "When Sensor Webs Start Being Taken Seriously…," Proceedings of the IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing (SUTC '06), Taichung, Taiwan. June 2006.

2. S.K. Rogers, M. Kabrisky, K. Bauer, and M. Oxley "Computing Machinery and Intelligence Amplification," Computational Intelligence, The Experts Speak (Chapter 3)," New Jersey: IEEE Press, 2003.

3. Paul W. Phister Jr., and John D. Cherry, "Knowledge centric operations: Implications to future command and control," IEEE Aerospace Conference Proceedings, Vol. 2005, p. 1559707, 2005.

4. Jeremy M. Wolfe, “Moving towards solutions to some enduring controversies in visual search,” Trends in Cognitive Sciences, Vol. 7, No. 2, Feb 1, 2003, pp. 70-76.

5. “SensorNet prototype system in boot camp at Fort Bragg,” Department of Energy, Oakridge National Laboratory,, http://www.ornl.gov/info/press_releases/get_press_release.cfm?ReleaseNumber=mr20060215-00

KEYWORDS: Surveillance, Human/Machine Sensing, Decision Aids

AF073-082 TITLE: Vertically Integrated Sensing, Tracking, and Attack (VISTA)

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: This effort will develop performance-driven collaborative system control algorithms for exploiting a layered architecture of sensors to rapidly and precisely collaboratively sense and seek.

DESCRIPTION: Past and current adversaries have conceded open-field force-on-force dominance to U.S. military forces. This dominance is largely due to rapid decision-making and precise strike capabilities. Consequently, adversaries are resorting to elusive and deceptive tactics meant to reduce their vulnerability. These tactics have resulted in targets operating increasingly in various forms of concealment, whether under trees, or by attempting to merge into noncombatant urban traffic. This tactic typically allows enemy combatants to hide in plain sight under the “cloak of the urban fog”. The focus of this topic is the novel integration of sensors and seekers, from space to surface, to extend the aforementioned rapid and precise dominance to the urban battlefield with the aid of advanced human-on-the-loop command and control (C2) technologies. In order to effectively prosecute strategic targets in tactical timelines, sensor and seeker systems must operate together, within a collaborative framework, and must be able to smoothly transition from collaborative intelligence, surveillance, and reconnaissance (ISR) sensing to collaborative seeking (using the same sensors and long-loiter sighted weapon systems). This will involve collaborative system control of a space sensor (such as spaced-based radar), a standoff sensor (such as a Global Hawk with Synthetic Aperture Radar), a close-in sensor (such as a small Unmanned Aerial Vehicle with an Electro-Optic/Ladar sensor), and a loitering sighted weapon system (such as a Predator with an Infrared sensor and missile). We shall principally consider high-value terrorist targets operating elusively within civilian vehicles. Effective control must be anchored in a first principles understanding of key sensor, platform, target, and environmental phenomenologies and characteristics.

The goal of this effort is to develop innovative sensor and seeker control, processing, and exploitation algorithms that lead to highly coordinated sensing and seeking against a wide range of urban targets, to include dismounts and operating in complex urban environments. The current state-of-the-art in several required component technology areas is unable to meet this challenge. For example Geolocation/Georegistration technology is unable to register images across different sensor modalities and viewing angles in real-time. Feature-Extraction algorithms cannot adequately perform high-confidence association across different sensor modalities. Resource Management technology cannot re-compute near optimal solutions at any arbitrary point in the mission, as battlefield events might dictate.

Suggested scenarios might involve highly reliable reports from the field that a high value target has been sighted. Since no air assets are within range, a tactical satellite is launched to provide overwatch to prevent escape until a number of long-loiter air assets arrives over the area a couple hours later. One of them launches several long-loiter smart weapons to aid in the search. Some of these, in turn, drop unattended ground sensors (UGS) from close in. At this point, the integrated team of sensors and seekers are conducting collaborative ISR until target has been re-acquired and identified with enough confidence for the system to transition to the collaborative strike phase.

Candidate focus areas for collaborative system control include:
1) Layered detection and tracking
2) Robust false alarm performance
3) High-confidence ID
4) Precision target location.

PHASE I: Develop approach, design, and algorithms to demonstrate collaborative system control to vertically integrate sensing, tracking, and attack. Identify trade space issues for vehicle and dismount tracking. Design experiments and demonstrate utility of prototype. Identify data and methods.

PHASE II: Develop the algorithms identified, conduct performance analysis. Demonstrate ability, via experiments and simulations, to improve operation against time-critical, high-dismount targets operating in urban environments.

DUAL USE COMMERCIALIZATION: Military application: A wide array of potential applications exist in theater for exploiting this capability.

COMMERCIAL APPLICATION: A wide array of potential applications exist, including law enforcement, border patrol, and counterterrorism surveillance.

REFERENCES: 1. D. Hall (ed.), Llinas, J (ed.), Handbook of Multisensor Data Fusion, CRC Press, 2001

2. Y. Bar-Shalom (ed.), Multitarget-Multisensor Tracking:Applications and Advances, Vol. 2, Artech House, Norwood,MA, 1992.

3. C. Papadimitriou, Steiglitz, K, Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, Englewood Cliffs, NJ, 1982.

4. T. Ibaraki, Katoh, N, Resource Allocation Problems: Algorithmic Approaches, The MIT Press, Cambridge, MA, 1988.

KEYWORDS: collaborative system control, space, remote sensors, small UAVs, loitering, smart weapons, UGS, human-on-the-loop C2.

AF073-083 TITLE: Polarization Selective Infrared Detection

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop new nanoscale polarization structures that support passive spectral and polarization sensing at infrared wavelengths without external components.

DESCRIPTION: The performance and operational feasibility of passive spectral and polarimetric imaging sensors in the thermal infrared (nominally 2 to 14 micron wavelengths) would be greatly enhanced by the ability to perform the spectral and polarization filtering within the detector elements or pixels, as opposed to using external means such as, polarizers and filters. This topic is intended to explore new nanoscale material structures, such as metallic or semiconductor nanoparticles, that offer the possibility of achieving the needed polarization sensitivity (100:1 extinction ratio) and tunability for future remote sensors with the selectivity performed inherently by the material absorption or transmission characteristics. Extracting the relative intensities of more than one polarization angle is a key area of interest. It is further intended to explore means for both spatial (lateral and along the growth direction) and electrical control of the fundamental detector properties in order to ultimately obtain spatially and/or temporally tunable devices.

PHASE I: Develop new nanoscale material constructs that support polarimetric tunability for infrared wavelengths between 2 and 14 µm. Perform theoretical and analytical modeling of the material structures to estimate the expected sensitivity and selectivity potential. Experiment the key device concepts.

PHASE II: Fully design and fabricate polarization agile infrared detector array devices. Perform thorough device characterization, compare to model predictions, and resolve discrepancies. If possible, mate the detector array with a readout integrated circuit and perform a sensor demonstration and evaluation.

DUAL USE COMMERCIALIZATION: Military application: This technology has the potential for use in a wide range of military remote sensing applications, including geology, agriculture, surveillance, disaster relief, and drug law enforcement. Commercial application: This technology has the potential for use in a wide range of civilian remote sensing applications, including geology, agriculture, surveillance, disaster relief, and drug law enforcement.

REFERENCES: 1. R. Gordon et al., “Strong Polarization in the Optical Transmission through Elliptical Nanohole Arrays,” Phys. Rev. Letters, Vol. 92, pp. 037401-1 to 4 (2004).
2. H. Mertens et al., “Polarization-selective Plasmon-enhanced Silicon Quantum-dot Luminescence,” Nano Letters, Vol. 6, pp. 2622-2625 (2006).
3. D. Kim et al., “Imaging multispectral polarimetric sensor: single-pixel design, fabrication, and characterization,” Applied Optics, Vol. 42, pp. 3756-3764 (July 2003).

KEYWORDS: polarization, plasmons, infrared detectors

AF073-084 TITLE: Actively Excited Bio-Taggant Sensor

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Human Systems

OBJECTIVE: Investigate methods for detecting, identifying, and tracking objects coated with bio-taggant materials based on active laser excitation and concurrently capturing resulting emission signature.

DESCRIPTION: In support of a range of defense and homeland security missions, the Air Force is investigating the use of specialized taggant materials to aid in the detection, identification, and tracking of higher priority threats, such as those related to terrorist networks and weapons of mass destruction. Recent research has explored the use of biological materials that exhibit fluorescent or phosphorescent characteristics with unique spectral emission characteristics when probed with laser radiation in particular wavelength bands. While most materials of this nature are probed in the ultraviolet or blue spectral region and emit in the visible spectrum, advanced materials are being developed that are both probed and emit in the infrared region. As an example, consider emission in the 650- to 1200- nm spectral region when probed with nominally 10- to 100- mW laser radiation at somewhat short wavelengths. Such materials are of specific interest since they may support more covert tagging, tracking, and locating operations.

The focus of this effort is to explore remote sensing concepts for the detection, identification, and tracking of objects coated with these specialized bio-taggant materials to support a range of possible defense and homeland security missions. Priority will be given to airborne operation at ranges from 100 m (from small unmanned aerial vehicle platforms) to 5 km (from larger aircraft), although deployment in a ground-based setting (e.g., vehicle portals) is also of interest. It is envisioned that the sensor research and development project will be performed in close conjunction with parallel bio-taggant development and signature characterization projects currently being undertaken by the Air Force, such that the ultimate sensor characteristics will be optimally matched to those of the taggant materials. A key concern of this project is the effective discrimination of small amounts of bio-taggant material amidst a complex urban background with a diverse range of materials.

PHASE I: Design a bio-taggant sensor system capable of detecting, identifying, and tracking objects coated with bio-taggant material in complex environments. Develop a sensor model and predict sensor performance for several deployment possibilities. Perform laboratory experiments for key sensing concepts.

PHASE II: Refine the baseline concept into a tailored airborne sensor design for specific bio-taggant materials of interest to the Air Force. Fabricate and assemble a prototype sensor and perform a thorough laboratory characterization to support the sensor performance predictions. Perform an airborne or ground-based demonstration at targeted operating ranges

DUAL USE COMMERCIALIZATION: Military application: tagging, tracking, and locating; homeland security Commercial application: This technology can support commercial applications in security monitoring as well as material handling and tracking. Biomedical applications are also a possibility.

REFERENCES: 1. Jia, Dongdong, et al. , "Synthesis and Characterization of YAG:CE^3+ LED Nanophosphors" in Journal of Electrochemical Society, 154 , available electronically 6 Nov 2006.

2. Ballou,Byron; Langerholm, B. Christopher; Ernst, Luaren; Bruchez,Marcel; and Waggoner, Alan. "Noninvasive Imaging of Quantum Dots in Mice", Bioconjugate Chem, 2004 pp79-86.

3. A. Koltunov, J. Koltunov, and E. Ben-Dor, "Adaptive Recognition Under Static and Dynamic Environment Assumptions," in Algorithms and Techniques for Multispectral, Hyperspectral, and Ultraspectral Imagery IX, Proc. SPIE 5093, Aerosense-2003 Symposium (Orlando, FL), April 21 - 25, 2003.

KEYWORDS: biological taggant, fluorescence sensing, target detection, tracking

AF073-086 TITLE: Store Trajectory Response to Unsteady Aerodynamic Loads

TECHNOLOGY AREAS: Air Platform, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop analytical tool/process for quantifying unsteady aerodynamics effects on weapon separation trajectory, Demonstrate significance of unsteady flow effects

OBJECTIVE: Investigate the effect of unsteady aerodynamic loading on store separation trajectories and develop an analysis procedure to assess susceptibility of store trajectory deviations due to unsteady flow.

DESCRIPTION: Trends in modern weapon design (both powered and nonpowered) have pushed stores toward neutral aerodynamic stability, to enhance glide time, etc. This trend, as well as the use of folding fins for packing efficiency has made some stores, under certain release conditions (including release with fins folded), susceptible to unsteady flows. In particular, this problem has been observed in several free drop wind tunnel tests and in computational fluid dynamics (CFD) simulations involving release from internal weapons bays. Wind tunnel observation suggests a variation in ejector force between tests, but repeated measurements of this force have eliminated this as the cause. In addition, the use of highly resolved, time-accurate CFD to simulate store free drop also eliminates ejector variation as the cause. This susceptibility to unsteady weapons bay flow manifests as dramatically different store trajectories, for identical releases under identical mean aerodynamic (Mach, Reynolds number, etc.) conditions. It is currently impossible to ascertain whether or not this type of susceptibility has ever occurred in flight, since the information required for this type of proof has never been collected. A conclusive demonstration that unsteady flow can be a significant factor in the store separation trajectory is sought.

The traditional path to store clearance involves the use of time-averaged forces and moments, collected from wind tunnel experiments or CFD. These averaged loads are used to step through a trajectory, utilizing a 6-degree of freedom (6DOF) analysis. The comparison of time-averaged CFD with time-averaged wind tunnel data is usually deemed sufficient proof that it is safe to proceed to full-scale flight test. The potential problem with this approach is that it is unable to detect those deviant cases which might be sensitive to time-dependent aerodynamic loads. Additionally, even if unsteady flow were to be identified as the culprit in a separation incident, neither CFD nor store separation wind tunnel testing currently has the ability to adequately analyze the problem. The typical solution to this dilemma is to restrict the delivery envelop of the aircraft/store combination in question. Testing and modeling techniques that incorporate unsteady flow effects are sought.

It is currently too expensive to utilize high-fidelity, time-accurate CFD to simulate a large number of release times relative to the unsteady periodic aerodynamic forcing to detect a potential problem. What is required instead is a methodology to identify those specific types of store/parent aircraft combinations which are susceptible and to focus the extensive time accurate release studies there. This will allow the bulk of the store release cases to be processed with the more cost-effective, time-averaged approach, while ensuring that no high-risk store separation cases have inadvertently slipped through the process. In addition, the process of studying the high-risk cases will potentially allow for a new technique which times store release for the most beneficial trajectory.

PHASE I: Identify aircraft weapons bay - store combinations susceptible to store separation bifurcations due to unsteady flow. Conceptualize and design innovative approaches to model unsteady flow effects, develop a strategy to include effects in the store certification process, and plan verification testing

PHASE II: Pursue development of conceptual models and execute verification testing. Compile results to develop a procedure/tool to identify high-risk separation cases. Demonstrate model use in the store certification process on a modern combat aircraft weapons bay configuration. Suggest techniques for timing the store release event based on real-time measurements to expand the deployment envelop.

DUAL USE COMMERCIALIZATION: Military application: Any aircraft (fighter, bomber, unmanned) that carry weapons or fuel tanks. Unsteady flow and moving surface technology can be applied to control surface, turbine engine, and flow control design. Commercial application: Potential rocket stage separation, weather sensor deployment, search & rescue systems analysis, and rapid package delivery system for humanitarian and business critical items to remote locations.

REFERENCES: 1. Coleman, L.A., "F-111/Small Smart Bomb Trajectory Predictions for Safe Separation Analysis using Computational Fluid Dynamics," Aircraft-Stores Compatibility Symposium, March 5 - 8, 2001.

2. Johnson, R.A., Stanek, M.J., and Grove, J. E., "Store Separation Trajectory Deviations Due to Unsteady Weapons Bay Aerodynamics," The Dayton-Cincinnati Aerospace Sciences Symposium, Dayton, OH, March 6, 2007.

3. Arnold, R.J.and Epstein, C.S., "AGARD Flight Test Techniques Series. Volume 5. Store Separation Flight Testing," AGARD-AG-300-VOL-5, Advisory Group for Aerospace Research And Development, Neuilly-Sur-Seine, France, Apr 1986. Available online from DTIC, ADA171301.

4. Jacob A. Freeman, Joseph M. Keen, and Bruce A. Jolly, "Quick-Reaction" Computational Fluid Dynamics Support of Aircraft-Store Compatibility," presentation slides 19-24, ITEA Aircraft Store Compatibility Symposium, FT Walton Beach, FL, April 11-13, 2006.

5. Jordan, J.K. and Denny, A.G., "Approximation Methods for Computational Trajectory Predictions of a Store Released from a Bay," AIAA-1997-2201, Applied Aerodynamics Conference, Atlanta, GA, June 1997.

KEYWORDS: store separation, unsteady store loads, weapons bay, store trajectory

AF073-087 TITLE: Enhanced Acoustical Environment for Modern Weapons Bays

TECHNOLOGY AREAS: Air Platform, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop acoustic suppression techniques and hardware for nonrectangular aircraft weapons bays

OBJECTIVE: Develop lightweight acoustic suppression options for modern, nonrectangular weapons bays that can be easily integrated onto developmental and existing aircraft.

DESCRIPTION: Transonic/supersonic fighter-bombers which utilize open cavities to dispense weapons are subject to cavity acoustic resonance. This phenomenon produces high-amplitude acoustic levels which can exceed the specifications to which armament carried within the bay has been qualified. In spite of the increased use of modern analysis tools, such as computational fluid dynamics (CFD), in the design process, the ability to accurately predict this resonance phenomena and the accompanying severe environment is still limited. This margin of error and the potential for damage motivates a need for innovative, non-obtrusive, light weight flow control schemes which can adapt to the modern weapon bay integration environment.

Historically acoustic levels (overall sound pressure levels) in simple rectangular weapons bays without flow control devices have been known to be as high as 170 dB in the transonic flight regime. This is sufficient to cause structural damage to both the aircraft and weapon. Suppressed bay levels of 150 dB are considered a desirable goal. Traditionally, leading edge spoilers have been used in nominally rectangular weapons bays for acoustic suppression, and these devices have performed adequately over limited Mach numbers. Within the past 10 years, a number of new, innovative approaches have emerged which extend good suppression performance to supersonic conditions.

In this effort our focus is shifted to nonrectangular weapons bays reminiscent of modern fighter aircraft in order to establish modern flow control technology applicability. The challenge is to adapt or develop new suppression techniques for modern bays which have non-rectangular volumes, multiple sweep angles at the cavity leading and trailing edges, protrusions of aircraft bulkheads into the bay, electrical conduits, and significant bay depth variation from both side to side and leading to trailing edge (see representative weapons bay picture in reference 4).

Weight, volume, support, maintenance, cost, etc., and possible effects on store separation must all be considered in successful approaches. The Air Force will provide relevant representative geometry to successful bidders under this topic.

PHASE I: Define requirements for an initial concept demonstration. In general, offerors will, in a laboratory environment, demonstrate a reduction in acoustic levels (as high as 170dB to as low as 150dB) using suppression concepts on the Air Force provided weapons bay geometry in the Mach range 0.6 -1.6.

PHASE II: Using a trade study with results from Phase I, down select to preferred suppression concept. Provide plans for full-scale integration using Air Force supplied aircraft information. Develop full-scale acoustic suppression hardware, with the required analysis, for a potential flight test demonstration. Aircraft Mach range and suppression goal remains the same.

DUAL USE COMMERCIALIZATION: Military application: Matured weapons bay acoustic suppression options will impact future weapon systems design and can be retrofit on existing platforms to extend lifecycles and expand weapon deployment envelop. Commercial application: Acoustic reduction flow control application includes landing gear bays and jet engine noise reduction (airport noise). Automotive applications include fuel injectors and passenger cabin wind noise.

REFERENCES: 1. Colonius, T., “An Overview of Simulation, Modeling, and Active Control of Flow/Acoustic Resonance in Open Cavities,” AIAA-2001-0076.

2. Cattafesta, L.N. III, et al., “Review of Active Control of Flow-Induced Cavity Resonance,” AIAA-2003-3567.

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4. Warwick, G. and Norris, G. "JSF special: Moving on up," Flight International, 27/06/06, available at: http://www.flightglobal.com/articles/2006/06/27/207392/jsf-special-moving-on-up.html

KEYWORDS: weapons bay, flow control, acoustic suppression

AF073-088 TITLE: Innovative Structural Concepts for Deep-Winged Large Transports

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop and demonstrate an innovative, weight-efficient structural wing design concept for a future deep-winged large transport.

DESCRIPTION: In this effort, unconventional and innovative design concepts are sought that would be applicable for the next-generation mobility transport. New and emerging materials and structural concepts offer promise for more structurally efficient designs for deep-winged, large transport structure. One such design concept is a nonorthogonal substructure system attached to the wing skins. The wing skins and the substructure system may be metallic and/or composite materials. The substructure system to the wing skins attachment may be with few or no mechanical fasteners; bonding is an alternative.

PHASE I: Design and analyze innovative structural concepts applicable to wings of large transport structures. Utilize emerging materials and manufacturing techniques as well as those currently in use.

PHASE II: Select the wing design design concept that leads to the most weight-efficient and cost-effective approach. Design a structural component, and manufacture and test the article to verify the concept. Establish the weight and cost for the concept.

DUAL USE COMMERCIALIZATION: Military application: The structural technology developed will be applicable to large transports and other military vehicles. Commercial application: Commercial airliners and military transports have similar loading requirements, and thus the technology generated will be applicable to each class.

REFERENCES: 1. Harold G. Bush, Martin M. Mikulas, Jr., and Walter L. Heard, Jr., "Some Design Considerations for Large Space Structures," AIAA Journal, Vol.16, N.4, AIAA/ASME 18th, Structures, Structural Dynamics, and Materials Conference, San Diego, California, March 21-23, 1977

2. Deepak S. Ramrkahani, George A. Lesieutre, Mary Frecker and Smita Bharti, "Aircraft Structural Morphing using Tendon Actuated Compliant Cellular Trusses," 45th AIAA/ASME/AHS/ASC Structures, Structural Dynamics & Materials Conference 19-22 April 2004, Palm Springs, California

KEYWORDS: transport wing, nonorthogonal structures, truss structures, metallic structures, composite structures

AF073-089 TITLE: Autonomous Control Technologies for Terminal Area Operations

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Develop an autonomous control technology solution for unmanned aerial vehicle (UAV) terminal area operations and demonstrate performance in simulated operations.

DESCRIPTION: The Air Vehicles Directorate (AFRL/VA) is currently interested in autonomous control technologies that will enable fixed-wing unmanned aerial systems (UAS) to integrate seamlessly with manned aircraft in the terminal area of operations (TAO). TAOs include ground operations and operations in the terminal airspace while in contact with either tower control, approach control, or departure control. This area is an especially congested environment for aircraft an atmosphere that is time critical, detail sensitive, and conducive to task saturation. Increased automation has the potential to reduce operator workload and improve UAS response time, making it possible for UAS to act like manned aircraft. Thus, the development of control technologies that enable unmanned systems to operate autonomously in the terminal area is critical to the successful integration of manned and unmanned systems.

The goal of this topic is to pursue innovative solutions to the technical problems associated with UAS operations in the terminal area environment. Specifically, the problems of interest for this solicitation are centered on communication with Air Traffic Control (ATC), runway identification and visual-based landing, and airspace deconfliction in high-traffic areas, as described below. All UAS operations in the terminal area will be man-in-the-loop, where the UAS will not require any input from the operator, but the operator will be able to intervene at any time.

o ATC Communication: Unmanned aircraft must be able to interact with ATC to receive instructions and convey intent. Most air traffic instructions today are communicated via radio transmissions, but time-delay presents a problem for UASs because of the detached operator. Therefore, unmanned aircraft must be able to interact autonomously with ATC in order to emulate the responsiveness of manned aircraft.

o Visual-Based Approach/Landing: Pilots are able to recognize airport features and identify runways from high altitudes using very simple drawings as reference. To emulate manned operations, especially in the absence of global positioning satellite (GPS), unmanned aircraft need to be capable of recognizing and interpreting airport features and runways when on approach and when on station in a terminal area.

o Deconfliction in a Congested Environment: As stated, the TOA is an especially congested environment, demanding timely execution of many complex tasks. Deconfliction should maintain the sense of a safe operating environment by ensuring appropriate separation between aircraft well before a collision is imminent. Methods of autonomous control are needed to emulate manned systems to ensure safe and timely operations while in this high-traffic area. Possible technology areas that could address this problem are command acceptance and execution of holding patterns, obstacle avoidance in the TAO airspace, and cooperative control in the case of multiple unmanned systems in the same airspace.

PHASE I: Identify and define technologies necessary to address one or more of the technical challenges presented. It is envisioned the Phase I demonstration will consist of computer modeling, analysis, and simulation of the proposed solution at a level of fidelity necessary to clearly assess its feasibility.

PHASE II: Develop prototype systems and evaluate their performance through high-fidelity computer or hardware-in-the-loop simulation. It is envisioned that hardware development will be a major component of this effort, ultimately leading to ground and/or flight test of the proposed solution. Also conduct a preliminary evaluation of the system's producibility, maintainability, and commercial viability.

DUAL USE COMMERCIALIZATION: Military application: This technology would apply to any military UAV that intends to operate in the terminal area (with or without GPS availability). Commercial application: This technology applies to any commercial UAV that intends to operate in the terminal area in conjunction with other manned or unmanned air vehicles.

REFERENCES: 1. FAA Order 7610.4, available at http://www.faa.gov, 2006.

2. Order 7110.10, Flight Services, available at http://www.faa.gov/atpubs/FSS/INDEX.HTM, 2006

3. Order 7110.65, Air Traffic Control, available at http://www.faa.gov/atpubs/ATC/index.htm, 2006

KEYWORDS: UAS, UAV, terminal area, airfield, autonomous, deconfliction, communication

AF073-090 TITLE: Towards a Systematic Approach for Micro Air Vehicles (MAVs) Flight-Enabling Technologies

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop flight-suitable enabling technologies for non-fixed-wing micro air vehicles (MAVs).

DESCRIPTION: The ultimate promise and practical significance of MAVs rests on the twin pillars of robustness of the vehicle and usefulness of the payload. Towards the latter, some progress can be obtained by applications of miniaturization and distributed sensing as these technologies evolve in other disciplines, some completely unrelated to aeronautics. Towards the former, efforts have focused on unsteady low-Reynolds number aerodynamics to populate the knowledge base of fundamental aerosciences on which successful MAV design would depend. Because of its inherent complexity and the present ambiguity of the engineering problem statement, this work remains immature, especially in terms of “biomimetic” study of bird/bat/insect flight for possible MAV exploitation. Progress is predicated less on development of technologies per se, than on maturity of fundamental mechanics of fluids and structures in the academic sense.

While payload (sensor, communications, data processing, etc.) and aerodynamics (gust response, vorticity transport and lift/thrust production for flapping wings, aeroelastic interactions for flexible and/or flapping wings, etc.) evolve, there is a complementary need to develop systematic tools bridging the two areas by engineering-level analysis. Vehicle stability and control, handling qualities assessment, airframe efficiency estimation, airframe-sensor integration and propulsion integration are examples of established disciplines in conventional unmanned air vehicles (UAV) design, as part of the usual design cycle from conceptualization through detail design. These in turn enable optimization and engineering system trades, completing the loop with requirements specification. Especially at the conceptual level, the approach is usually numerical. In the context of MAVs, such methodology is tenuous at best, and that only for fixed-wing MAVs. For rotary-wing and especially for flapping-wing MAVs, the vehicle designer is left to empiricism. It then becomes difficult to transition research in the fundamental aerodynamics, and to systematically incorporate advances in payload technologies.

One pressing area for MAV modeling and simulation is development of MAV flight dynamics models based on rigorous state-space representation (or alternatives) that can sufficiently describe the vehicle dynamics, with uncertainties in aerodynamic and structural models, at a level suitable for optimization.

The present philosophy is to pursue technology development in the middle ground between fundamental physics (vorticity transport and the like) and near-term demonstration (flight test of an empirically-evolved configuration), in particular departing from the rubric of downscaling fixed-wing aircraft or rotorcraft to fit the usual size definitions of MAVs. In so doing, the engineering maturity of MAV design will approach the level already demonstrated more conventional larger UAVs.

PHASE I: Conceptualize a multiphysics (aerodynamics, structures, flight mechanics, controls) simulation environment for low-level analysis enabling exploration of micro air vehicle design trade space. Propose model validation schemes for Phase II.

PHASE II: Demonstrate the simulation environment from Phase I relative to existing fixed-wing and flapping-wing MAVs. Compare estimates of stability derivatives, airframe and propulsion performance with results of wind tunnel and/or flight test. Integrate simulation environment with modern optimization tools. Deliverables should include analysis and design methods, and not specific vehicles.

DUAL USE COMMERCIALIZATION: Military application: Besides the typical applications for MAVs (reconnaissance/surveillance, tagging), the multidisciplinary aerodynamics/materials/controls modeling covers a broad range of military systems. Commercial application: Applications include surveillance and sampling in austere environments and industrial monitoring missions.

REFERENCES: 1. Mueller, T., Kellogg, J., Ifju, P., and Shkarayev, S. "Introduction to the Design of Fixed-Wing Micro Air Vehicles, Including Three Case Studies." AIAA, AIAA Education Series, 2007.

2. Sane, S.P. "The Aerodynamics of Insect Flight." J. Exp. Bio., Vol. 206, pp. 4191-4208, October 2003

KEYWORDS: MAV, micro air vehicle, flexible wing, gust alleviation, flapping wing, aeroelastic, flight control, autopilots, flight testing, miniaturization, modeling and simulation

AF073-091 TITLE: High-Speed Airbreathing Propulsion Integration

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop rapid design/analysis/testing methods for hypersonic inlet/exhaust systems (Mach 4-15), including combined-cycle engines for upper-stage launch vehicle, cruise missile, and aircraft apps.

DESCRIPTION: (Military) Air Force interest in operationally responsive space access and prompt global strike capabilities has driven a need for new technologies that will provide increased payload, faster response times, and lower operations costs. Air vehicle propulsion systems that combine conventional turbine or rocket propulsion systems with advanced hypersonic airbreathing propulsion concepts (e.g., dual-mode scramjets) have been proposed as a means to achieve these payoffs.

(Technical Challenges) Hypersonic aero-propulsion systems (including dual-mode scramjets and CCEs) are characterized by high Mach gas flows through a "flowpath" that includes vehicle forebody/aftbody surfaces, and multiple internal ducts connecting air intake and exhaust elements of the propulsion system. Interaction of high Mach gases with the flowpath generates fluid dynamic phenomenon and interactions including shock waves, shear layers, vortices, and separated flows, which are influenced by thermochemical behavior of high-temperature air and combustion products.

Close coupling between air vehicle aerodynamic surfaces and propulsion flowpath requires the designs of each be performed concurrently. However, the wide range of length and time scales, and physical processes associated with highly-integrated aero-propulsion configurations promote design, analysis, and test methods that are time consuming and expensive. A key technical challenge that must be addressed to enable hypersonic aero-propulsion systems is rapid design, analysis, and test of airframe-integrated inlets and nozzles at steady-state and transient conditions.

(State of the Art) Current hypersonic design tools enable parametric vehicle and trajectory design, but are limited to streamline-traced inlet and exhaust system designs and don't possess multiple flowpath design capability required for combined-cycle configurations. The ability to use methods other than streamline tracing or to mix multiple design methods are not in current design tools.

Wind tunnel models tested in high enthalpy flow are constructed out of heat treated stainless steel or titanium or inconel. Models tested for short duration in a shock tunnel may be constructed out of aluminum. These models, depending on their complexity and the lead-time required for materials, can take up to 4 months to fabricate without excessive cost.. Stereolithography can be used to fabricate wind tunnel models tested in low speed flows, but these models cannot withstand high temperature test conditions or typical starting loads of hypersonic test facilities.

Specific technical objectives of this topic are the following:

1. Develop rapid and flexible configuration design and analysis software for hypersonic aero-propulsion systems. Extend existing air vehicle conceptual design and analysis software to include optimization of integrated external aerodynamic configurations with external and internal inlet and nozzle flowpaths. Include capability to model and analyze configurations with multiple internal flowpath ducts, and apply multiple inlet and nozzle design methodologies.

2. Develop rapid prototyping and test technologies to reduce the time/cost associated with fabricating/testing conceptual inlet and nozzle configurations. Develop and extend existing rapid prototyping technologies to enable:

a. Testing at high dynamic pressures/temperatures associated with operation of hypersonic aero-propulsion systems.

b. Integrated test model instrumentation and diagnostics to reduce test model setup and installation times. Examples include, but are not limited to, spray-on applications and integrated circuitry lay up techniques.

PHASE I: Develop preliminary design tool / modify tool to handle hypersonic aeropropulsion (multiple flow paths, etc). Apply tool to representative combined-cycle air-vehicle concept. Develop new rapid prototype system with built-in instrumentation. Build candidate robust, rapid prototype test article.

PHASE II: Expand matrix of test cases/features for new design tool. Perform parametric sweep to demonstrate optimization ability. Incorporate advanced tool improvements based upon initial use. Integrate with high-fidelity analysis to iterate design. Test low-cost, robust, high load/high temp rapid prototype test article at relevant operating conditions. Improve prototype technique based on results.

DUAL USE COMMERCIALIZATION: Military Application: Operationally responsive space access (rapid turn-around, inexpensive launch for satellites and other payloads). Prompt global strike for time-sensitive targets.

Commercial Application: Reduced-cost satellite launch/recovery. New inexpensive rapid design techniques. Rapid prototyping with embedded sensors for health monitoring/maintenance.

REFERENCES: 1. Escher, W.J.D., and Flornes, B.J., “A Study of Composite Propulsion Systems for Advanced Launch Vehicle Applications,” The Marquardt Corporation, Report No. 25194, Final Report under NASA Contract NAS 7-377 (Vols. 1 through 7), September 1966.

2. Heiser, W. H., and Pratt, D.T., Hypersonic Airbreathing Propulsion, AIAA Education Series, American Institute of Aeronautics and Astronautics, Washington, DC, 1994.

3. Murthy, S.N.B., and Curran, E.T., (eds.), High-Speed Flight Propulsion Systems, AIAA Progress in Astronautics and Aeronautics Series, Vol. 137, Washington, DC, 1991.

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5. Holden, M. “Historical Review of Experimental Studies and Prediction Methods to Describe Laminar and Turbulent Shock Wave / Boundary Layer Interactions in Hypersonic Flows.” AIAA-2006-494, January 2006.

KEYWORDS: hypersonic, combined cycle, propulsion integration, inlet, nozzle, mode transition, shock-boundary layer interaction, shock-shock interaction

AF073-093 TITLE: Pre-processing Algorithms for Exploitation of Remotely Sensed Optical Spectral Imagery for Automated Target Recognition/Cueing and Multi-INT Fusion

TECHNOLOGY AREAS: Information Systems, Battlespace

STATEMENT OF INTENT: Develop innovative algorithms to pre-process optical spectral imagery for processing and exploitation detection, characterization, identification and multi-INT fusion techniques to optimize ATR/ATC.

OBJECTIVE: Develop innovative algorithms to pre-process optical spectral imagery for processing and exploitation detection, characterization, identification and multi-INT fusion techniques to optimize ATR/ATC.

DESCRIPTION: The Spectral Surveillance Technologies Section of the Air Force Research Laboratory's Battlespace Surveillance Innovation Center is interested in innovative pre-processing techniques to optimize the performance of optical spectral (visible and infrared) remote-sensing/stand-off detection systems. Optimization requires the development of advanced algorithms to exploit target-to-background contrast phenomenology. Measurements have been conducted from visible and infrared airborne and space-based optical sensors to characterize the optical properties of the environment. It is expected that the proposal will exploit this data to explore pre-processing techniques for enhanced target detection. It is also expected that new algorithms will be devised and tested. Figures of merit used to assess algorithm effectiveness include improvements in material detection, identification and characterization, and an enhanced probability of detection with reduced false-alarm rates. PAYOFF/WARFIGHTER IMPACT: Algorithms developed in this SBIR effort will result in enhanced detection of targets in backgrounds with reduced false-alarm rates as compared with the current state of the art.

PHASE I: Explore pre-processing approaches to enhance target-to-background contrast to optimize target detection in structured environments. Demonstrate the feasibility of the approaches.

PHASE II: Perform analyses and demonstrate efficacy of algorithms for target. Assess, validate and optimize the algorithms. Develop and demonstrate automated, NRT, processing using real-world data sets.

DUAL USE COMMERCIALIZATION: Military application: Military application:Algorithms and processing techniques will be useful in military systems requiring autonomous stand-off target detection, characterization and identification of targets. Commercial application: Commercial examples of autonomous detection include pre-processing systems for application in fields such as medicine, industrial processing and quality control.

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2. Howes, D. J., P. E. Clare, W. J. Oxford, and S. Murphy, "Endmember Selection Techniques for Improved Spectral Unmixing," Proceedings of SPIE, Volume 5425, p. 65-76, August 2004.

3. Gruninger, J. H., A. J. Ratkowski, and Michael L. Hoke, "The Extension of Endmember Extraction to Multispectral Scenes," Proceedings of SPIE, Volume 5425, p. 15-30, August 2004.

4. Liu, Y., and G. E. Healey, "Using Nonparametric Distribution Estimates for Sub-pixel Detection of 3D Objects," Proceedings of SPIE, Volume 5425, p. 91-96, August 2004.

5. Bajorski, P., E. J. Ientilucci, and J. R. Schott, "Comparison of Basis-Vector Selection Methods for Target and Background Subspaces as Applied to Sub-pixel Target Detection," Proceedings of SPIE, Volume 5425, p. 77-90, August 2004.

KEYWORDS: Remote sensing/standoff detection, pre-processing algorithms, multispectral/hyperspectral imaging, adaptive data-processing algorithm(s) (for:) autonomous/automated/automatic target detection/recognition/cueing, target-to-background contrast enhancement, target signature enhancement, background signature suppression, clutter mitigation/suppression

AF073-094 TITLE: Design-Hardened Radiation Tolerant Microelectronics

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: Develop a Radiation Hardened by Design integrated circuit technology with performance and cost superior to Radiation Hardened By Process.

OBJECTIVE: Develop a Radiation Hardened By Design integrated circuit technology with performance and cost superior to Radiation Hardened By Process.

DESCRIPTION: Microelectronic components used on satellites are exposed to radiation effects, which threaten mission performance and duration, and frequently cause system designers to implement costly and difficult-to-validate redundancy. With transistor and circuit sizes shrinking, single event effects are becoming increasingly problematic. Transistor leakage currents caused by ionizing radiation also remain a problem, and reliability over long space mission lifetimes is a concern. The traditional approach of process modification for radiation hardness (Radiation Hardening by Process, or RHBP) is subject to low volume issues such as high unit costs, process stability and yield problems, and difficulty in financing technology upgrades. An alternative approach to RHBP at a specialized foundry is Radiation Hardening By Design (RHBD)at a commercial foundry. In this approach, radiation hardness, extended temperature range, and assured reliability (perhaps including embedded reliability monitors) are achieved through optimization of circuit design and architecture, allowing fabrication on one or more standard commercial process lines. Both RHBP and RHBD impose performance and capability penalties when compared to commercial integrated circuits. The purpose of this topic is to develop and demonstrate innovative transistor and/or circuit improvements that can be implemented in commercial fabrication facilities, which enable advances over state-of-the-art in radiation effects hardening, reliability, and extended operating temperatures. There is a premium on "optimal" approaches, defined as aproaches that introduce minimal impact on size of layout, power consumption, and electrical performance over indigenous libraries. Portability, the ability to migrate rapidly to alternative foundries and newly developed processes, is another desired property, since library development is expensive and time-consuming. Because the objective of the topic is to increase the capability available to space avionics system developers, the ability of the proposer to show a viable path to commercialization is a key discriminator. A wide variety of proposed approaches are encouraged for this topic.

PHASE I: Show through analysis and/or hardware demonstration that key technology developments or adaptations can benefit space computer systems. Develop initial concepts and designs for products and describe a strategy for making a product available for developers.

PHASE II: Finalize detail design, prototype and validate Phase I solutions.

DUAL USE COMMERCIALIZATION: Military application: Future military systems need huge leaps in the ability to acquire, process, and distribute information. Greatly increased microelectronic capabilities are key to meeting that need. (ISR, Comm) Commercial application: Potential customers are microelectronics applications in most commercial and DoD space vehicles. Other applications include microelectronics application close to a reactor, or in medical devices.

REFERENCES: 1. Lacoe, R., D. Mayer, J. Osborn and S. Brown, “New Strategies for Radiation Hard Electronics,” 2001 MRQW, December 11, 2001.

2. Gambles, J. W., K. J. Hass, S. R. Whitaker, “Radiation Hardness of Ultra Low Power CMOS VLSI,” 11th Annual NASA Symposium on VLSI Design, May 28-29, 2003.

3. Lacoe, R., Osborne, Brown, and Mayer, “Application of hardness by design methodology to radiation-tolerant ASIC technologies,” IEEE Trans. Nuc. Science, 47, December 2000.

KEYWORDS: Radiation Hardened, Radiation Tolerance, RHBD, RHBP, Radiation Hardened CMOS, Radiation Hardened Integrated Circuits

AF073-095 TITLE: Radiation Resistant Solar Cell Coverglass Adhesives

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop innovative solar cell coverglass bonding technologies and/or materials with increased resistance to the space environment.

OBJECTIVE: Develop innovative solar cell coverglass bonding technologies and/or materials with increased resistance to the space environment.

DESCRIPTION: The End-of-Life (EOL) performance of space power solar arrays could be improved with the use of innovative coverglass adhesives that exhibit enhanced resistance to combined effects of the space environment including electron, proton and ultraviolet (UV) radiation. The development of radiation resistant adhesives has not been a primary focus of the military or commercial space community. Research efforts are normally focused on the solar cell coverglass or other components, but not on the bonding techniques or adhesive materials. The coverglass adhesive (DC-93500) presently used to bond coverglass to solar cells has not changed since the 1960’s. Coverglass is typically doped to mitigate radiation induced darkening effects and protect the bonding adhesive from ultraviolet exposure. This solicitation is pursuing novel materials or innovative processes for adhering coverglass to multijunction solar cells. Possible approaches include direct bonding of coverglass, development of new adhesives, or replacement of traditional coverglass with new material. Materials and adhesives must demonstrate increased resistance to electron, proton and UV radiation while maintaining a high degree of transmissivity over the solar spectrum used by solar cells.

Present state-of-the-art (SOA) technology uses DC-93500 adhesive, which darkens when exposed to ultraviolet radiation. Thus, the coverglass and or coverglass coatings must include ultraviolet filtering to protect the cover glass adhesive. Advanced multijunction solar cells, which will have 4 to 6 junctions, will increase the bandwidth for usable incident sunlight into the infrared and ultraviolet parts of the solar spectrum. Therefore, to take advantage of these new solar cell technologies, a new adhesive system will be required. Offerors should propose development concepts that can achieve an operational service-life threshold goal of 15 years in geosynchronous earth orbit (GEO), with the objective goal of 15 years in medium earth orbit (MEO), with no more than 3% transmission degradation for a broadband bandwidth between 400nm to 2000nm.

PHASE I: Develop and validate innovative technologies for solar cell coverglass adhesive with increased radiation resistance, combined with broadband transmission. Demonstrate technology on small area solar cell. Identify key technology challenges and provide a viable mitigation strategy.

PHASE II: Optimize the coverglass adhesive material properties for solar cells. Establish metrics including resistance to particle and UV radiation and broadband transmission. Characterize mechanisms of degradation and provide detailed model to predict mission performance. Fabricate adhesive material and perform preliminary environmental testing to demonstrate performance.

DUAL USE COMMERCIALIZATION: Military application: This technology is applicable to military satellites and is enabling for higher radiation orbits. EOL power improvements enabled by this technology will have broad application.
Commercial application: EOL power generation will be enhanced for commercial satellites through the use of the proposed technology, especially for higher radiation operational environments.

REFERENCES: 1. Brandhorst, Henry W., Joseph D. Lichtenhan, Bruce X. Fu, "A POSS® Coating for Thin Film Solar Cells and Concentrator Lenses," 31st IEEE PVSC, p. 778, Orlando, FL, January 2005.

2. Aiken, D. J., "High Performance Anti-Reflection Coatings for Broadband Multi-Junction Solar Cells," Solar Energy Materials & Solar Cells, 64, p. 393-404, 2000.

3. Walters, Robert J., Jeffrey H. Warner, Geoffrey P. Summers, Scott R. Messenger, Justin R. Lorentzen, "Radiation Response Mechanisms in Multijunction III-V Space Solar Cells," 31st IEEE PVSC, p. 542, Orlando, FL, January 2005.

KEYWORDS: Solar Cell Cover Glass Adhesive, Coating Deposition Technologies, Solar Arrays, Optical Properties, Radiation Environments, Multijunction Solar Cells

AF073-096 TITLE: Advanced Lithium Ion Batteries for Space Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop a lithium ion battery terminal seal that is corrosion-resistant and capable of twenty years of service life in a space environment.

OBJECTIVE: Develop a lithium ion battery terminal seal that is corrosion-resistant and capable of twenty years service life in a space environment.

DESCRIPTION: Battery terminal seals are one of the life limiting components that will ultimately limit the service life of lithium ion batteries. Lithium ion batteries hold the potential of increasing the energy density of satellite energy storage systems over conventional nickel hydrogen batteries by at least a factor of two. The service life for space lithium ion batteries, which includes mission life and storage periods, is twenty years.

The terminal seals for cells in these batteries must provide electrical isolation for the terminal, be compatible with the cell electrolyte and remain hermetic throughout the service life. Presently, battery terminal seals developed primarily for commercial lithium ion batteries are not designed for a twenty-year service life. Thus, there is a technology shortfall in battery terminal seals for lithium ion batteries that can provide the required twenty-year service life.

The goal of this technology development is to design, develop and validate a hermetic terminal seal for space rated lithium ion battery cells that provides electrical isolation for the terminal, is compatible with the cell electrolyte and is capable of a twenty-year service life required for DoD space systems.

PHASE I: Design, develop and validate innovative approaches for producing a terminal seal for advanced lithium ion space battery cells that will meet the terminal-isolation, hermeticity, electrolyte-compatibility requirements to provide a twenty year service life.

PHASE II: Apply results from Phase I to design and fabricate seals for prototype lithium ion battery cells. Test and evaluate performance of prototype lithium ion battery.

DUAL USE COMMERCIALIZATION: Military application: The availability of lithium ion batteries that would be suitable for LEO and GEO missions with improved energy densities will allow increased power storage capacity.
Commercial application: The proposed lithium ion battery technology will also improve power storage capacities for commercial spacecraft.
REFERENCES: 1. Miyanaga, N., Y. Inoue, H. Yoshida, K. Komada, and M. Goto, “Large Scale Lithium-Ion Battery Cells for Space Use,” The 25th International Telecommunications Energy Conference, p. 241-248, October 2003.

2. Leising, Randolph A., Marcus J. Palazzo, Esther Sans Takeuchi, and Kenneth J. Takeuchi, “Abuse Testing of Lithium-Ion Batteries: Characterization of the Overcharge Reaction of LiCoO2/Graphite Cells,” J. Electrochem. Soc., Volume 148, Issue 8, p. A838-A844, August 2001.

KEYWORDS: batteries, lithium ion, Li-Ion, space power, energy storage, depth-of-discharge, energy density

AF073-097 TITLE: <u>Space Qualified SDRAM Memory</u>

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: Intent is to develop Space qualified SDRAM.

OBJECTIVE: Development of a space-qualified Synchronous Dynamic Random Access Memory (SDRAM) mass storage memory based on commercial semiconductor memory technology.

DESCRIPTION: Radiation hardened memory will be used extensively in future communications satellites for data storage and processing. Current space computer systems use either radiation hardened Static Random Access Memory (SRAM), which is expensive and low-density, or Dynamic Random Access Memory (DRAM) for main memory. Generally, commercial DRAM chips are very soft to total dose, single event effects or are susceptible to latchup, or some combination of the three. In the past, a 1Mb Hitachi DRAM has been the part of choice for space DRAM. Unfortunately, this part is no longer manufactured and no replacement is in sight.

One possible response to this need is redesign or adaptation of a currently manufactured DRAM memory to harden the device to space environmental conditions. The environmental requirements include immunity to destructive latchup, and total ionizing dose tolerance in the 100 krad(Si) or greater range. Single event effects, including single event functional interrupt, should also be considered, although single event upset may also be masked at the system architecture level if upset rates are manageable. Tolerance to even higher radiation levels is desirable, if affordable. Increasing temperature tolerance up to the Mil-Spec temperature range (-55 to 125C) is desirable. Reliability for long-term missions should be addressed. The adaptations proposed should provide greatly increased memory density (closer to the 256Mb and 512Mb parts available commercially) to space computer designers.

Modification of an existing commercial capability is seen as the most plausible approach, although other approaches are possible. Modifications may consist of changes at the transistor level, circuit level, or architectural level. Offerors should not hesitate to propose approaches other than the one laid out in the Phase I and Phase II descriptions below, but should be prepared to explain clearly how their approach will achieve the desired outcome. Since the desired outcome of this project is a commercially available hardened SDRAM, the proposer must be able to show a plausible path to producing and marketing a qualified product. For most small businesses, this could require teaming with a supplier of commercial SDRAMs, where the small business provides environmental hardening expertise which can overlay a basic SDRAM production and marketing capability.

PHASE I: Show through analysis and/or hardware demonstration that key technology developments or adaptations can achieve requirements and enhance capability for many, if not all, space computer systems using SDRAM.

PHASE II: Finalize detail design, prototype and validate Phase I solutions.

DUAL USE COMMERCIALIZATION: Military application: Military space systems need much larger memory capacity than currently available through rad-hard SRAM. Availability of large space qualified SDRAM will enable simpler computer system development. Commercial application: Commercial space systems also require hard memory, but may be even more sensitive to SRAM cost. Extended temperature terrestrial systems are also possible users.

REFERENCES: 1. http://www.webopedia.com/TERM/D/DRAM.htm, Overview of the various flavors of DRAM.

2. Johnston, A. H. "Radiation Effects in Advanced Microelectronic Technologies," IEEE Transactions on Nuclear Science, v. 45, issue 3,3, p. 1339-1354, June 1998.

3. Lacoe, R., Osborne, Brown, and Mayer; “Application of hardness by design methodology to radiation-tolerant ASIC technologies,” IEEE Transactions on Nuclear Science, 47, December 2000.

KEYWORDS: Radiation Hardened SDRAM, Single Event Effects, Total Ionizing Dose, Memory, Access Time, Data Storage

AF073-098 TITLE: Thin Multijunction Solar Cells

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

STATEMENT OF INTENT: Develop radiation-hard thin multijunction solar cells.

OBJECTIVE: Develop and demonstrate radiation-hard thin flexible single-crystal multijunction space solar cells to enable solar array subsystems capable of 1000 W/kg specific power.

DESCRIPTION: Virtually all DoD spacecraft rely on arrays of multijunction solar cells for generation of electrical power. The mass and stowed volume of solar arrays have been reduced over the past decade through the introduction of higher efficiency multijunction solar cells. State-of-the-art solar arrays employ Ge/GaAs/InGaP multijunction (MJ) solar cells grown on single-crystal Ge substrates, with efficiencies approaching 30%. Even with these high efficiencies, the specific power of crystalline-based solar arrays is limited to a maximum value of somewhere between 100 and 200 W/kg. Further increases in crystalline-based cell efficiency will not result in dramatic increases in the specific power of solar array systems without a change in the nature of the solar cells. Substantial increases to specific power are limited because thick single crystal solar cells require a stiff and heavy support structure, which consists of rigid flat honeycomb panels and associated support structures. For thin-film photovoltaics, it has been demonstrated that the specific power of solar arrays can be increased to values approaching 1000 W/kg by depositing flexible thin film solar cells on lightweight substrates such as polymers. However, thin-film solar cells, such as amorphous silicon or CIGS cells, have relatively low solar conversion efficiencies yet high radiation resistance, which results in array sizes that are two to three times as large as conventional crystalline-based solar arrays that use multijunction solar cells, except in high radiation orbits.

Therefore, the Air Force is interested in the development of a solar cell concept that combines the best attributes of crystalline and thin-film solar cells to achieve the specific power capabilities of thin-film photovoltaics within a solar array system that utilizes high efficiency multijunction crystalline solar cells. The Air Force is expecting to receive a range of development strategies since there are many innovative approaches that could be proposed to meet this goal. One potential strategy is to work with existing 30+% crystalline multijunction cell technology and focus the development effort on the solar cell thinning methodology and the bonding process onto a flexible substrate. The offeror must validate that their proposed solar cell concept is scaleable and thereby enables the production of solar array subsystems with a minimum specific power capability of 1000 W/kg in a space environment.

PHASE I: Develop innovative approaches to produce thin multijunction solar cells compatible with a lightweight array structure. Identify technical challenges, propose mitigation strategies, and demonstrate proof-of-concept.

PHASE II: Design, demonstrate, and characterize an innovative approach to produce thin multijunction solar cells, and deliver a scaleable prototype solar array demonstrating 1000 W/kg specific power.

DUAL USE COMMERCIALIZATION: Military application: All DoD spacecraft use multijunction space solar cells for electric power generation. Solar arrays with specific power of 1000 W/kg will increase the power producing capability of military spacecraft. Commercial application: Commercial spacecraft will also benefit from dramatically higher specific power, providing industry with a much better economic value for their power generation needs.

REFERENCES: 1. Law, D. C., C. M. Fetzer, R. R. King, P. C. Colter, H. Yoon, T. D. Isshiki, K. M. Edmondson, N. H. Karam, M. Haddad, "Multijunction Solar Cells with Subcell Materials Highly Lattice-Mismatched to Germanium," 31st IEEE PVSC, p. 575, Orlando, FL, January 2005.

2. Wanlass, Mark W., J. F. Geisz, Sarah Kurtz, R. J. Wehrer, B. Wernsman, S. P. Ahrenkiel, R. K. Ahrenkiel, D. S. Albin, J. J. Carapella, A. Duba, T. Moriaty, "Lattice-Mismatched Approaches for High Performance III-V Photovoltaic Energy," 31st IEEE PVSC, p. 530, Orlando, FL, January 2005.

3. Takamoto, Tatsuya, T. Agui, H. Washio, N. Takahashi, K. Nakamura, O. Anzawa, M. Kaneiwa, K. Kamimura, Kouji Okamoto, Masafumi Yamaguchi, "Future Development of InGaP/(In)GaAs Based Multijunction Solar Cells," 31st IEEE PVSC, p. 519, Orlando, FL, January 2005.

KEYWORDS: High-Efficiency Solar Cells, Thin Multijunction Solar Cells, Space Power, Solar Arrays

AF073-099 TITLE: Ultra-Dense Three-Dimensional Electronics for Space

TECHNOLOGY AREAS: Sensors, Space Platforms

OBJECTIVE: Develop innovative electronics components and systems that exploit extended planar (2.5-D) and true 3-D connections between elements at a monolithic, multichip, and system level.

DESCRIPTION: It is well known that the transistor count per area doubles every 18 months on an integrated circuit chip, a trend referred to as “Moore’s Law.” By a rough consensus, the industry projects the end of Moore’s Law by the end of the next decade. If we could translate the benefits of 2-D integrated circuits into the third (vertical) dimension, it may be possible to extend Moore’s Law to the year 2060, opening with it a new frontier of dramatic possibilities in missile and space systems.

In space, we have more pressing incentives to find an answer, as radiation-hardened electronics suffers from a two-generation penalty due to the need for special processes or design approaches. In order to close this gap, creative methods for advanced packaging, in particular 3-D approaches, could provide an answer. Three-dimensional packaging research is not a new idea. Generically, the approaches include 3-D integrated circuits, densely stacked 2-D integrated circuits employing feedthroughs or perimeter connects, stacked multichip modules (MCMs) and stacked packages. In fact, simple stacking (2-5 chips) is ubiquitous, but is largely based on wirebonding low pincount components within a common package. In order to achieve Moore’s Law-like benefits, we need dramatic interchip bandwidth improvements, potentially thousands of interdie signals. Such approaches have been technologically infeasible until very recently. Vast numbers of interlevel contacts is usually consistent with hyperthinning die (i.e., <25 um). In this program, we seek extremely aggressive packaging and compatible architectures that exploit the dense packaging. The application domain of interest is space, where this pursuit is complicated by radiation effects in space systems.

PHASE I: In Phase I, we seek imaginative but practical means to dramatically increase the density and performance of systems through 3-D integration. The approaches can include schemes such as monolithic 3-D IC fabrication and post-lamination/fusion of 2-D IC plies into a 3-D arrangement. Phase I must establish the efficacy of building high-yield assemblies through modeling, simulation, fabrication with electrically inert components (such as interconnect-only die) or other means to provide a convincing argument to support a Phase II award.

PHASE II: The contractor shall demonstrate practical prototypes of a gigascale (order billion device)-per-cubic-centimeter system, addressing each and every one of the aforementioned fundamental challenges. The prototypes, if not directly useful to a DoD space acquisition program, must clearly trace feasibility to such a program with at least one breakthrough capability not before possible.

DUAL USE COMMERCIALIZATION: Military application: The contractor will seek to transition components to major DoD systems. Commercial application: This work is of great value in high-end telco systems, high-performance computing, and ultra-high-speed imagers and analyzers.

REFERENCES: 1. Kwiatkowski, K., J. C. Lyke, R. Wojnarowski, C. Kapusta, S. Kleinfelder, M. Wilke, “3-D Electronics Interconnect for High-Performance Imaging Detectors,” IEEE Transactions on Nuclear Science, Volume 51, Issue 4, p. 1829 – 1834, August 2004.

2. Lyke, J. C., and K. G. Merkel, "Survey And Taxonomy Of Three-Dimensional Packaging Approaches," Proc. of the AIAA/IEEE 15th Digital Avionics Systems Conference (DASC), Atlanta, GA, October 27-31, 1996, IEEE Press Inc., Piscataway, NJ, vol. A96-45660, p. 139-144, 1996.

3. Abbott, R., Aerospace Conference Proceedings, 2002. IEEE, Volume 5, p. 5-2171 - 5-2176, 2002.

4. Lyke, J., “Multichip and Three-Dimensional Packaging,” Chapter 14 in textbook “Advanced Electronics Packaging,” R.K. Ulrich and W.D. Brown editors, IEEE Press Series on Microelectronic Systems, Piscataway, NJ, second edition, 2006 (ISB-13 978-0-471-46609-X, available at http://www.amazon.com or http://www.ieee.org).

KEYWORDS: radiation effects on electronics, single event effects, single event transients

AF073-100 TITLE: Ultra-Low-Power Radiation-Hard Electronics

TECHNOLOGY AREAS: Electronics, Space Platforms

OBJECTIVE: Develop ultra-low-power, robust electronics that exploit aggressive power reduction and asynchronous design approaches.

DESCRIPTION: The trend in electronics at the component and system level is for ever more increasing density. As electronics devices get smaller they consume less power; but since they are smaller, more of them can be fit into a unit area, and hence the power consumed by an integrated circuit does not necessarily decrease with time. With the advent of two-dimensional multi-chip modules (MCMs) and the increasing interest in three-dimensional MCMs, the power density of a system in area and volume is expected to grow dramatically. Heat density goes up at approximately the same rate as the power density goes up, hence thermal management becomes a paramount factor. Potential solutions include (1) the introduction of various apparatus to improve the heat removal ability of as-built electronics and (2) lowering the power (and heat generation) of the electronic components. While much attention is beginning to be placed on the first approach, relatively little attention has been placed on the reduction of power in electronic components themselves, other than that which comes about naturally through feature size reduction. If semiconductor components/logic devices were built (utilizing an existing process) that consumed five to ten times less power, then the dissipated heat generated would be reduced by a similar factor. The need, therefore, is for innovative solutions that go beyond increased heat removal of as-built electronics, yet minimize the impact on existing semiconductor fabrication processes. On a system level, where millions of such devices would be employed, the savings translates into improved size and weight and therefore cost due to the reduction of power and heat. In some cases, these ultra-low power devices would enable systems to be built that were previously inconceivable due simply to the inability to place all of the components within proximity because of the heat dissipation problem.

With space systems, furthermore, comes the added complexity of the space radiation environment. Low voltage processes may find that threshold voltage shifts and device leakage currents may render ordinary low power design approaches useless. Packaging strategies, such as “tightly coupled MCMs” can provide an architecture where components are united in a controlled impedance environment. Drivers between components can exploit the significantly reduced capacitance and inductance as compared to printed wiring boards. Additional structures and functions can be introduced for level shifting, mitigation of simultaneous switching noise, threshold voltage stabilization (by exploiting body effect of field effect transistors), etc., in a manner transparent to a system designer.

PHASE I: Analyze, design and test electronic components/device and/or device concepts that generate significantly less heat than comparable current devices. The basis/proof of concept for lower power devices that achieve approximate density parity to devices built in the current state-of-the-art must be clearly established through simulation and, if possible, through development or leverage of test device developments.

PHASE II: Demonstrate systems constructed to prove that ultra-low power, high component density device technology is possible. The Phase II systems shall be compared against conventional versions of the same systems to fully quantify the advantages of the proposed approach.

DUAL USE COMMERCIALIZATION: Military application: Military systems benefit from dense packaging of high-performance electronics in a pervasive sensor for surveillance, fusion, protection, and communications applications. Commercial application: Electronic components displaying the attributes of ultra-low power and high component density will be in demand for commercial electronic systems.

REFERENCES: 1. Martin, Alain, and Mika Nystrom, "Asynchronous Techniques for System-on-Chip Design," Proceedings of the IEEE, 94(6), June 2006.

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3. Yun, K.Y.,"Recent Advances in Asynchronous Design Methodologies," Proceedings of the ASP-DAC '99 Design Automation Conference, 18-21 January 1999, Vol. 1, pp. 253 - 259.

KEYWORDS: asynchronous, rad-hard, low-power, electronics

AF073-101 TITLE: Low Cost Deployable Reflector Support Structure

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Develop deployable reflector technologies (up to Ka band) that are lower cost and quicker to manufacture than state-of-the-art mesh systems.

DESCRIPTION: Contemporary space deployed RF reflector antennas typically employ shaped mesh surfaces to focus RF energy. These architectures utilize tensioned cable networks to shape the mesh and, while they have been highly successful, there are inherent limitations to the technology. For example, higher frequency reflectors require more complicated cable networks that do not lend themselves to quick and low cost fabrication techniques. Inflatable thin film reflectors have been investigated as a method to achieve a high frequency solid surface reflector without complex and expensive cable networks. These architectures use an inflation pressure to generate shaping tensions and exhibit related challenges. To lower reflector costs, technology alternatives to tension based mesh and inflatable reflector surfaces have been investigated (e.g. membrane reflectors) and have reached a significant level of maturity. However, precision support structure concepts that enable compact packaging, deployment and thermal dimensional stability of these reflective surfaces are limited and have not been demonstrated. The goal of this topic is to facilitate the development of deployable support structures for RF reflectors based on alternative (tensionless) reflective surfaces.

PHASE I: Increase technical maturity of proposed reflector concept given mission specifications from AFRL. Assess system cost, time to manufacture, deployment reliability, RF performance, mass and packaged volume. Develop manufacturing plan to develop prototype in Phase II. Component hardware tests are encouraged.

PHASE II: Further refine concept and develop prototype(s). Raise concept Technology Readiness Level (TRL). Develop cost and manufacturing models. Conduct testing, provide detailed evaluation report and recommendations. Testing should include deployment, mechanical and thermal load cases, demonstration of component integration and RF performance.

DUAL USE COMMERCIALIZATION: Military application: The envisioned antenna is needed for DoD RF missions requiring low cost and rapid fabrication: communications, signals intelligence, surveillance and broadcasting from orbits ranging from LEO to GEO. Commercial application: The envisioned antenna is needed for commercial RF systems requiring low cost and rapid fabrication: communications, remote sensing and broadcasting from orbits ranging from LEO to GEO.

REFERENCES: 1. Col. Tom Doyne, et. al., "A TacSat and ORS Update Including TacSat-4," AIAA 4th Responsive Space Conference, RS4-2006-4006.

2. de Blonk, B. J., "Membrane Mirrors in Space Telescopes," In Jenkins, C.H.M. (Ed.), "Recent Advances in Gossamer Spacecraft," AIAA Progress in Astronautics and Aeronautics, Vol 212, p. 45-108, 2006.

3. Freeland, R. E., R. G. Helms, and M. M. Mikulas, “The Applicability of Past Innovative Concepts to the Technology for New Extremely Large Space Antenna/Telescope Structures,” 2006 SAE International, 06ICES-224.

KEYWORDS: deployable, structures, radio-frequency, antenna, membrane, reflector

AF073-102 TITLE: Satellite Structures with Engineered or Variable Electomagnetic Properties

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop satellite structures or coatings with engineered or variable electromagnetic properties.

DESCRIPTION: As current satellites achieve ever increasing performance, structural materials must also improve to enable further advancements. However, the improvements required are not purely mechanical; dramatic improvements in the structure’s ability to manipulate and interact with the electromagnetic (EM) spectrum can provide dramatic improvements to satellite system-level performance. What is needed are symbiotic structures that merge advantageous mechanical and electromagnetic properties. Electromagnetic properties of interest include, but are not limited to, transmittance, reflectivity, absorptivity, emissivity and index of refraction. Frequencies of interest include optical, infrared (IR) and microwave spectrums.

The following are examples of how these new structures can break through the limitations of traditional aerospace materials:

- Sunshades that are able to control their reflectivity, absorptivity or index of refraction could reduce their temperatures dramatically, thereby reducing the amount of thermal noise introduced into an IR focal plane.

- Shutters with no moving parts and extremely quick response times can prevent focal planes from becoming saturated if a satellite is inadvertently pointed at the sun. This can be achieved by manipulating any number of electromagnetic properties.

- Phased arrays will have improved performance if surface waves are reduced, "look angles" are expanded and the dielectric is capable of further refining the dispersal pattern via index of refraction modifications.

- Thermal management can be greatly improved if a coating could turn highly reflective in response to solar radiation, or highly emissive when it reached a specific temperature. Also of benefit are materials whose absorptivity, reflectivity and emissivity are controlled via more active methods.

These examples were merely illustrative. It is NOT the intent of this topic to unnecessarily limit the scope to only those given above.

Proposals are expected to address multiple technical areas if they are to be considered for award:

- Integration onto a representative satellite structure. This includes discussion of manufacturing methods and potential degradations of the structure's mechanical performance (when compared to a traditional aerospace material). If it can not be integrated into or onto a satellite structural member, this is not the appropriate topic for the technology.

- Anticipated electromagnetic properties. This includes a discussion of the structure's expected EM properties, controllability/variability of those properties (if applicable), current state-of-the-art, and potential benefits to be derived by implementing these structures on a satellite.

- Modeling capability. The coupling of mechanical and electromagnetic properties can be a daunting task. However, robust models are necessary to successfully transition these structures onto an operational system. Proposals should discuss limitations of current modeling techniques as well as potential solutions and required investment.

PHASE I: Design concept of tailored EM structures. Provide analysis showing limits of EM properties, variability and control method (if applicable) and mechanical properties of symbiotic structure. Develop sub-scale hardware demonstrator and manufacturing plan for Phase II.

PHASE II: Refine concept, develop prototype hardware to AFRL specification. Conduct EM and mechanical testing, provide detailed evaluation report, and recommendations. Testing includes EM and mechanical property characterization, assessments of control methodology (if applicable) and suitability to space environment. Provide AFRL with working prototype.

DUAL USE COMMERCIALIZATION: Military application: AFRL and major satellite programs can procure the technology in order to provide greater performance of their systems. Commercial application: With the proliferation of wireless communications, car-based radar systems, etc., such structures may provide improved performance and greater connectivity to a wide range of potential customers.

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KEYWORDS: Symbiotic Structures, Multifunctional Structures, Electromagnetic Radiation, Optical, Infrared, Microwave, Variable, Engineered Properties, Satellites

AF073-103 TITLE: High Performance Miniaturized Space Weather Instruments

TECHNOLOGY AREAS: Battlespace, Space Platforms

OBJECTIVE: Develop small low power instruments for small and micro satellites.

DESCRIPTION: Small dedicated mission satellites are increasingly seen as viable low cost alternatives to large expensive multi-mission platforms. Satellite size is often limited by instrument size and power requirements. The objective of this topic is to develop new miniaturized instruments that can be flown on small or micro satellites at altitudes of 300-800 km. Either improvements on current techniques or new approaches are acceptable. Respondents are solicited to meet needs for certain types of measurements/instruments. These include: (1) Miniature accelerometer capable of deducing high-accuracy satellite drag and atmospheric winds from a nano-satellite at 300-500 km altitudes. Current accelerometer technology can quantify the non-gravitational forces acting on the spacecraft due to satellite drag and neutral winds; however, present instruments are costly as well as relatively large and heavy. The micro-accelerometer shall be capable of measuring accelerations of 10 nano-g or less in the direction of the velocity vector for satellite drag, and perpendicular to the velocity vector for cross-track neutral winds. (2) Space-based remote monitoring of the neutral winds in the upper atmosphere. Traditional instruments are heavy, large, fragile, and produce data that are difficult to translate into thermospheric parameters. Performance goals are the neutral wind speed and direction to accuracy of 20 m/s at altitudes from 90 to 300 km in the ionosphere under sunlit and nighttime conditions. New concepts including on-board processing of data to yield neutral wind are useful. (3) Sensors for space-based measurements of thermal plasma to measure thermal environment in the ionosphere. The common techniques used to measure such thermal plasma parameters employ analog measurements of electrical current to conducting surfaces, requiring a large and heavy sensor. The miniaturized sensors shall have a mass less than 0.5 kg and an exposed surface or aperture less than 5 cm square.

Successful proposals will demonstrate an understanding of what current spacecraft instruments are available for measuring neutral density, neutral wind or thermal plasma parameters; what physical principles measurements are based upon; what observational values can realistically be obtained; and what the limiting factors on the observation would be (spacecraft attitude, daylight, latitude, energetic particle flux, temperature, spatial gradients, etc.). Successful proposals need to employ innovative methods to improve existing techniques for spacecraft instruments that have reduced weight, size and power in comparison with the currently flown spacecraft instruments. Robustness and durability under spaceflight conditions are critical. Successful proposals are also expected to evidence thorough understanding of the trade-offs between spacecraft motion, integration time, spatial resolution, and signal-to-noise ratios, as well as design features necessary for successful operation in the space environment.

PHASE I: Develop a concept with a detailed design for a low-power, lightweight miniaturized instrument for measuring neutral density, neutral wind, or thermal plasma parameters in the ionosphere, including a detailed formulation relating the measured parameter(s) to the ionospheric quantities.

PHASE II: Produce a functioning engineering prototype for the miniaturized instrument developed in Phase I. Include these tasks: (1) Improve the Phase I design; (2) Perform analyses and calibration to predict the performance, reliability and physical characteristics of production design; and (3) Demonstrate and evaluate the performance.

DUAL USE COMMERCIALIZATION: Military application: Miniaturized sensors on small satellites are essential for future ionospheric specification and forecasting required for communication, navigation, radar ranging, and tracking of objects in space. Commercial application: The space-qualified, miniaturized instrument has many applications in advanced scientific and engineering systems. Accelerometers are used in inertial guidance and airbag deployment systems.

REFERENCES: 1. http://en.wikipedia.org/wiki/Accelerometer, Accelerometer, Wikiepdia

2. Marcos, et. al., "Accuracy of Earth's Thermospheric Neutral Density Models," AIAA 1006-6167, 2006.

3. "Measurement Techniques in Space Plasmas: Particles," Ed by R. F. Pfaff, J. E. Borovsky and D. T. Young, American Geophysical Union, Geophy. Monograph 102, Washington, D.C., 1998.

4. Enloe, et. al., "Miniaturized electrostatic analyzer manufactured using photolithographic etching," Rev. Sci. Instr., 74, 1192, 2003.

5. Harlander, J. M., et. al., "Robust monolithic ultraviolet interferometer for the SHIMMER instrument on STPSat-1," Applied Optics, 42, 2829, 2003.

KEYWORDS: satellite, miniaturized instrument, accelerometer, space weather, neutral density, thermal plasma

AF073-105 TITLE: Just In Time (JIT) Component Presentation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop inventory flow tools based on low volume production processes to meet requirements for Just In Time principles to be integrated into a Manufacturing Repair Overhaul (MRO) environment.

DESCRIPTION: To complete an aircraft repair, components are needed from many different sources. Piece parts, repaired parts, purchased new parts, or FOM (Facilitate Other Maintenance) parts could all be used to make a single repair. Because the parts vary greatly in size, many different types of support equipment and tools could also be used for each repair. Many different factors cause these components to be located elsewhere and transported to the production line in a JIT (Just-In-Time) fashion based on the scheduled workload for each day. Unlike an automotive assembly line where schedules are fixed, precise workload is planned, and neatly organized components are available due to straightforward planning and the fact that all parts are new, there are many uncontrollable variables which impact the aircraft repair process. These factors force short notice schedule changes and/or introduce new requirements that require immediate attention. The coordination and presentation of the repair components (parts, equipment, and tools) are the primary factors limiting the effectiveness of the process. While the JIT concept works well for a dedicated assembly line involving only new components, a new or revised concept of the processes are needed to adapt the JIT component presentation principles to a Manufacturing Repair Overhaul (MRO) environment.

While much research has been conducted on JIT in assembly line processes, there are significant gaps in the research associated with JIT component presentation principles in an MRO setting. The research that has been conducted has focused on large scale production sites and has not focused in detailed component presentation in small batch and one piece flow environments. Any approach to solving the issues must take into account the physical constraints, security protocols, and personnel restriction/limitations. The resulting concepts/processes/tools must be demonstrated with the context of the MRO environment and must follow the strategic, operational, and tactical framework of the DoD depot repair processes.

PHASE I: Research and develop concept demonstration of a Just in Time scheduling tool that can demonstrate planning for the uncertainty and flexibility needed in a low volume MRO environment for delivering needed components, support equipment and facility availability.

PHASE II: Develop a tool to be used by a low volume MRO facility that can be assessed by managers involved in the production lines, shops, and support processes. The demonstration should include integration of concepts/processes/tools in at least two different areas.

DUAL USE COMMERCIALIZATION: Military application: Application to all weapons systems and easily extensible to similar DoD operations. It could have a significant impact on material presentation, efficiencies, and throughput. Commercial application: Process could have a significant impact on material presentation, efficiencies, and throughput. The processes and/or technology selected will reduce costs while increasing throughput.

REFERENCES: 1. Hiroyuki Hirano; Makoto Furuya, “JIT Is Flow: Practice and Principles of Lean Manufacturing”, PCS Press, c2006.

2. John M Nicholas; Avi Soni, “The portal to lean production : principles and practices for doing more with less”, Taylor & Francis, c2006.

3. Hiroyuki Hirano, “Putting 5S to Work”, The PHP Institute of America Inc., c1998.

4. James P. Womack; Daniel T. Jones, “Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Revised and Updated”, Simon & Schuster, c1996.

KEYWORDS: Component Presentation, JIT, Material Flow, Material Staging

AF073-106 TITLE: Penetrant Material Waste Reduction and Process Improvement

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Reduce material waste streams, decrease processing time, and maintenance required for fluorescent penetrant inspection (FPI) processes.

DESCRIPTION: Conversion to water washable penetrants and use of dry powder developers shows promise to improve performance while significantly reducing waste streams by elimination of hydrophilic emulsifier and water based developer. These materials also will reduce equipment maintenance costs and costs associated with process control.

The FPI process is used to identify defects during manufacture and maintenance of aircraft and engine components. Penetrants are oil based liquids containing fluorescent dyes. Penetrants are applied to parts and allowed to dwell long enough to be drawn into part flaws and discontinuities. The excess penetrant must be removed from the part surfaces to provide contrast between the penetrant in the discontinuities and the surrounding part surfaces. The Method D process requires application of a hydrophilic emulsifier to render the oil based penetrant water washable. A water based developer is then applied to the part surfaces, which upon drying draws penetrant from the flaws to enlarge the indications and provide a contrasting background when the part is viewed under black light. This process is used at each depot and at each field base having an NDI laboratory. The emulsifier application represents an additional material that has to be purchased, mixed, maintained and disposed that would not be necessary if water washable penetrants could be used.

The Method D process has been used instead of the Method A because of a long standing belief that Method A penetrants are easily rinsed from flaws and do not have comparable sensitivity. In fact T.O. 33B-1-1 and ASTM E 1417 do not permit use of Method A penetrants on all engine components and critical aircraft components unless specifically approved by cognizant engineering authority. Today Method A penetrants are tested in the laboratory per AMS 2644 and have all the sensitivity levels of the Method D penetrants, and informal tests have shown they are not easily removed by over rinsing. A formal research effort is needed to document the performance of Method A penetrants compared to Method D and the sensitivity to over washing before the use of Method A penetrants can be broadly approved. Such a report would be the basis for permitting use of Method A penetrants..

Secondly, the USAF uses water soluble (form b) and water suspendible (form c) developers instead of dry powder developer (form a). The aqueous developers contain the inert developer plus additives to prevent corrosion, algae growth, and wetting agents. Eventually the aqueous developer tanks have to be cleaned. This may require disposal in drums at some facilities or treatment for disposal. The advantage of the aqueous developers is the inspector can readily see coverage over the part surfaces; however, there is additional maintenance such as checking for penetrant contamination, wettability, and concentration. Form “a” developers can be applied dry with a low pressure spray wand and only need to be checked for contamination and moisture absorption. Dry powder is also used throughout industry. The reputation of form "a" developer has been that it is not as sensitive as form "b" or "c"; however, recent experiments performed informally and while visiting contractor facilities have shown higher sensitivity. A formal research effort is needed to document the performance of form "a" developers over forms "b" and "c", and how to apply and remove a developers in an automated system.

PHASE I: Manufacture set of crack specimen; perform study on potential over rinsing Method A penetrants from crack specimen compared to Method D. Compare performance of form a developer to forms b and c.

PHASE II: Obtain necessary equipment for one water washable line including dry powder developer (spray application) and perform tests verifying capability and submit a completed report of the findings using USAF standard probability of detection crack specimen.

DUAL USE COMMERCIALIZATION: Military application: Results would be used to change specifications and general series technical order to permit use in commercial industry and AF depots and field bases. Commercial application: Results would be used to change specifications and general series technical order to permit use in commercial industry and AF depots and field bases.

REFERENCES: 1. AMS 2644. This standard can be purchased at: http://store.ihs.com/

2. ASTM E 1417 This standard can be purchased at: http://store.ihs.com/

3. T.O. 33B-1-1 available at http://www.tinker.af.mil/shared/media/document/AFD-061220-062.pdf

KEYWORDS: Fluorescent Penetrant Inspection, Method A, Method D, hydrophilic emulsifier, form a, form b, form c

AF073-107 TITLE: Sulfur Hexafluride (SF6) Replacement or Reduction in high voltage switchgear and airborne radar

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Reduce or replace SF6 gas with an alternate material that produces the same or better results without the harmful effects on the environment.

DESCRIPTION: Sulfur Hexafluride (SF6) is the electric power industry's presently preferred gaseous dielectric (besides air) and is present in airborne military radar systems, such as airborne warning and control systems (AWACs) for military radar applications. However, SF6 is also a greenhouse gas with high global warming potential (GWP). SF6 can escape through seals, especially in older equipment, and is vented in airborne radar systems where it then becomes a source of green house gas emissions. The military could possibly substitute with a lower GWP replacement gas or use a mixture of SF6 with another gas such as nitrogen. The military standards currently use pure SF6 and no alternatives have been proposed.

SF6 is a man-made gas. Its basic physical and chemical properties, behavior in various types of gas discharges, and uses by the electric power industry have been broadly investigated. In its normal state, SF6 is chemically inert, non-toxic, non-flammable, non-explosive, and thermally stable. It is a strong electronegative (electron attaching) gas both at room temperature and at temperatures well above ambient, which principally accounts for its high dielectric strength and good arc-interruption properties. The breakdown voltage of SF6 is nearly three times higher than air at atmospheric pressure. Furthermore, it has good heat transfer properties and it readily reforms itself when dissociated under high gas-pressure conditions in an electrical discharge or an arc. Most of its stable decomposition byproducts do not significantly degrade its dielectric strength and are removable by filtering. It produces no polymerization, carbon, or other conductive materials used in electrical equipment at temperatures up to about 200 degrees Celsius. Besides its good insulating and heat transfer properties, SF6 has a relatively high pressure when contained at room temperature. The pressure required to liquefy SF6 at 21 degree C is about 2100 kPa; its boiling point is reasonably low, –63.8 degree C, which allows pressures of 400 kPa to 600 kPa (4 to 6 atmospheres) to be employed in SF6-insulated equipment. It is easily liquefied under pressure at room temperature allowing for compact storage in gas cylinders. It presents no handling problems, is readily available, and up until recently has been reasonably inexpensive. The electric power industry has become familiar and experienced with using SF6 in electrical equipment. However, SF6 has some undesirable properties: it forms highly toxic and corrosive compounds when subjected to electrical discharges (e.g., S2F10, SOF2); nonpolar contaminants (e.g., air, CF4) are not easily removed from it; its breakdown voltage is sensitive to water vapor, conducting particles, and conductor surface roughness; and it exhibits non-ideal gas behavior at the lowest temperatures that can be encountered in the environment, i.e., in cold climatic conditions (about –50 degree C), SF6 becomes partially liquefied at normal operating pressures (400 kPa to 500 kPa). Sulfur hexafluoride is also an efficient infrared (IR) absorber and due to its chemical inertness, is not rapidly removed from the earth's atmosphere. Both of these latter properties make SF6 a potent greenhouse gas, although due to its chemical inertness (and the absence of chlorine or bromine atoms in the SF6 molecule) it is benign with regard to stratospheric ozone depletion.

PHASE I: Build on existing knowledge to research full replacement of SF6 or replace with a lower ratio SF6 mixture to find best method(s). Replacement gas must preform as well or better than current SF6 gas. Present findings showing feasibility to replace SF6 gas.

PHASE II: Work with the government on approval of SF6 replacement (Full or mixture) by showing same or better results can be achieved with the results of adequate research and develop/manufacture of replacement gas.

DUAL USE COMMERCIALIZATION: Military application: SF6 is present in airborne military radar systems, such as airborne warning and control systems (AWACs) for military radar applications. Commercial application: SF6 is the electric power industry's preferred gaseous dielectric (besides air). As it is used so extensively, there would be great demand for a environmentally friendly, low-cost alternative.

REFERENCES: 1. http://www.epa.gov/highgwp/electricpower-sf6/pdf/new_report_final.pdf

2. http://www.ornl.gov/sci/eere/PDFs/CCTP_Wkshp_Rpt_6-28Final.pdf

KEYWORDS: SF6, Sulfur Hexafluride, Greenhouse gas, dielectric

AF073-108 TITLE: Distributed, Multi-Echelon Logistics Management

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop logistics management concepts and tools to provide informed management decision functions for the Manufacturing Repair Overhaul (MRO) environment.

DESCRIPTION: While much research has been conducted on the planning and scheduling of processes, there are gaps in the research associated with techniques regarding the physical execution and management of the logistics processes in an MRO setting. Past efforts have focused on a single element of the process and not total logistics management (material, personnel, and equipment). In an aging aircraft MRO environment, the shop floor must respond to events and conditions never anticipated. This MRO environment is chaotic and never is in a steady-state thus is impossible to predict. To make sound/informed decisions, supervisors at many different levels across numerous organizations need specific information concerning the shop floor production. The current process overwhelms the supervisors with data in certain areas, is missing critical data in other areas, and is available, but difficult and time-consuming to obtain in others.

The objective of this research is to provide an Agile MRO Business Model that can capture the chaotic processes and will provide an enterprise ability to process information and make decisions based on ever changing parameters such as capacity, availability, equipment downtime, aircraft and part scheduling, back shop manufacturing processes, and manpower resources. The research should identify all of the needed characteristics of a manufacturing system that can support a MRO agility model. Identify toolkit functionality and framework attributes required for such a model and development of a Logistics Management application.

The goal in obtaining a MRO logistics management tool based on the above modeling concepts will allow for an agile manufacturing enterprise that has frequent changes to shop floor production to have improved throughput and allow for increased system responsiveness when production capabilities change.

PHASE I: Research and develop concept demonstration of a MRO Business Model with defined metrics for assessing feasibility for a management decision assistance tool. The tool must be flexible and able to account for many different business elements.

PHASE II: Develop a management decision tool based on a MRO environment, demonstrating how all constraints (personnel, material, tool, etc) will be considered for different repair production lines, repair shops, and repair support processes. Provide a plan to transition technology to commercial development and deployment.

DUAL USE COMMERCIALIZATION: Military application: Application to all weapons systems and extensible to similar DoD operations. It could have a significant impact on material tracking visibility, accuracy, efficiencies, and throughput. Commercial application: It could have a significant impact on material tracking visibility, accuracy, efficiencies, and throughput.

REFERENCES: 1. Alan Rushton; Phil Croucher; Peter Baker, “The Handbook of Logistics and Distribution Management”, Kogan Page Ltd, c2006

2. Kimiz Dalkir, “Knowledge Management In Theory and Practice”, Butterworth-Heinemann, c2005.

KEYWORDS: Multi-Echelon, Logistics Management, throughput

AF073-109 TITLE: Airframe Structural Remote Detection for Stress and Corrosion Crack Damage

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop the ability to remotely sense Aircraft Frame problems particularly in hard to reach areas increasing reliability while decreasing inspection intervals.

DESCRIPTION: Aluminum alloys that contain appreciable amounts of soluble alloying elements, primarily copper, magnesium, silicon, and zinc, are susceptible to stress-corrosion cracking. Aluminum and its alloys can fail by cracking along grain boundaries when simultaneously exposed to specific environments and stresses of sufficient magnitude. Several metallurgical, mechanical and environmental factors influence the corrosion process in aluminum alloys. Metallurgically induced factors include heat treatment, chemical composition, and material discontinuities such as the presence of voids, inclusions, precipitates, second phase particles, and grain boundaries as well as grain orientation. Stresses sufficient for crack initiation and crack growth in aircraft can be far below the stresses required for normal conditions. External surfaces of aircraft are exposed to a variety of environments including rain, humidity, acid-rain, deicing fluid, industrial pollutants, hot and cold extremes, dust, and high content of deposits of exhaust gases. Due to the constantly changing conditions, there is no accurate way to predict damage due to stress corrosion cracking in aircraft airframes.

The aerospace industry is developing structural health monitoring systems to reliably detect, locate and quantify damage in components and use the identified damage feature to make a decision on whether to repair or replace the component or for prognosis of the remaining useful component life and system performance. Mission-readiness, minimization of costs due to unnecessary tear downs and Nondestructive Evaluation (NDE) inspections as well as safety are some of the major goals of systems health monitoring. Current structural health monitoring systems focus on detecting the damage at component level and focus less on the failure of the material. It is anticipated that micro structure-based methods will offer higher quality prognosis and avoid unexpected and expensive failures. Methods based on vibration signature of the structure, for example, are useful in detecting damage at a global level and help predict damage level in a component; however such methods do not furnish information of failure processes at a micro structure level.

The ultimate goal is a continuous method of monitoring the structure of aircraft airframes to permit replacement or repair on an as-needed basis. This would increase reliability while decreasing time and costs involved in a timed interval inspection.

PHASE I: To research the possible methods of structural health monitoring to reliably detect, locate and quantify damage in components.

PHASE II: Further develop the best method discovered in phase I to report and track status of aircraft frame items. Show how sensors would be added to existing airframes, and estimate reliability of sensors over a long term time period (years).

DUAL USE COMMERCIALIZATION: Military application: Widespread multi-use application—for airframes, and any existing structure. Commercial application: Widespread multi-use application—for airframes, and any existing structure.

REFERENCES: 1. http://www.key-to-metals.com/Article17.htm

2. http://ic.arc.nasa.gov/projects/ishem/Papers/Jata_Physics_Failure.pdf

3. http://www.faside.com/home/Report-Final.pdf

KEYWORDS: Remote Sensor, airframe, structural damage, cracking, detection

AF073-110 TITLE: Handheld Real Time (RT) Climatic/Environmental Sensor

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Develop and Demonstrate a low cost, durable, portable (handheld desired) RT climatic/environmental sensors with opacity determination.

DESCRIPTION: The objective of this SBIR is to research, develop, and demonstrate solutions for a Human mobile device that integrates digital opacity measurements with real-time metrological/environmental (met-e) data. The mission requirement is to asses and record regulated (Title V-Clean Air Act [CAA]) opacity events (e.g. Vehicles on ranges [dust], tanks training in desert conditions, Helicopter LTO's, painting/plating operations, open burn/open detonation). Simultaneous met-e data and event acquisition is paramount to assessing Title V compliance risk, and defensible compliance records. This SBIR will provide immediate decision support data, enabling appropriate and cost effective responses (shut down vs. continue) for training exercises/facilities. Specifically, the DoD requires we "train as we fight and fight as we train", however training is severely limited by visible emissions compliance in the current regulatory environment. Regulated facilities will have the ability to measure, report, and defend their visible emissions compliance status. The bidder should be familiar with Environmental Protection Agency (EPA) Method 9 as well as methods which could be used to identify salient met-e features for acquisition and analysis. The developed sensor will be indispensable to DoD, and industry, both of whom have Title V compliance and reporting requirements.

PHASE I: Develop the means by which a prototype sensing device can be designed which accounts for Human Interface, Opacity Determination, affects of weather, barometric pressure, sun angle, ambient light, distance, location (x,y,z coordinates) on opacity determination, and archiving.

PHASE II: Further develop the results of the PHI research into a portable device prototype. Field demonstrate the prototype under various climatic conditions with various types of regulated air sources. Demonstrate the unit's ability to output the data for electronically sending data for archiving and electronic mailing. Evaluate prototype with regard to security based on Air Force and DoD requirements.

DUAL USE COMMERCIALIZATION: Military application: Applicable to any Military or Government operation with maintenance or training activities which invoke Title V Compliance issues via visible emissions. Commercial application: Applicable to any industrial entity with activities which invoke Title V Compliance issues via visible emissions.

REFERENCES: 1. Reitze, A. W. (2001) Air Pollution Control Law: Compliance and Enforcement Environmental Law Institute Washington, D.C.

2. Federal Register (1971) "Method 9 – Visual Determination of the Opacity of Emissions from Stationary Sources" vol. 36 No. 247 December 23, 1971

3. Environmental Security Technology Certification Program (2005) "An Alternative to EPA Method 9 – Field Validation of the Digital Opacity Compliance System (DOCS)" Draft Final Report Project No. CP-200119 February 2005

4. Rasmussen, S. L. , McFarland, M. J., Stone, D.A., Calidonna, M.J., Kerch, P.E and S.H. Terry, (2004) "Measuring Visual Opacity Using Digital Imaging Technology" Journal of Air and Waste Management Association vol. 54 pp. 296–306

5. Rasmussen, S. L "Visible Emissions Impact on Range Operations and Sustainment ", Joint Services Environmental Management Symposium, Range Sustainability Track, http://www.jsemconference.com/2007/index.htm

KEYWORDS: Visible Opacity,Digital,Low Cost,Title V,EPA,Compliance

AF073-111 TITLE: Compact Immersive Display Components

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop compact immersive display components for future deployable training systems for fighter and wide body aircraft, helicopter, special operations forces, and Joint Tactical Air Controllers.

DESCRIPTION: Future training systems will need to meet requirements for modularity, transportability, assembly, and operations to support training exercises or mission rehearsals at contingency exercise locations. The format, design, and function of practically every visual system available today do not meet these deployable requirements. Significant size reductions are needed. The components should be applicable to a broad range of visual systems. The components should include existing and new functions in a compact deployable package. Technologies of interest to this solicitation include but are not limited to: compact, collimating, off-the-head displays; 360 degree rotational scanners for off-the-head displays; micro-scanners for head-mounted displays; and retro-reflective displays.

The Air Force is seeking innovative solutions for the development of compact modular visual display technology that provides for future deployable simulator-based training. Low production cost, high reliability, and large commercial potential are critical requirements for the technology being proposed for this solicitation.

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

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

DUAL USE COMMERCIALIZATION: Military application: Many applications in modeling, training and simulation throughout DoD. Commercial application: The expanding world of virtual reality for industrial, medical, special effects for motion picture industries, CAD/CAM, and home entertainment systems of the future.

REFERENCES: 1. Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Readiness Research Division. http://www.mesa.afmc.af.mil/

2. Niall, K.K. and Pierce, B.J. (2000). Assessment of visual requirements, Aircrew Training: Methods, Technologies, and Assessments. Lawrence Erlbaum Associates, Inc.

3. Wight, D., Best, L., Peppler, P., (1999). M2DART Visual Display, A Real Image Simulator Display System, Aerosense Conf., Orlando, Fla.

4. Bifano, T.G., Perreault, J., Mali, R.K., and Horenstein, M.N., (1999). Microelectromechanical Deformable Mirrors, IEEE Journal of Selected Topics in Quantum Electronics, VOL. 5, NO. 1, January/February 1999

5. Pierce, B.J., Geri, G.A. and Hitt, J. (1998). Display Collimation and the Perceived Size of Flight Simulator Imagery. AFRL-TP-1998-0058. Mesa, AZ.: Warfighter Training Research Division, Air Force Research Laboratory.

KEYWORDS: Deployable, Compact, Scanner, Retroreflective, Helmet Mounted Optics, Laser, Helmet, Simulator, Graphics Visualization, High-Resolution, Image Generator, Low-Cost, 3-D, Collimated, Terrain, Ultra, Visual System

AF073-113 TITLE: <u>Hydrophobic/Non-Delaminating Radome Material</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a low-cost structural radome material with excellent hydrophobic properties, high transparency for communication, and immunity to skin delamination.

DESCRIPTION: Research for this topic should yield superior hydrophobic radome materials that also will not delaminate. The ideal radome design as a result of research spurred by this topic would include: 1) Excellent hydrophobic properties through innovative radome design. 2) Highly transparent RF/dielectric properties. 3) Structural immunity to delamination. 4) Reliable structural protection for radar/antenna from all applicable environmental factors (e.g. precipitation, wind, UV, sand, etc.). 5) Lightweight design.

PHASE I: The contractor shall conduct research into various materials, manufacturing processes for use in the development of Air Force radomes with regard to the necessary dielectric properties and structural demands typical to radomes, specifically addressing hydrophobic and delamination concerns.

PHASE II: The contractor shall manufacture a prototype radome using the most economically beneficial processes while ensuring all RF and structural requirements are met, with special attention paid to increased hydrophobicity and decreased delamination.

DUAL USE COMMERCIALIZATION: Military application: Hydrophobic, non-delaminating radomes may be utilized successfully in all military applications requiring radomes, including remote locations and sites with extreme weather conditions. Commercial application: Hydrophobic, non-delaminating transparent radomes may be used in commercial airports, marinas, etc. and can be utilized to protect weather, astronomy, and sensitive communication equipment.

REFERENCES: 1. Kay, A.F., “Electrical Design of Metal Space Frame Radome”, IEEE Trans. Antennas and Propagation, AP-13

2. ASTM D-570-98 Standard Test Method for Water Absorption of Plastics

3. MIL-STD-810 “Test Method Standard for Environmental Engineering Considerations”

4. MIL-STD-454 “Standard General Requirements for Electronic Equipment”

5. MIL-STD-461 “Testing Electromagnetic Interference”

KEYWORDS: Radome, hydrophobic, delamination, dielectric, sandwich panel, solid laminate, low-cost manufacturing, innovative design

AF073-114 TITLE: Identification of the Anisotropic Rigidities and Damping of Composite Panels for Radomes and Shelters

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a portable analyzer to govern the design and performance of anisotropic material identification, especially for shelters and radomes.

DESCRIPTION: Anisotropic materials exhibit different physical properties in different directions. Ordinarily the measured mechanical properties for a structure are given as input into a finite element program, and the structural response is predicted as output. The reverse of measuring key response parameters and backing out the material properties has become possible in recent years. Advances in data analysis, and multi-parameter optimization now allow the design of small portable analyzers which could feasibly measure system response while running a finite element model backwards.

PHASE I: Evaluate various methods for the determination of anisotropic material properties for the composite panels typical in radome and shelter. Perform tests on these panels using both the analyzer and traditional testing and analysis methods to show the feasibility of utilizing the analyzer.

PHASE II: Consolidate the method and technique from Phase I for anisotropic material property determination into a small and lightweight prototype which can be carried into the field or factory. The analyzer must be capable of operating in an environment of frequent vibration and shock, and be user friendly.

DUAL USE COMMERCIALIZATION: Military application: Determine anisotropic material properties, material damping, and quality of sandwich panels used for AF shelters and radomes with a portable analyzer. Commercial application: Determine anisotropic material properties, material damping, and quality of panels for structures such as curtain side trailers, reefer trailers, barges, floating docks etc. using a portable analyzer

REFERENCES: 1. Vautrin, A., and Sol, H., "Mechanical Identification of Composites," Else vier Applied Science, 1990.

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4. Whittingham, B.; Li, H. C.; Herszberg, I.; Chiu, W. K. , "Disbond detection in adhesively bonded composite structures using vibration signatures," Page 351-363, Composite Structures, 2006; Vol. 75; Number 1-4, 2006

KEYWORDS: Radome, shelter, composite, damping, anisotropic, analyzer, material identification

AF073-115 TITLE: Restoration of Dimensional Tolerances

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: A need exists to restore internal dimensions for out-of- tolerance aluminum landing gear components (LG).

DESCRIPTION: Aluminum LG outer-cylinders become damaged during handling or in service. Damage consists of deep scratches, 5 thousandths of an inch deep, or more, on the inside diameter (ID) surface causing seal failure and the cylinder to leak hydraulic fluid and causing loss of aircraft mission capable status. Cylinders are condemned for being out of dimensional tolerance. The condemnation of the outer cylinder due to being out of dimensional tolerance is in excess of $3 Million annually. There is currently no repair process to restore the LG outer cylinders to serviceable condition. The technology will provide the Air Force the capability of restoring unserviceable LG components to serviceable condition, eliminating condemnation of costly assets. Physical Vapor Deposition (PVD) processes have the ability to deposit thin coatings under 1 thousandths of an inch to a variety of parts. This process is not used to build up coatings to drawing requirements, or re-anodize for wear. Currently, long vacuum chamber pump-down lead times are required to begin depositing the desired coating. Innovative approaches are sought overcome this process inefficiency. This Topic seeks to advance PVD technology by developing the ability to shorten deposition process lead times and quickly buildup a thick layer of aluminum on aluminum parent material to restore dimensional tolerances to condemned LG parts. Additional research and development is required in order to develop the optimum process and process controls that will quickly deposit 8 to 10 thousandths, or more, of aluminum on the ID of an aluminum LG outer cylinder with deep scratches on the ID surface. Process controls include, but are not limited to, maintaining parent material to less than 225 degrees farenhieght while increasing the deposition rate. Careful analysis of the deposited aluminum, including but not limited to, morphology, adhesion, hardness, brittleness, bend, wear and anodizing coating etc., shall be completed to qualify the repair process for condemned LG outer cylinders.

PHASE I: Deposit a thick coating of aluminum on the internal diameter (ID) of aluminum tubular specimens and produce micrograph images of the coating to the specimen. Produce engineering reports that present the process' requirements and results.

PHASE II: Further develop and test the PVD method developed in PHI. Demonstrate the ability of the PVD process to deposit aluminum on an out-of-tolerance LG component, provided by the Air Force, adequate to restore the dimensional tolerance of the LG part. Further test, evaluate, and report the results of the PHII effort.

DUAL USE COMMERCIALIZATION: Military application: This SBIR will provide the basis for the restoration of numerous Air Force assets in addition to aluminum LG parts. Commercial application: Aluminum LG parts on commercial aircraft could be restored to dimensional tolerances through this technology, providing significant savings to aircraft operators

REFERENCES: 1. PF Online Feature Article - Hard Chrome Plating... Its Past, Present and Future http://www.pfonline.com/articles/web120301.html By Scott Moore, Thintri, Inc.

2. S.M. Rossnagel and J. Hopwood, "Metal Ion Deposition From Ionized Magnetron Sputtering Discharge", J. Vac. Sci. Technol. B 12(1), 449 (1994).

3. U. Schulz, K. Fritscher, C. Leyens, M. Peters, and W.A. Kaysser, "The Thermocyclic Behavior of Differently Stabilized and Structured EB-PVD TBCs" Published by The Minerals, Metals & Materials Society (TMS) http://www.tms.org/pubs/journals/JOM/9710/Schulz/Schulz-9710.html

KEYWORDS: PVD, Physical Vapor Deposition, Restoration of Dimensional Tolerances,

AF073-117 TITLE: Damage Detection and Identification in Advanced Composites

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an accurate, rapid, inexpensive method for easy, repeatable detection of internal damage and health determination at different depths of aircraft structures made from advanced composites.

DESCRIPTION: Composite materials such as boron, Kevlar, graphite and carbon are widely used in many advanced aerospace structures. Reliable damage assessment for these structures, which may be subject to routine wear, impact damage or sometimes extreme operational conditions, represents a significant and costly problem for routine depot maintenance. The problem of detection and evaluation of damage in composites is compounded by the fact that damage is not visible to the naked eye and can occur in many different forms, such as delamination, disbond (including kissing bond), water ingress, and/or fiber breakage.

In principle, damage in composite structures can be detected in several ways, but traditional detection methods are often limited to specific materials and/or structural geometries, with limited ability for quantitative assessment of the damage. Moreover, they often require the structure to be at least partially disassembled and require a skilled technician to interpret the observations, increasing labor costs and adding to the time needed to complete the inspection. Finally, disassembly and subsequent reassembly of components can potentially cause damage to the structures.

An innovative proposal should therefore address defect signature analysis with a view towards implementing automated defect identification, extraction and classification (e.g. disbond, delamination, water penetration) methodology which will ensure minimum operator intervention and interpretation.

PHASE I: Develop and formulate a technique capable of assessing damage to composite aerospace structures that improves upon existing methods in terms of speed, accuracy, and cost. Demonstrate the proof-of-concept on representative test articles by determining the location and extent of damage.

PHASE II: Develop and deliver a portable protoype for on-site application. Demonstrate damage-detection and system operation on actual composite aircraft structures with known flaws, similar to those found in practice, and demonstrate that the method and data analysis supports defect characterization. Evaluate the efficacy of the damage-detection system with corroborating data using conventional methods.

DUAL USE COMMERCIALIZATION: Military application: Non-destructive Inspection (NDI) tools to inspect composites in aircraft and possibly vehicles and ships. Commercial application: NDI tools to inspect composites in aircraft and possibly vehicles and ships.

REFERENCES: 1. Doebling, S. W., Farrar, C. R., Prime, M. B., and Shevitz, D. W., Damage Identification and Health Monitoring of Structural and Mechanical Systems from Changes in Their Vibration Characteristics: A Literature Review, Report No. LA- I 3070-MS, Los Alamos National Laboratory, 1996.

2. C.R. Farrar, et Al, Damage Prognosis: Current Status and Future Needs LA-14051-MS Los Alamos National Laboratories, July, 2003.

4. http://www.robins.af.mil/units/330asw.asp

KEYWORDS: Vibration-based damage detection, surface evaluation, cracks, delamination, composite and metallic structures

AF073-118 TITLE: Aircraft Corrosion Inspection

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a non-destructive inspection (NDI) system/technique that can inspect for subsurface corrosion in deep, multi layer, tapered-thickness, and potentially dissimilar metallic structures.

DESCRIPTION: The next generation of aircraft and the current aging Air Force fleet require a reliable, portable, easy-to-use method to inspect in situ for corrosion in multi-layer metallic structures. Corrosion is a leading cause of reduced mission availability rates due to extensive inspection, troubleshooting, and repair, and these actions significantly add to Air Force sustainment costs. Unless found during a post-flight inspection, corrosion is not detected until an aircraft has been removed from service and some disassembly accomplished- a major drawback to utilizing current inspection methods. Disassembly and subsequent reassembly of components is costly, time-consuming, and can potentially cause unintended damage to the structures.

An innovative proposal will research and develop a method to detect the presence of corrosion without removing the skin of the aircraft. Methods and techniques must be developed to allow determination of the corrosion in multiple layers of the aircraft structure. Demonstrating the ability to detect corrosion between first four layers of structure is necessary. Corrosion detection between 4th and 5th layers would be exceptional. Focus should primarily be on aluminum alloys, but results should be applicable to titanium and steel alloys typical to aerospace structural composition.

PHASE I: Research and develop a method to detect corrosion in multi-layer metallic structures in aerospace vehicles. Demonstrate the ability to detect corrosion within the material on a sample aircraft component between first two layers is necessary. Develop design specs for the Phase II prototype.

PHASE II: Demonstrate a portable, easy to use, and cost effective system for inspection of internal aircraft corrosion without structure disassembly. Apply Phase I results to the design, fabrication, and experimental validation of the prototype. Demonstrate the operability to detect corrosion on a sample aircraft component between first four layers of structure.

DUAL USE COMMERCIALIZATION: Military application: Potential applications include inspection of metallic structures including military aircraft and ships. Potential customers include aerospace, FAA, DoD and the DOE. Commercial application: Potential applications include inspection of metallic structures including commercial aircraft and ships. Potential customers include aerospace, 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.

2. http://www.robins.af.mil/units/330asw.asp

KEYWORDS: Aging aircraft, NDE, NDI, inspection

AF073-119 TITLE: Inspection of Subsurface Flaws around Fasteners on Aircraft

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a non-destructive inspection (NDI) system/technique that can detect subsurface flaws around in-situ aircraft fasteners.

DESCRIPTION: With the Air Force fleet becoming older there is increasing need for in situ inspection around fasteners for cracks and flaws, and this ability has long been sought after as an inspection tool. Cracks and flaws require extensive inspection, troubleshooting, and repair, significantly adding to Air Force sustainment costs and reducing mission availability. Unless found during a post-flight inspection, cracks are not detected until an aircraft has been removed from service and some disassembly accomplished- a major drawback to utilizing current inspection methods. Disassembly and subsequent reassembly of components is costly, time-consuming, and can potentially cause unintended damage to the structures.

An innovative SBIR proposal will research and develop methods to inspect for subsurface flaws around fasteners without fastener removal. Demonstrating the ability to detect 0.050-inch corner flaws between the first four layers is necessary. Flaw detection between 4th and 5th layers would be exceptional. Constraints of next-generation aircraft must be considered and addressed. Focus should primarily be on aluminum alloys, but results should be applicable to titanium and steel alloys typical to aerospace structural composition.

PHASE I: Research and demonstrate the ability to detect corner flaws emanating from fastener holes. Demonstrating concept feasibility and detecting corner flaws between first two layers is necessary. Develop design considerations for the Phase II prototype.

PHASE II: Develop with AF personnel and demonstrate a portable, easy to use, and cost effective system to be used both inside and outside the aircraft. Develop and demonstrate the system prototype on a relevant mock-up to detect corner flaws between first four layers. Demonstrate operability and provide a users/maintenance manual for expected operation.

DUAL USE COMMERCIALIZATION: Military application: Potential applications include inspection of metallic structures including military aircraft, naval vessels, automobiles, rail systems, or building structures. Commercial application: Potential applications include inspection of metallic structures including commercial aircraft, sea-going vessels, automobiles, rail systems, or building structures.

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.

2. http://www.robins.af.mil/units/330asw.asp

KEYWORDS: Nondestructive inspection, Crack detection, Inspection

AF073-121 TITLE: Development of Novel Cooling and Temperature Monitoring for High Velocity Oxygen Fuel (HVOF) Coating Applications

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop novel coolant and temperature monitoring system to allow HVOF Tungsten-Carbide-Colbalt-Chrome (WC-Co-Cr) coating applications on metallic aircraft components and propeller components.

DESCRIPTION: During HVOF-applied coating processes, variable temperature controls are required to prevent component overheat for each substrate common to aircraft - aluminum, titanium, stainless, low and high strength steels. It is extremely difficult to control HVOF temperatures adequately with just shop air, thus a variable material cooling system option is needed, which efficiently controls the heat input. Currently, aircraft components such as airframe, wing, stabilizer components (i.e. flap tracks, slat tracks, etc.), propeller system, and landing gear which are processed utilizing HVOF tungsten carbide (WC-Co-Cr) coatings are typically cooled with shop air to control heat / temperature during the actual application.

These control issues have prevented USAF depots from extensive usage of HVOF coatings on aluminum and titanium components due to application temperature and cost concerns. Current repairs to these alloys are severely limited in thickness; an innovative cooling system such as liquid nitrogen would enable wide-spread repair using HVOF coatings.

In addition, temperature is currently monitored with a single point IR gun aimed at a single location on the part being sprayed. As a result, expensive WC-Co-Cr powder and combustion gases can be wasted as the HVOF gun dwells off the part as the part cools to an acceptable temperature. An enhanced coolant system and multi-location temperature monitoring system would allow for the HVOF application production to increase as it would allow the HVOF coating to be applied faster, resulting in man-hour savings and reduced material (powder and gases) usage.

PHASE I: Research the feasibility of a novel cooling & temp monitoring system for the HVOF tungsten carbide (WC-Co-Cr) coating process on aluminum, titanium, stainless, low and high strength steels on aircraft and propeller components.

PHASE II: Further develop, optimize and implement the approach from Phase I and demonstrate the process improvements by manufacturing multiple development & test articles . Mechanical & environmental properties, as well as process techniques, will be optimized and validated. Component alloy qualification testing and actual part service evaluation testing will be conducted.

DUAL USE COMMERCIALIZATION: Military application: Any process currently utilizing HVOF tungsten carbide (WC-Co-Cr) coatings on aluminum, steel and titanium components utilizing flame spray techniques will have applications for this approach. Commercial application: Any process currently utilizing HVOF tungsten carbide (WC-Co-Cr) coatings on aluminum, steel and titanium components utilizing flame spray techniques will have applications for this approach.

REFERENCES: 1. HVOF webpage of Diamond Jet 2600 mfg-http://www.sulzermetco.com/en/desktopdefault.aspx/tabid-2008//3390_read-5302

2. http://www.iot.rwth-aachen.de/index.php?id=919

KEYWORDS: Low and high strength steels, stainless steel, aluminum, titanium, HVOF, tungsten carbide HVOF coating, enhanced coolant, temperature monitoring system

AF073-123   TITLE: Trace Level Sulfur Sensor

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an on the chip sensor capable of detecting part per billion trace levels of sulfur organic compounds and other compounds in the liquid or gaseous phase.

DESCRIPTION: Progress towards a hydrogen economy is being made, bringing with it field level production and quality checks. Hydrogen reformers capable of dealing with military logistics fuel sulfur are being developed for contingency and mobile purposes. These hydrogen reformers create the hydrogen to feed proton exchange membrane (PEM) fuel cells; PEM's currently require 99.999% pure hydrogen. As a result, extensive diagnostic equipment is required to monitor reformer hydrogen output purity. Missing any organosulfur in the production stream will degrade the Fuel Cell's production, eventually leading to its replacement. To reduce system costs and logistical footprint, an inexpensive method is needed to continuously monitor the process stream of military logistical fuel (JP8) for sulfur and other compounds which would harm the reformer catalyst.

This topic seeks a sensor for detection of organosulfur compounds to the part per billion trace levels typically present in military logistics fuels. For example, a candidate sensor technology could use an integrated optic waveguide interferometer [1, 2] to meet this need. The design would require a small form factor with multiple analyte sensing capabilities. The sensor should be capable of functioning in both vapor and aqueous phase media. A simple notification system is necessary to bring notice of potential production quality problems to the user: visual, tactile, auditory, etc.

PHASE I: Research and formulate a candidate surface sensing methodology. Create a preliminary bread boarded sensor concept to detect sulfur compounds in the ppb range. Develop design considerations for the Phase II prototype.

PHASE II: Demonstrate a portable, easy to use, and cost effective system for detecting harmful sulfur compounds in JP8 fuel reformer streams. Apply Phase I results to the design, fabrication, and experimental validation of the prototype. Demonstrate operability to detect sulfur compounds harmful to the reformer catalyst.

DUAL USE COMMERCIALIZATION: Military application: Vehicle and ground support equipment fuel monitoring. Commercial application: Potential applications include the need for portable and cost effective instrumentation suitable for ambient exposure assessment or use as an unattended site monitoring instrument.

REFERENCES: 1. Hartman, N.F., "Integrated Optic Interferometric Sensor", U. S. Patent # 5,623,561   April 22, 1997.

2. Controlling Light With Light Via Structural Transformations in Metallic Nanoparticles, MacDonald, K.F. Soares, B.F., Bashevoy, M.V., and Zheludev, N.I., IEEE Journal of Selected topics in Quantum Electronics, Vol 12, No 3 May/June 2006.

3. Vapor sensing using surface functionalized gold nanoparticles., H-L Zhang et al 2002 Nanotechnology 13 439-444 doi:10.1088/0957-4484/13/3/339.

4. http://www.robins.af.mil/units/542csw.asp

KEYWORDS: Sensor, sulfur, nanoparticles, reformer

AF073-125 TITLE: Multi-Spectral Projection Sources

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Investigate, develop, and demonstrate feasibility of enhanced infrared scene projectors operating in the 2-5 and 8-12 micron bands for spatial resolution, response times, and radiant intensity.

DESCRIPTION: High performance infrared scene generation capabilities are increasingly important for defense system development, validation and verification. Scene generation and projection is used to test and evaluate warfare sensors and countermeasure applications at low costs. Infrared scene projectors provide non-destructive testing of defense hardware components at minimal risk. Numerous infrared scene projectors and types are used in hardware-in-the-loop facilities. However, existing infrared scene projectors are limited in performance. Projectors have always had limitations but as seeker/sensor technology improves, increases in projector performance become critical. Therefore, research of fundamental projector technologies to improve scene projector performance is highly desired to overcome current projector limitations.

Any or all of the following parameters, though not inclusive, are acceptable enhancements to the infrared scene projector performance: multi-spectral output, greater radiant intensity, faster response time, wider field of view, higher resolution, real time functionality, increased dynamic range, low background temperature, low background noise, high reliability, non-flickering imaging, compact packaging, and ruggedization. Projector sources able to achieve temperatures greater than 1000K (apparent), resolutions greater than 1024K by 1024, response times of less than 1 millisecond are desirable and with agile apparent color are desirable. Typical fields of view achievable at acceptable resolution are currently on the order of 8 degrees. The ability to simulate much larger areas (greater than 45 degrees) are desireable for some applications. Stable point sources with radiant intensities greater than those achievable with blackbodies or commercially available arc lamps are also desirable as are novel concepts combining high intensity point sources and array based sources.

Create an innovative design, exploiting many novel concepts in improving infrared scene projector sources. Successful research will be identification of promising concepts in Phase I with delivery of a build to design of the most promising concept. Prototyping and demonstration of the critical elements will be the culmination of this small business innovative research in Phase II.

PHASE I: Develop initial concept design to improve infrared projection performance. Model improved key performance elements. Determine promising concepts that are viable to implement successfully in synthetic test environments. Provide key concepts design requiring demonstration, set demonstration goals.

PHASE II: Refine design and demonstrate performance improvements of working prototype through experiments of critical elements. Complete component design, fabrication and laboratory characterization experiments. Define performance test objectives and conduct prototype testing using success criteria developed in Phase I.

DUAL USE COMMERCIALIZATION: Military application: Non-destructive performance testing of weapon seekers using a synthetic environment. Commercial application: Test beds for commercial sensors with applications in infrared vision, monitoring, and imaging systems.

REFERENCES: 1. Owen M. Williams, George C. Goldsmith, Robert G. Stockbridge. “History of resistor array infrared projectors: hindsight is always 100% operability”, Proc. SPIE, Vol. 5785, 208 (2005)

2. Steven Solomon, Robert Ginn, Stephen Campbell, Maryam Jalali, George Goldsmith. “High Temperature Materials for Resistive Infrared Scene Projectors”, Vol. 6208, 27, (2006)

3. R. Bryan Sisko, David S. Flynn, Breck A. Sieglinger, James D. Norman. “Studies of the Spectral “Crosstalk” in Two-Color IR Projection Systems”, Proc. SPIE, Vol. 5092, 176, (2003)

4. Francisco A. Arredondo, Stockbridge Robert, Eric W. Glattke, Robert W. Copeland. Walker. “Multi-Spectral Scene Projection (MSSP) demonstration”, Proc. SPIE, Vol. 4366, 29, (2001)

KEYWORDS: Hardware-in-the-loop, multi-spectral, dynamic infrared scene projector, real-time, spatial resolution, radiant intensity, response time, apparent temperature, simulation

AF073-130 TITLE: Wireless Fire Detector

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop, design, build, and demonstrate an innovative rapid wireless fire detector system compatible with future and legacy aircraft.

DESCRIPTION: Rapid and reliable fire detection is necessary to ensure modern fire extinguishing systems maintain aircraft safety and survivability. The efficacy of a fire extinguishing system is dependent upon its ability to accurately detect and react quickly to a fire emergency, particularly in areas where the crew or passengers cannot confirm the presence of a fire (wing void space areas, avionics compartments, storage compartments, etc.). Delays in detection put at risk sensitive electronics, flight and data systems, and primary structure in new and future aircraft platforms. Previous on-board fire detector systems have proven susceptible to false alarms. The combination of cost and weight, particularly with the necessity to run conventional wiring to all protected areas, along with false alarms, often causes aircraft designers to remove fire detection/suppression equipment in trade studies. Retrofitting aircraft with these systems at a later date (once a safety issue is fully realized) becomes an even more costly proposition.

Needed is a rapid, low-cost, lightweight, wireless fire detection system that is suitable for military aircraft. The system must be quick reacting with the time from fire ignition to detection occurring in the millisecond time range and the time from initial sensor input to signal transfer in the 1 ms range, including data interpretation. The detector must also be very reliable, clearly distinguishing fires from “noise” – no false alarms. The wireless fire detector must be designed for easy installation within confined, remote, and hard to access areas aboard the aircraft. Wireless capability provides an ability to position detectors “on-demand” as opposed to determining their permanent location during the initial design of the areas being protected. Being wireless, weight will be saved by the lack of wiring, but the weight of the detector itself must improve upon current state-of-the art (current wired aircraft detectors are in the 1 pound range) so it can be positioned in many places, if line-of-sight is required. The newly developed system must address communication issues between the detector, cockpit warning system, and automatic fire extinguishing subsystem. It must be demonstrated that the signal logic from the detector can be interpreted properly by a controller. The selected approach must not interfere with other electrical systems as specified in MIL STD 461, providing lightweight plug and play fire suppression onboard both future and legacy aircraft. Deliverables are the design, development, and feasibility demonstration of the wireless fire detector device for Phase I. Phase II deliverables are prototype fabrication and demonstration of the fire detector meeting performance parameters.

Many wired sensory methods (i.e. active and passive optical spectroscopy) are already capable of capturing data within the time domain necessary, but data discrimination, line-of-sight issues, computational time requirements, power requirements, and communication issues all pose a formidable challenge.

PHASE I: Define and develop a rapid, reliable, low-cost, lightweight, wireless fire detector device. Design must address environmental factors in an operational aircraft environment, attachment methods, sensor, and power needs, plus wireless communication to a cockpit warning system and to a fire extinguishing controller.

PHASE II: Refine a design, fabricate a prototype, and demonstrate the capabilities of a wireless fire detector. Demonstrate suitability for plug and play aircraft application. Prove it can unambiguously detect a fire, distinguishing from sources that may lead to a fire (e.g., missile fragment flash) and send a warning to the pilot and discharge signal to the fire extinguisher.

DUAL USE COMMERCIALIZATION: Military application: proposed capability is directly applicable to other military platforms (naval vessels, land vehicles, test facilities, and ground installations). Commercial application: proposed capability is directly applicable to civil aerospace and commercial industries. Low-cost, lightweight, and reliability features are attractive to all these industries and applications.

REFERENCES: 1. MIL-STD-461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, DoD, 20 August, 1999.

2. R. M. Mugele, P. T. Dzwilewski, J. T. Cilke, Aircraft Fire Sentry, Final Technical Report Volume I - Summary; Volume II- Appendices A, B, C, and D, January, 1993.

3. Goedeke, A. D., “Characterization and Testing of Optical Fire Detectors and Immunity to False Alarm Sources”, April, 1992.

4. Delaney,Charles L., “Fire Detection System Performance in USAF Aircraft”, August 1972.

KEYWORDS: wireless, fire, detection, sensor, onboard, aircraft, reliable, low false alarms

AF073-131 TITLE: Cryo-Motion for Space Simulation Testing

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a dynamic positioning hardware capable of high speeds without freezing in the cryovacuum environment.

DESCRIPTION: Develop dynamic positioning hardware capable of high speeds without mechanically locking up or freezing in the cryovacuum environment for accurate, dynamic positioning of point source targets in cryogenic environments. Precision is crucial to the simulation of space defense scenarios in a space simulation test chambers. Current ball screw positioning systems, which use rotary motors with bearing technologies, are subject to freezing and binding from cryo-contaminants or particulates. Test interruptions undertaken to warm and free the device are expensive, greatly limits the drive speed and limits the range of test conditions. The binding also causes significant wear leading to premature replacement of the mechanical components. Other types of positioners coupled with feedback devices may have potential for mitigating this problem. Linear induction motors, for instance, produce linear rather than rotary torque, and can produce fast response, and high acceleration and braking forces. They are an excellent variable speed drive with no gears or chains to cause backlash or excessive vibration, and no lubrication required. However, their use is currently designed for ambient operation and has only been evaluated in that environment. It is not known whether this technology can be implemented in the cryogenic vacuum environment due to the thermo-mechanical stresses produced in the moving components caused by differential material contraction, and changes in material properties under cryogenic conditions. Any successful technology concept would require component integration for cryogenic conditions and a thorough evaluation to establish the viability of this technology in the space simulation chamber arena. A key technical innovation will be the materials needed to sustain long duration, rapid, and constant motions and acceleration changes under cryo-vacuum conditions without the use of lubricants which freeze and/or produce significant contaminants. Regardless of the approach proposed, Phase I should show feasibility of operation over a 0.3 meter range at a velocity of at least 0.05 m/sec without binding in a cryovacuum environment (20K) and provide an engineering estimate of achievable speeds. Phase I should demonstrate operation at cryovacuum conditions of <77K and 10-6 Torr. Phase II should develop and demonstrate a prototype device capable of operation over a 1-meter range at maximum speeds achievable (> 0.15 m/sec) at cryovacuum conditions of <20K and 10-6 Torr.

PHASE I: Demonstrate the feasibility of operation over a 0.3 m range at a velocity of at least 0.05 m/sec in cryovacuum conditions (<77K, 10-6 Torr).

PHASE II: Develop and demonstrate a prototype system over a 1-meter range at maximum speeds achievable (> 0.15 m/sec) for cryovacuum conditions (<20K, 10-6 Torr).

DUAL USE COMMERCIALIZATION: This device would be of great interest to the many test facilities that operate at cryogenic temperature and need dynamic position capabilities. This would include those involved in the satellite industry (e.g., Boeing, Raytheon, the AFRL Space Vehicles Directorate). This technology could be useful for satellite positioning systems as well.

REFERENCES: 1. Joshi, C. H., Compact Magnetostrictive Actuators and Linear Motors, Energen, Inc., Billerica, MA, USA, presented at Actuator 2000 Conference, Bremen, Germany, June, 2000.

2. SDN0022 Investigation of GNIRS Slit/IFU Slide Operation, http://www.noao.edu/ets/gnirs/SDN0022.htm

3. KIRMOS PROJECT REPORT, http://www.astro.caltech.edu/oir/kirmos/reports/monthly/2002/Sept02.pdf

4. Magnetostrictive Inertial-Reaction Linear Motors, http://www.nasatech.com/Briefs/Jun98/NPO20153.html

KEYWORDS: space testing, linear motor, cryogenic motor

AF073-132 TITLE: <u>High Temperature Hypersonic Force Measurement System</u>

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a force and moment measurement system for wind tunnel article/models.

DESCRIPTION: Measurements of vehicle/test article component loads and control-surface loads are required during testing to provide vital information for flight vehicle control, design and performance estimation and for structural design loads prediction. Accurate measurements of forces and moments experienced by the test article (e.g., aircraft, missile, etc.) and measurements of the attitude (angle of attack, yaw, and roll) are critical measurements taken during wind tunnel tests. Typical wind tunnel conditions are speeds of Mach 8 at total temperature up to 900 °F. The measurement system will be implemented repeatedly for minutes at a time during multiple-hour test periods. Thermal effects associated with testing in the continuous-flow hypersonic wind tunnels impose challenges for strain-gage balances or other force/moment measuring devices used for component loads. There is a need for three-component force balances. For continuous-flow wind tunnel applications, thermal protection must be a part of the design consideration for those relatively-compact force/moment measurement balances. A non-water-cooled thermal protection and compensation design solution is needed. Innovative alternate material concepts and/or strain measurement devices are encouraged. A non-water-cooled thermally-protected/compensated measurement system concept should be demonstrated at total temperatures of 900 °F during Phase I. During Phase II, a thermally-protected/compensated prototype system capable of measuring three components of force on wind tunnel models should be developed and demonstrated.

PHASE I: Demonstrate the feasibility of a high temperature measurement system.

PHASE II: Develop and demonstrate a prototype system as described above.

DUAL USE COMMERCIALIZATION: Military application: Viable applications include stress/strain measurements on components of high temperature devices such as turbine engines, power production facilities, and other rotary combustion engines. Commercial application: Viable applications include stress/strain measurements on components of high temperature devices such as turbine engines, power production facilities, and other rotary combustion engines.

REFERENCES: 1. Veazey, D. T., “Current AEDC Weapons Separation Testing and Analysis to Support Flight Testing,” AIAA-2004-6847, 2004.

2. Maus, J. R., et al, “Hypersonic Mach Number and Real Gas Effects on Space Shuttle Orbiter Aerodynamics,” J. of Spacecraft and Rockets, Vol. 21, No. 2, Mar-Apr 1984, pp. 136-141.

3. Watanabe, S, et al, “Aerodynamic Characteristics Evaluation of Hypersonic Flight Experiment Vehicle Based on Flight Data,” J. of Spacecraft and Rockets, Vol. 34, No. 4, July-Aug 1997, pp. 464-470.

4. Chang, C. J., et al, “Study of Aerodynamic Surface Control of Space Shuttle Boost and Reentry, Volume I, Final Report,” NASA-CR-123644, Mar 1972.

KEYWORDS: force measurement, hypersonic, high temperature gage, strain measurement

AF073-133 TITLE: Mass Flow-Through Measurement System for Transient Jet Interaction Testing

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a system to measure jet interaction in continuous-flow wind tunnel environments.

DESCRIPTION: The Air Force has a need to measure short-duration forces and moments generated by impulse control devices, e.g., transient transverse gaseous jets. The measurement of short-duration loads/impulses from pulsating control jets of intercept missiles is important to the missile defense program offices. The jet interaction wind tunnel model typically uses 5-50 millisecond duration jet-control air pulses. Typical wind tunnel test conditions occur between Mach 4 and Mach 8. Testing requires very versatile but precise valves capable of providing simulated jet for control of future weapon systems. This includes the capability to provide up to 10 lbm/sec at a total pressure to about 1000 psi for a pulse time of 5-50 msec with a rise time of less than one msec. Supersonic and hypersonic ballistic missile defense interceptors as well as recently emerging ship-board defense systems, air-to-air missiles and guided rockets concepts require a level of maneuverability available almost exclusively through the use of control jets issuing at large angles relative to the direction of flight. This is driven by the extremely fast response times required of these missions as well as the inability of conventional aerodynamic control techniques to meet this requirement. When these reaction jets are activated on a missile, it can cause a significant interference with the interceptor’s jet-off aerodynamic stability and control characteristics. The valve system should be small so that it can be placed in the test article and should be balanced so that it doesn't influence any transient force measurements. The valve should be capable of operating at temperatures as high as 500 deg F and should be able to flow various gas types. The supply gas for the valve will either be stored on board the test article or could be supplied using a flow-through balance and is not the subject of this solicitation. The goal is to develop and demonstrate a valve and associated control system to generate short-duration gas streams for transient jet interaction measurements during force/moment testing in a continuous-flow wind tunnel or equivalent environment.

PHASE I: Demonstrate the feasibility of the system.

PHASE II: Development and demonstrate a prototype system as described above.

DUAL USE COMMERCIALIZATION: Military application: Transient Jet Interaction applications include a high response valves and impulse measurements. Commercial application: Commercial applications include a variety of gas-flow controllers and meters for industrial pipe transient flows.

REFERENCES: 1. Marquart, E. J. and Coulter, S. M., "Impulse Measurement Technology Development at the Arnold Engineering Development Center (AEDC)," AIAA-1998-203, Aerospace Sciences Meeting and Exhibit, 36th, Reno, NV, Jan. 12-15, 1998.

2. Lawrence, F. C., et al, "Extending the Impulse Measurement Capability at the Arnold Engineering Development Center to Six Degrees of Freedom," AIAA-2002-2925, 2002.

3. Smith, C. L., et al, "Current Airframe Propulsion Integration Testing Techniques at AEDC," AIAA 2004-6819, USAF Developmental Test and Evaluation Summit, Woodland Hills, CA, 16-18 Nov 2004.

4. Chamberlain, R., et al, "CFD Analysis of Lateral Jet Interaction Phenomena for the THAAD Interceptor," AIAA-00-0963, 38th AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV, 10-13 Jan 2000.

KEYWORDS: jet interaction, high response valves, impulse measurements

AF073-134 TITLE: Fiber-Based Coherent Anti-Stokes Raman Spectroscopy System

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop a fiber-based Coherent Anti-Stokes Raman Spectroscopy System.

DESCRIPTION: The propulsion community has a need for non-intrusive measurements of gas species concentrations and gas temperature in high enthalpy gas flows inaccessible by conventional diagnostics. Coherent Anti-Stokes Raman Spectroscopy (CARS) is a powerful non-intrusive optical diagnostic tool that has been used extensively to investigate high temperature, corrosive, or otherwise inaccessible gaseous processes. Coherent Anti-Stokes Raman Spectroscopy can be used to measure both species and temperature. Implementation of a CARS system in wind tunnels or gas turbine engine test facilities is challenging since very precise alignment of multiple high-energy pulsed laser beams is required. A CARS system requires temporal and spatial superposition of multiple laser pulses in order to generate the coherent scattered signals. Hence CARS produces a point measurement. The requirement for high energy laser pulses combined with a complex alignment requirements have traditionally resulted in complex, open space optical arrangements. Requirements to traverse the probed volume across a plane of interest in the test medium further complicates implementation of this diagnostic method in a ground test facility. A fiber coupled CARS system is required to alleviate the implementation challenges. However, the laser pulse energy thresholds required to generate detectable signals have historically been well above the damage threshold of the available optical fibers. Development of a state-of-the-art fiber-coupled CARS system will push fiber-coupled lasers and other technologies, but with a high payoff. The feasibility of fiber-delivered laser beams with appropriate characteristics to produce CARS signals should be demonstrated. CARS systems have been used successfully in flow-field applications allowing optical access for high power lasers and detection optics. The final goal is to develop and demonstrate a prototype fiber-based Coherent Anti-Stokes Raman Spectroscopy system.

PHASE I: Demonstrate the feasibility of fiber-delivered laser beams to produce CARS signals.

PHASE II: Develop and demonstrate a prototype fiber-based Coherent Anti-Stokes Raman Spectroscopy system.

DUAL USE COMMERCIALIZATION: Military application: A fiber optic CARS system is applicable to turbine combustors, turbine test facilities and hypersonic flow field applications. Commercial application: A fiber optic CARS system will have a much broader range of applications making this technology applicable to turbine combustors and turbine test facilities.

REFERENCES: 1. O'Byrne, S., Danehy, P.M., Cutler, A.D., "Dual-Pump CARS Thermometry and Species Concentration Measurements in a Supersonic Combustor," AIAA Paper 2004-0719, 42nd Aerospace Sciences Meeting and Exhibit, Reno, NV, January 5-8, 2004.

2. Kristiansen, R.E., "Guiding Light with Holey Fibers," SPIE OE Magazine, pp.25-28, June 2002.

3. P. Russell, "Photonic crystal fibers," Science, Vol: 299, No. 5605, pp. 358-362, 2003.

4. Eckbreth, A.C., Laser Diagnostics for Combustion Temperature and Species, Gordon and Breach, The Netherlands (1996).

KEYWORDS: Coherent Anti-Stokes Raman Spectroscopy, CARS, Optical Diagnostics, Laser Diagnostics

AF073-135 TITLE: Vibration Analysis of Rotating Plant Machinery

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Develop advanced signal processing techniques to perform facility vibration analyses.

DESCRIPTION: Recent advances in high speed signal processing techniques have allowed researchers to identify anomalous frequencies in the vibration spectra as fault or no fault conditions in similar rotating components. These techniques could be used to identify vibratory excitation sources and isolate potentially damaging responses in facility hardware systems. Several long term vibration problems at AEDC have combined to deplete thousands of labor hours from maintenance resources. These problems, involving compressors and synchronous motors, continue to threaten testing operations and the maintenance budget with a significant risk of catastrophic failure. Once demonstrated, these techniques could be extended to health monitoring and detailed analysis of turbine and liquid rocket engine test articles. The system should include the development of advanced signal processing techniques that identify resonances, distinguish acoustically and mechanically driven vibrations, discern electrical faults from mechanical faults in synchronous and induction motors, extract information from conventional facility vibration data with low signal-to-noise, include source point identification, and resolve rotor related responses from anomalous frequencies and/or noise. The principles required for a vibration analysis of rotating plant machinery should be analytically and experimentally demonstrated. The end goal is to produce a prototype system for general application to rotating machinery health monitoring.

PHASE I: Demonstrate the feasibility of the system.

PHASE II: Develop and demonstrate a prototype system as described above.

DUAL USE COMMERCIALIZATION: Military application: Military jet engine maintenance and overhaul facilities will be able to accurately determine the actual condition of an engine; possibly avoiding unnecessary and costly premature overhauls. Commercial application: Heavy industries and utilities using large motors, compressors, and pumps will be able to avoid in service catastrophic failures by early warning of system anomalies.

REFERENCES: 1. Tang, Genglin, Yates, Charlie L., Zhang, et al., "A Practical Intelligent System for Condition Monitoring and Fault Diagnosis of Jet Engines", AIAA Paper 99-2533, AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 35th, Los Angeles, CA, June 20-24, 1999.

2. Hite, Sid W., "An Algorithm for Determination of Bearing Health through Automated Vibration Monitoring"AEDC TR 93 19, Dec 1993.

3. Suarez, E. L., Duffy, M. J., Seto, D., and Cote, S. M., "Advanced Life Prediction Systems for Gas Turbine Engines", AIAA Paper 2003-4985, 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Huntsville, AL, July 20-23, 2003.

KEYWORDS: vibration analysis, rotating machinery, signal processing

AF073-136 TITLE: Secure Plant Operations Data Network

TECHNOLOGY AREAS: Information Systems, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a secure communication system for plant operations.

DESCRIPTION: A secure communications network is sought for use in a plant environment. The system shall consist of a set of small, wearable communication devices which interface with way stations located throughout the plant. The proposed system should have the following characteristics: 1)The network should work in the typical plant environment, which includes high levels of ambient noise, EMI interference, dead zones where building and equipment blocks RF signals, grease, dirt, water, and other contaminants. 2) The system must transmit data in a secure manner which is nearly impossible to either intercept or decode. This requirement goes beyond simple encryption to technologies such that the data cannot be reassembled without the appropriate key and that the signal cannot be detected above ambient noise levels. 3) The system should identify and locate individuals wearing communicators within user-defined areas. 4) The system should provide the capability to translate voice to text and record a text-based log to a PC. During Phase I, demonstrated the system architecture which includes concepts for communication systems, the relay stations, and the central control system. Furthermore, the technologies developed to provide signal security must be demonstrated, along with proof through analysis or demonstration of non-interference with plant data systems. During Phase II, develop and demonstrate the prototype system with encrypted communications as described above.

PHASE I: Develop system architecture and technologies for signal security and non-interference with data collection.

PHASE II: Develop and demonstrate the prototype system with the following capabiities: 1) wearable communicators, 2) secure transmission, 3) locate individuals, and 4) translation of voice to text and text to voice.

DUAL USE COMMERCIALIZATION: Military application: Homeland Security efforts to protect power plants, dams, facility plants and other potential targets such as chemical plants, industrial facilities. Commercial application: The system will be desirable to any large plant or factory to increase the safety and productivity such as chemical plants, electrical stations and other industries.

REFERENCES: 1. Stallings, W., Wireless Communications and Networks, Prentice Hall, 2002.

2. "An Introduction to Industrial Ethernet," B&B Electronics Manufacturing Co., Ottawa, IL, 2005, www.bb-elec.com > Tech Notes. Look under the Ethernet heading.

3. Morrow, R., Bluetooth: Operation and Use, McGraw-Hill, New York, NY, 2002.

KEYWORDS: communication, wireless, network

AF073-138 TITLE: Low Temperature Multi-Spectral Image Projector

TECHNOLOGY AREAS: Materials/Processes, Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a multi-spectral image projection device that can operate from +50°C to -35°C at a frame rate of 60 Hertz.

DESCRIPTION: The goal of this topic is to develop a multi-spectral projection system that can operate at background temperatures seen in the real world. The testing of many defense and commercial infrared (IR) sensors requires the ability to generate flickerless, high contrast scenes that are a combination of visible (red, green, and blue (RGB)) and IR. The evaluation of critical sensor performance parameters relies on the ability to generate midwave IR (MWIR) and visible scenes over a realistic, +50°C to -35°C, background range. Current low temperature technology is limited to infrared projection while current visible projector technology is limited to operating at temperatures of slightly below room temperature to about 0°C. This effort seeks to produce both RGB and infrared projection devices that can operate with high frame rates at temperatures below -35°C to provide better backgrounds.

Material technology advancements are needed to create a robust multi-spectral, RGB and MWIR, projection device that can operate at temperatures representative of the scene background. At a minimum, characteristics that need to be addressed in the development phase include:

1. Visible and infrared pixels should be the same physical size and less than 40 microns across.
2. Image format needs to be 3 high by 4 wide, with a goal of 9 x 16.
3. Images need to have the same pixel count with resolution of at least 960 x 1280.
4. The image needs to be flickerless.
5. Pixels need to change intensity from max to min or vice versa in a single frame time, typically assumed to be 16.66 msec.
6. Uniformity needs to be less than 20 mK in midwave.
7. Dynamic range needs to be from the uniformity limit to 5500K (sun) in midwave and visible.
8. Operability needs to be 100%, but if outages occur, they need to be OFF (black and cold) and individual pixels (no groups or clumps).
9. Both the visible and IR imaging arrays need to be able to project a sky equivalent background temp of -35°C or less.

PHASE I: Demonstrate the feasibility of an image projection device capable of operating at -35°C or less for visible and IR.

PHASE II: Develop and demonstrate a prototype multi-spectral projection device, based on the Phase I effort, that can operate at low temperatures and be incorporated into an existing projector.

DUAL USE COMMERCIALIZATION: Military application: This technology will be used for scene projection for all imaging EO sensor packages used for reconnaissance, surveillance, and target acquisition (RSTA) applications. Commercial application: This technology can be used to test low-light and visible to IR industrial cameras. The visible portion of this device will have potential for use in digital movie projection.

REFERENCES: 1. Testing a new generation 512x512, >200 Hz capable, Liquid Crystal on Silicon (LCoS) with ferro-electric liquid crystal, IR scene projector , Jack R Lippert, Dynetics, Inc, 2 Clifford Drive, Shalimar, FL, 32579 (850) and Kipp Bauchert, Boulder Nonlinear Systems, Inc., 450 Courtney Way, Lafayette, CO http://bookstore.spie.org/index.cfm?fuseaction=DetailPaper&ProductId=687975&coden=

2. Distributed Test Capability Using Infrared Scene Projector Technology http://www.springerlink.com/content/m2t3p976029vcpm9/

3. Proceedings of SPIE Volume: 6208, Technologies for Synthetic Environments: Hardware-in-the-Loop Testing XI, http://bookstore.spie.org/index.cfm?fuseaction=DetailVolume&productid=634890&showabstracts=1

4. Hardware-in-the-Loop Tools for Next Generation Multi-Spectral Missile Systems, http://www.scs.org/confernc/hsc/hsc02/hsc/abstracts/034.pdf

KEYWORDS: low background, scene projection, multi-spectral, flickerless display, low temperature background, low temperature display

AF073-139 TITLE: Field Sensor for Measuring Total Trihalomethanes (TTHM) Concentrations in Drinking Water

TECHNOLOGY AREAS: Materials/Processes, Biomedical, Human Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a hand-held, field portable, low cost rapid response sensor to quantitatively measure the concentration of TTHMs in water samples.

DESCRIPTION: The Environmental Protection Agency's (EPA) Stage 2 Disinfectants and Disinfection By-Products (DPB) Rule that goes into effect in Oct 2007 stipulates that drinking water distribution systems exceeding the maximum contaminant level (MCL) for TTHMs, 80 micrograms per liter (µg/L) or parts per billion (ppb) calculated using an annual running average for each sampling point, will be required to implement actions to mitigate future elevated TTHM concentrations. Recent TTHM concentrations levels at Edwards AFB and AFRL have ranged from none-detected to 168 ppb.

Currently, TTHMs are analyzed in a certified laboratory using gas chromatography methods. The most widely used are EPA Methods 502.2 and 551.1. These EPA methods are relatively expensive and usually involve laboratory turnaround times of at least two to four weeks. Sandia National Laboratories (SNL) has developed a portable system for the detection of TTHMs. The system weighs 32 pounds and is basically a portable laboratory. The SNL system has been assembled but it has not been field tested; its detection limits still must be quantified.

The rapid response, real time measurement of TTHM concentrations in DOD water systems would be vital to identifying contaminant "hot spots" and allow system operators to implement immediate mitigation measures to prevent MCL violations. However, a rapid, on-site detection method for TTHMs is not available at this time and the traditional methods of sample collection and analysis are slow and costly.

A hand-held compact portable sensor is needed that has the capability of rapidly identifying TTHM concentrations in the 0-200 ppb range, with an operating range from 1-45°C, sensitivity of plus or minus 3 ppb, and measurement time of 5-10 minutes. The preferred design would use no reagents and require little or no maintenance.

PHASE I: Demonstrate the feasibility of a basic design for a device suitable for measuring TTHM concentrations in water.

PHASE II: Develop and demonstrate a prototype device, based on the Phase I results, suitable for measuring TTHM concentrations in water.

DUAL USE COMMERCIALIZATION: Military application: This device will find application at any DOD installation in the United States and abroad which disinfects its potable water system. Commercial application: This device will find application at any public or private drinking water distribution system in the United States or abroad which disinfects its potable water system and monitors TTHM concentrations.

REFERENCES: 1. Real-time Discriminatory Sensors for Water Contamination Events: LDRD 52595 Final Report (http://www.osti.gov/bridge/purl.cover.jsp?purl=/881055-cpuk0Y/).

2. U.S. Environmental Protection Agency, Stage 2 Disinfectants and Disinfection Byproducts Rule (DBP rule) (http://www.epa.gov/safewater/disinfection/stage2/index.html).

3. Safe Drinking Water Act (SDWA).

KEYWORDS: Total Trihalomethanes, Disinfectant By-Products, Safe Drinking Water Act

AF073-140 TITLE: Test and Evaluation Metadata Support Tools

TECHNOLOGY AREAS: Information Systems, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate metadata structures and tools to support the complete test and evaluation process.

DESCRIPTION: The Test & Evaluation (T&E) of military vehicles encompasses a wide variety of data and utilizes myriad systems to generate, store and analyze this data. This data includes sensor data, avionics data, and other data describing the physics and activity of the vehicle during test as well as including analytical derivatives of this raw information. The data also includes numerous documents describing vehicle modification, test plans, flight cards, final test reports, etc, and is often stored in various organizations and (increasingly) at various test facilities or other offices. From a storage and retrieval point of view, this implies many different systems and platforms that must interact with each other.

Various levels of efforts have been (and continue to be) implemented to aid in providing the tools necessary to manipulate this data between these systems. One example of this is the IRIG 106 standard which provides a metadata standard for a specific subdomain of T&E data. However, many of these efforts are local and limited in scope. Indeed, the enormity of the task and the number of systems and organizations does not lend itself to development of a single system solution.

Development of a standardized metadata language describing the types and sources of T&E data is needed to unify the storage, transfer and retrieval of this data across multiple systems. This will require research into existing data and document generation and archival systems within the T&E community as well as researching existing techniques for the development of high level abstraction languages and semantic retrieval techniques. The key characteristics of such a language and related support tools include: semantic retrieval (How do I get data 10 years after it was generated?), ease of semantic entry (How do I easily put in metadata and keywords to facilitate later retrieval?), and ease of data transfer (How do I get everything I need onto my desktop?).

The emphasis of this effort should be on developing an abstraction language that describes data in existing systems – not to develop a new database or system to replace existing databases or systems.

The product of this effort should support and interface with existing and future subdomain metadata standards rather than recreate them. It is expected that the metadata language will be established as a formal, non-proprietary, standard. Although other solutions might be looked at, the use of eXtensible Markup Language (XML) schemas to describe this metadata language appears highly likely. Further, support tools should be integratable with existing systems.

PHASE I: Demonstrate the feasibility of the proposed concept by identifying an initial list of target systems and data to be included in the end product and providing an initial description of the metadata language with initial mappings between systems and an initial description of appropriate support tools.

PHASE II: Develop tools designed in Phase I. Update and improve the metadata language including the mapping of data between systems. Provide demonstrations that the language captures a large percent of the target data and systems. Demonstrate that the tools facilitate semantic retrieval, semantic entry, and data transfer. Work towards having the language adopted as a formal standard.

DUAL USE COMMERCIALIZATION: Military application: The results of this effort will be utilized extensively by the various DoD T&E centers and laboratories as well as other government agencies needing to process large volumes of scientific data. Commercial application: The results of this effort will be utilized by commercial T&E organizations that have the same basic problem of multiple data sources and multiple data storage systems as the government.

REFERENCES: 1. Telemetry Group, Range Commanders Council, IRIG Standard 106-01, Telemetry Standards, Secretariat, Range Commanders Council, U.S. Army White Sands Missile Range, NM, (2001).

2. Thomas Grace and Clay Fink, Metadata For Range Telemetry, Proc. International Telemetering Conf., Vol XXXXII, (2006) Paper 06-10-04.

3. Diamurd Cory, XidML – Two Years On, Proc. International Telemetering Conf., Vol XXXXII, (2006) Paper 06-10-01.

4. John Hamilton, Ronald Fernandes, Paul Koola, and Charles H. Jones, An Overview of an Instrumentation Hardware Abstraction Language, Proc. International Telemetering Conf., Vol XXXXII, (2006) Paper 06-10-02.

5. Michael Graul, Ronald Fernandes, John L. Hamilton, and Charles H. Jones, Enhancements to the Data Display Markup Language, Proc. International Telemetering Conf., Vol XXXXII, (2006) Paper 06-10-04.

KEYWORDS: Data Exchange, Semantic Retrieval, Data Analysis, Data Acquisition, XML, Mathematical and Computer Sciences

AF073-141 TITLE: Portable Biomass Liquid/Gaseous Fuel Reactor

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a portable biofuel reactor for production of high grade alternate liquid and/or gaseous fuels from a variety of readily available feedstock.

DESCRIPTION: The Main Base Landfill at Edwards Air Force Base will reach full capacity by no later than 2017. Many other landfills across the country are reaching their capacity. As landfills reach capacity, the waste streams that were taken to these landfills need to be redirected. This is partially accomplished by transporting the wastes to new landfills, usually requiring greater travel distances for waste haulers (resulting in increased air emissions and fuel consumption), and creating increased environmental impact in the areas in which the new landfills are located.

A preferred alternative is reducing waste streams through diversion (reduce, reuse, recycle). One diversion alternative is the family of processes that use biomass feedstock to create liquid fuels. These processes are generally focused on creating cellulose ethanol and biodiesel, but may also be designed to create methanol, propanol, and butanol. Several of these fuels may be suitable for use in forward deployed fuel cells. Aside from landfill waste, other biomass feedstock includes agricultural wastes and residues, sludge, and forest product residues. The use of these processes also have the ability to reduce the United States' dependency on imported petroleum products, reduce motor vehicle emissions which are harmful to the atmosphere by producing low carbon fuels, and reduce greenhouse gas methane emissions associated with landfills; all of which are mandated in the Executive Order of January 24, 2007, "Strengthening Federal Environmental, Energy, and Transportation Management."

While several processes exist at various stages of development, there are currently no commercially viable production plants in operation. Plants in development are typically large, producing in the range of millions of gallons per year, or not easily relocated or deployed. Military installations, both CONUS and in forward overseas locations generate and must dispose of significant amounts of biomass. While not on the scale of some large commercial and municipal landfills, there still is a potential to generate a significant amount of fuel from this biomass.

The goal of this research effort is to develop the technology needed to design a suitcase to multiple trailer sized, portable, modular or single unit biofuel reactor that can utilize a wide variety of unprocessed biomass feedstock. In addition, the biofuel reactor will need to be easily installed and safely operated with a minimal logistics footprint at developed, remote, and austere locations such as small landfills, construction sites, waste treatment facilities, and forward dining facilities.

PHASE I: Demonstrate the feasibility of a basic reactor design capable of reliably producing a high grade alternative fuel using the widest range possible of biomass feedstock types with minimal or no adjustments or modifications.

PHASE II: Develop and demonstrate a prototype portable biofuel reactor using the technology developed in Phase I to produce a high grade quality fuel from a variety of feedstock.

DUAL USE COMMERCIALIZATION: Military application: A portable biofuel reactor would reduce the amount of waste, generated at military installations at home and abroad, disposed of in local landfill facilities while generating a source of usable fuel. Commercial application: A portable biofuel reactor would allow towns, farms, schools, prisons, sawmills, and others to generate clean burning biofuels while keeping waste out of landfills and wastewater treatment plants.

REFERENCES: 1. Executive Order: Strengthening Federal Environmental, Energy, and Transportation Management, http://www.whitehouse.gov/news/releases/2007/01/20070124-2.html

2. The U.S. Department of Energy (DOE) Biomass Program, http://www1.eere.energy.gov/biomass/

KEYWORDS: Fuel Cell, Biomass, Landfill, Ethanol, Methanol, Deploy

AF073-142 TITLE: Aeroelastic Model Updating

TECHNOLOGY AREAS: Air Platform, Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve the efficiency and safety of planning and conducting flutter envelope expansion testing for military aircraft.

DESCRIPTION: Currently, predictive flutter analysis methods are inadequate for direct applications to manufactured aircraft due to discrepancies between the "as designed aircraft" and the "as manufactured aircraft." DoD requires development of quantitative models for planning and conducting flutter envelope expansion testing for military aircraft. An effective method is required for updating aeroelastic models using the flight test data from the Ground Vibration Test and the first few flutter test points.

One possible approach would be to create a Reduced Order Model through Proper Orthogonal Decomposition or some other model reduction algorithm. A challenge is the limited data available from a flight test as compared to data available from a Full Order Model, and the signal to noise ratio is much lower. Specifically, the flight test data provides accelerometer or strain gage data at dozens of points and almost no aerodynamic data, while the Full Order Model will have hundreds of thousands of data points on the structure, and millions of data points for the fluid dynamics. To get around this limitation it may be possible to develop a blended model that incorporates a model reduction algorithm, that uses much of the data from the Full Order Model and blends in flight test data, such that the results of the reduced order model will produce the same results as the flight test within the uncertainty of the flight test data. Other methods or techniques may also be suitable and should be considered.

PHASE I: Demonstrate the feasibly of a methodology for a blended model that can reproduce the results of a simple structure like the AGARD 445.6 wing for which aeroelastic wind tunnel data is available in the public domain.

PHASE II: Further develop the methodology, demonstrated in Phase I, to be applicable to full aircraft configurations. Develop and produce the requisite software for and documentation of the methodology and apply it to a full aircraft configuration.

DUAL USE COMMERCIALIZATION: Military application: This software will support flight testing of all forms of aircraft or airborne assets. It will also find application in support of ground testing in wind tunnels. Commercial application: This technology can be used in the civilian aircraft industry during test. Industries with aeroelastic stability challenges such as race cars, and disk drive manufacturing could also benefit.

REFERENCES: 1. Mark E. Campbell, Uncertainty Effects in Model-Data Correlation, AIAA-97-1030, AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference and Exhibit, 38th, and AIAA/ASME/AHS Adaptive Structures Forum, Kissimmee, FL, Apr. 7-10, 1997

2. C. Hindman, M. Balas, M. Lesoinne, A Reduced Order Eigenmodel for an Aeroelastic Airfoil, AIAA 2001-4031, AIAA Guidance, Navigation, and Control, 6-9 August 2001, Montrial, Canada.

3. C. Farhat, C. Harris, D. J. Rixen, Expanding a Flutter Envelope Using Accelerated Flight Data: Application to an F-16 Fighter Configuration, AIAA 2000-1702, 41st AIAA/ASMC/ASCE/AHS/ASC SDM, 3-6 April 2000, Atlanta, GA.

4. E. C. Yates, AGARD Standard Aeroelastic Configurations For Dynamic Response I-Wing 445.6, AGARD Report 765, North Atlantic Treaty Organization, Group For Aerospace Research and Development, 1988.

KEYWORDS: Model Updating, Reduced Order Modeling, Proper Orthogonal Decomposition, Aeroelasticity, Flutter, Flight Test

AF073-144 TITLE: <u>Wireless Brake and Tire Monitoring System (WBTMS)</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

TITLE: Wireless Brake and Tire Monitoring Device (WBTMD)

OBJECTIVE: Develop a Wireless Brake and Tire Monitoring Device for use on manned and unmanned aircraft.

DESCRIPTION: The goal of this effort is to develop a handheld wireless brake and tire monitoring device that reduces safety risks and improves flight and ground testing efficiency. Hot brakes and tires adversely impact safe and efficient testing of manned and unmanned aircraft. Brake and tire temperature limits mitigate risk but increase costs due to instrumentation installation, manual data collection, and delays for brake and tire cooling.

Hardwired instrumentation can monitor brake temperatures but is costly to install. Existing handheld instrumentation can monitor brake and tire parameters but incur increased risk to personnel due to the potential for catastrophic tire failure. Tire pressure is not currently measured during taxi tests due to the difficulty of instrumenting a rotating tire.

State of the art wireless pressure and temperature devices used to assess tire conditions on the latest large commercial passenger aircraft are limited to tire pressures below 350 pounds force per square inch (psi) and tire temperatures below 347 degrees Fahrenheit (F). Brake temperature is not measured. Transmission distance is limited to less than two feet requiring hardwired data acquisition/relay hardware be mounted on the landing gear for transmission to the cockpit.

To provide a more accurate assessment of tire condition, development of a robust Wireless Brake and Tire Monitoring Device (WBTMD) is needed with the capability to safely measure and record multiple channels of data, from multiple wheels, for tire pressure and temperature as well as brake temperature in extreme environments.

Advancements in sensors and transmission capabilities for electronics placed in harsh environments are needed to create a robust WBTMD. At a minimum, critical characteristics and performance parameters that need to be addressed in the development phase include:

1. The ability to measure tire pressure, while the wheel is rotating, to at least 1200 psi; well over three times the limits of current commercially available devices,

2. The ability to measure the actual tire temperature (Not just the temperature of the gas within the tire.) to at least 450 F,

3. The ability to measure the brake temperature at multiple points to at least 2,200 F,

4. The ability to simultaneously transmit many multiple channels of temperature and pressure data from sensors over 300 feet in a common format, and not interfere with aircraft avionics, to both mobile and on-board recording/display devices.

5. Can the sensors and associated electronics survive and operate in extreme environments; wet, hot, cold, dust, and high vibration levels?

6. Can the recording/display device be reduced to a handheld unit able to be easily manipulated with heavy gloves for use in cold environments?

PHASE I: Demonstrate the feasibility of a conceptualized design for a WBTMD.

PHASE II: Develop, test, demonstrate, and report the results of a prototype WBTMD based upon the Phase I design.

PHASE III DUAL APPLICATION: Military Applications: A WBTMD could be used in the testing of numerous military aircraft and ground vehicles. It will also be suitable for laboratory and production testing of landing gear, wheels, tires and brakes. Commercial Application: A WBTMD can be used to test/monitor commercial/private aircraft and ground vehicles. It can be used for lab/production testing of landing gear, wheels, tires and brakes used in commercial aircraft.

REFERENCES: 1. Plews, Larry D. and Mandt, Gregory A., Aircraft Brake Systems Testing Handbook, AFFTC-TIH-81-1, Air Force Flight Test Center, Edwards AFB, CA, May 1981.

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KEYWORDS: Wireless, Brake, Tire, Temperature, Pressure, Instrumentation, Manned, Unmanned, Aircraft.

AF073-145 TITLE: Aerothermoelastic Simulation

TECHNOLOGY AREAS: Air Platform, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Research and develop an updating thermal model for aircraft simulations where previous fluid energy assumptions are no longer valid.

DESCRIPTION: The foremost characteristic of hypersonic aerodynamics is considered to be the thermal effects of the flow caused by aerodynamic heating and skin friction that contribute largely to both the aerodynamics and structural response of an aircraft at high (Hypersonic) Mach numbers. Analyzing the shape and structural response of any hypersonic flight vehicle becomes very complicated due to these effects.

In most previous work at subsonic, transonic, and low supersonic Mach numbers the temperature affect has been considered negligible in coupled field predictive tools. Thermal assumptions for modeling and simulation in the past include constant wall (isothermal) and variable wall temperature (adiabatic) boundary conditions that in effect eliminate heat transfer through the wall.

Coupled field technology exists that is capable of accurately representing the aerodynamics (using Computational Fluid Dynamics (CFD)) and the elastic structure (using non-linear Finite Elements), but not the influence of temperature variation. A high-fidelity heat transfer boundary condition must be applied at the wall for an adequate predictive coupled field tool.

A coupled field analysis that includes a model for the fluid, structure, and temperature variations needs to be developed and implemented to perform more realistic aerothermoelastic modeling and simulation. Incorporating these variables will require advanced development of the requisite algorithms to ensure the order of accuracy of the overall simulation is not lost during message passing between the fluid dynamics, the structural dynamics, and thermal dynamics that must take place in order to capture the interaction between these three disciplines. Ideally, a capability for this technology would also be developed and implemented in a Reduced Order Modeling (ROM) environment.

Development and validation should focus on an available CFD-based aeroelastic code that has been validated for a complete aircraft configuration in the subsonic, transonic, and all supersonic flight regimes.

PHASE I: Demonstrate the feasibility of an aerothermoelastic simulation using a coupled field analysis software code that includes energy modeling.

PHASE II: Refine the modeling technologies demonstrated in Phase I into a fully developed and validated coupled field analysis code.

DUAL USE COMMERCIALIZATION: Military application: This effort will benefit the military segment of the aviation industry. The use of a high-fidelity simulation in this field to augment development, prototyping, and testing will be a valuable asset. Commercial application: As demand for future commercial hypersonic vehicles develops, the commercial aviation industry will use this technology for the same reasons as the military.

REFERENCES: 1. John D. Anderson. “Hypersonic and High Temperature Gas Dynamics” AIAA, Inc, Reston, Virginia, 2000.

2. Jack J. McNamara and Peretz P. Friedmann, “Aeroelastic and Aerothermoelastic Analysis of Hypersonic Vehicales: Current Status and Future Trends” AIAA-2006-8058 14th AIAA/AHI Space Planes and Hypersonic Systems and Technologies Conference, Canberra, Australia, Nov. 6-9, 2006.

KEYWORDS: Fluid Structure Interaction, Aeroelastic, Aerothermoelastic, Coupled Field Analysis, instability, modeling, simulation