AIR FORCE
SBIR 06.1 Proposal Submission Instructions

The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the Air Force SBIR Program.

The Air Force 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 (1 Nov through 12 Dec 05), 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 (13 Dec 05 through 13 Jan 06), 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. Information can be found at the following website: **http://www.afrl.af.mil/sbir/index.htm.**

PHASE I PROPOSAL SUBMISSION

Read the DoD program solicitation at www.dodsbir.net/solicitation **for detailed instructions on proposal format and 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 proposals have a 25 page-limit (excluding 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.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** 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, 13 January 2006 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).

Acceptable Format for On-Line Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. 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 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 additional cost proposal information.)

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. 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.

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 January, 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.

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).

NOTE: Even if your company has had no previous Phase I or II awards, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company has never had any SBIR Phase Is or IIs in the past.

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 THIS WORK PLAN

Your proposal work plan section should include the following:

1) Scope

List the major requirements and specifications of the effort.

2) Work Task Plan

Provide an 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 is part of your proposal's 25 page limit and 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) on how funds will be used if the contract is awarded. Include any additional cost proposal information as an appendix in your technical proposal. The additional cost proposal information will not count against the 25 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 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 Phase II proposals must have a complete electronic submission. **COMPLETE** electronic submission includes the submission of the Cover Sheet, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal with any appendices via the DoD submission site. The DoD proposal submission site at http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Your proposal **must** be submitted via the submission site on or before the Air Force activity specified deadline. Phase II Technical proposal is limited to 75 pages. Phase II Cost Proposal information should be provided by completing the on-line Cost Proposal form and including the itemized listing (a-h) specified in the Cost Proposal section earlier in these instructions. The commercialization report, any advocacy letters, and the additional cost proposal itemized listing (a through h) will not count against the 75 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.)

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 uses the same login information as the DoD SBIR / STTR Submission Site. Small Businesses can view information for their company 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 will be within 90 days. If the initial notification indicates the debriefing will be available 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-May. All questions concerning the evaluation and selection process 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).

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)

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

All 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 Contract Data Requirements List (CDRL). Companies **should not** submit final reports directly to the Defense Technical Information Center (DTIC).

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF06-001 thru AF06-011	Directed Energy Directorate AFRL / DE 3600 Hamilton Ave. SE Kirtland AFB NM 87117-5776	Ardeth Walker (505) 846-4418	Ernestine Stewart (505) 846-0150
AF06-015 thru AF06-045	Human Effectiveness Directorate AFRL / HE 2610 Seventh Street, Bldg. 441 Rm 216 Wright-Patterson AFB OH 45433-7901	Sabrina Davis (937) 255-2423 Ex 226	LeeAnn Haughton (937) 656-9032
AF06-047 thru AF06-077	Information Directorate AFRL / IF 26 Electronic Parkway Rome NY 13441-4514	Janis Norelli (315) 330-3311	Lori Smith (315) 330-1955
AF06-079 thru AF06-121	Materials & Mfg. Directorate AFRL / ML 2977 Hobson Way, Rm 406 Wright-Patterson AFB, OH 45433-7746	Marvin Gale (937) 255-4839	Terry Rogers (937) 656-9001
AF06-123 thru AF06-153	Munitions Directorate AFRL / MN 101 West Eglin Blvd. Suite 143 Eglin AFB, FL 32542-6810	Jill Barfield (850) 882-8591 Ex 1204	Judie Jacobson (850) 882-4294
AF06-162 thru AF06-189	Propulsion Directorate AFRL / PR 1950 Fifth Street Wright-Patterson AFB, OH 45433-7251	Laurie Regazzi (937) 255-1465	Susan L. Day (937) 255-5499
AF06-190 thru AF06-196	Propulsion Directorate AFRL / PRO 5 Pollux Drive Edwards AFB, CA 93524-7033	Chanda Smith (661) 275-5617	Melissa Petter (661) 277-9553

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF05-197 thru AF06-223	Sensors Directorate AFRL / SN 2241 Avionics Circle, Rm N2S24 Wright-Patterson AFB, OH 45433-7320	Marleen Fannin (937) 255-5285 Ex 4117	Sharon Hall (937) 656-9828
AF06-231 thru AF06-244	Air Vehicles Directorate AFRL / VA 2130 Eighth Street Wright-Patterson AFB, OH 45433-7542	Madie Tillman (937) 255-5066 Larry Byram (937) 904-8169	Douglas Harris (937) 255-3427
AF06-245 thru AF06-284	Space Vehicles Directorate AFRL / VS 3600 Hamilton Ave SE Kirtland AFB, NM 87117-5776	Danielle Lythgoe (505) 853-7947	Francisco Tapia (505) 846-5021
AF06-292 thru AF06-294	Air Armament Center 46 TW / XPXR 101 West D Avenue Bldg. 1 Rm 210 Eglin AFB, FL 93524-6843	Ramsey Sallman (850) 883-0537	Vicki Keider (850) 882-0170
AF06-297 thru AF06-306	Arnold Engineering Development Center AEDC / DOT 1099 Avenue C Arnold AFB, TN 37389-9011	Ron Bishel (931) 454-7734	Kathy Swanson (931) 454-4409
AF06-311 thru AF06-320	Air Force Flight Test Center AFFTC / XPDT 307 East Popson Ave, Bldg.1400 Edwards AFB, CA 93524-6843	Abraham Atachbarian (661) 277-5946	Lisa Jackson (661) 277-7708
AF06-325 thru AF06-332	Oklahoma City Air Logistics Center OC-ALC / ENET 3001 Staff Drive, Suite 2AG70A Tinker AFB, OK 73145-3040	Oscar Diaz-Valle (405) 736-2158	Joe Starzenski (405) 739-5510

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF06-338 thru AF06-347	Ogden Air Logistic Center OO-ALC / LHH 6021 Gum Lane Hill AFB, UT 84056-2721	Craig Shaw (801) 586-2721	Mark McInnis (801) 775-2377
AF06-350 thru AF06-356	Warner Robins Air Logistic Center WR-ALC / ENES 450 Third Street, Bldg. 23 Robins AFB, GA 31098-1654	Greg Sutton (478) 926-1132	Nita Steinmetz (478) 926-3695

AirForce SBIR 06.1 Topic Index

AF06-061	Multi-INT Ontology Mediation Services
AF06-062	Reprogrammable High Assurance Internet Protocol Encryptor
AF06-063	Asymmetric Adversary Tactics and Strategy Generation
AF06-064	Automated Signal Processing for Information Exploitation
AF06-065	Acquiring Probabilistic Knowledge for Information Fusion
AF06-066	Systems-of-Systems Data Utilization Patterns
AF06-067	Robust Complex Systems
AF06-068	Cyber Operations
AF06-069	Advanced Radio Frequency and Optical Connectivity to support Network-Centric Operations
AF06-070	Innovative Command and Control (C2) Technologies to Enable Force Synchronization for Effect
AF06-071	TACTICAL INFORMATION INTEROPERABILITY & MANAGEMENT (TIIM)
AF06-072	Locating and integrating members for virtual ad-hoc teams
AF06-073	Collaborative Sense Making
AF06-076	Anticipatory Capabilities for Complex, Dynamic Environments
AF06-077	Command Decision Support and Explanation from Fused Structured and Unstructured Information Sources
AF06-079	Data Fusion of Eddy Current, Ultrasonic, and Radiographic Data
AF06-080	Nonfluid Transportable Aircraft Deicing System
AF06-081	Recycling Composite Material
AF06-082	Affordable Manufacturing for Lightweight High Thermal Conductivity Graphite Heat Sinks for Fighter Avionics Modules
AF06-083	Coolanol 25R Replacement for Military Aircraft Radar Cooling Systems
AF06-084	Friction Stir Welded Aluminum Machining Preforms
AF06-085	Nanocomposites for Lightweight Electronic Enclosures
AF06-086	Net Shape Forming of Ceramic Matrix Composites
AF06-087	Warpage/Distortion in Machining 7050-T7451 Alloy Components
AF06-088	Protective Coating for Large-Diameter Bearing Races
AF06-089	Innovative Corrosion Protection via Cold Spray Kinetic Metallization
AF06-090	Clutch Material for Aircraft Vertical Takeoff Systems
AF06-091	Corrosion Modeling and Life Prediction Supporting Structural Prognostic Health Management
AF06-092	Automated Delamination Onset and Growth Prediction in Composite Structures
AF06-093	Techniques for Producing High Strength, Affordable Spinel Windows
AF06-094	High Performance Cage Sensors for Rolling Element Bearing Health Monitoring
AF06-095	Three-Dimensional Nonlinear Structural Analysis Methods for Gas Turbine Engine Metallic Components and Component Assemblies
AF06-096	Wear Resistant Coatings for Aluminum and Titanium Alloy Housings and Flanges
AF06-097	Damage Identification Algorithms for Composite Structures
AF06-098	Erosion Resistant Coatings for Polymer Matrix Composites
AF06-099	Methodologies for Integration of Prognostic Health Management Systems with Maintenance Data
AF06-100	Improved Additives for Perfluoropolyalkylether (PFPAE) Lubricants with Silicon Nitride Rolling Elements
AF06-101	Advanced Prognostic Health Management Technologies Using Integrated Detection Techniques with Physics of Failure Mode
AF06-102	Aircraft Damage Locator
AF06-103	Advanced Manufacturing Processes for Reduced Cost of Ceramic Matrix Composite Engine Components
AF06-104	Three-Dimensional Deformation and Life Prediction Methods for Ceramic Matrix Composite Components
AF06-105	Solid Rocket Motor Nozzles Made From Tantalum Carbide Continuous Fiber Composites for Boost Applications
AF06-106	Lightweight Conformal Electromagnetic Interference (EMI) Shielding
AF06-107	Air Sensor for Hydraulic Fluid
AF06-108	Integrated Materials for Efficient Airframe Structures
AF06-109	Photo-Electrochemical Generation of Hydrogen for Fuel Cell Operation
AF06-110	Materials for Terahertz Frequencies
AF06-111	Materials for Midinfrared (mid-IR) Laser Sources

AF06-112 Continuous Runway Load-Deflection Evaluation Methodology
AF06-113 Advanced Detection of Improvised Explosive Devices (IEDs)
AF06-114 Improved Manufacturing Technology for Investment Casting Cores
AF06-115 Improved Manufacturing Technologies for Polymer Matrix Composite Engine Components
AF06-116 Corrosion Prediction for Nonchrome Based Coatings Systems
AF06-118 Resistant Coatings for Metal Turbine Blades
AF06-119 High Temperature Sensors for In Situ Interrogation of Damage States in Structural Materials Components
AF06-120 Manufacturing Structures in a Limited Production Environment
AF06-121 Graphical User Interface for Fire Modeling Codes
AF06-123 Analytical Techniques for Complex Logic Devices in Safety-Critical Applications
AF06-124 Air Target Sensor Techniques for Automatic Target Recognition (ATR)
AF06-125 Miniature Wide Band Power Amplifiers for Miniature Munitions
AF06-126 Airframe Materials for Hypersonic Tactical Missiles
AF06-127 Techniques for Remotely/Autonomously Detecting and Destroying Chem/Bio Agents
AF06-128 Modeling and Simulation of Biological Agent Response to Combustion Effects
AF06-130 Improved Omnidirectional Multiband Antenna for Miniature Munitions
AF06-131 Measuring Particulate Entrained Mass-Flow from Internal Detonations
AF06-132 Fatigue Resistant Wire for Airborne Applications
AF06-133 Multi-mode Weapon Algorithms for Future Miniature Munitions
AF06-135 Novel Power Supply for Miniature Munition
AF06-136 Desensitizing Weapons Via Multi-part Explosives
AF06-137 Novel Multi-mode Seeker Dome for Miniature Munitions
AF06-138 Self Healing Materials for Airframe Structures
AF06-139 Airborne Radar Ground Clutter Mitigation
AF06-140 NOVEL INFRARED (IR) EMISSIVE DEVICES
AF06-141 Micro Munition Technologies
AF06-142 Advanced LADAR Research for Munition Seekers
AF06-143 Home on Structured Interference/Multipath
AF06-144 Micro Fuel Cell (MFC) for Micro Air Vehicle (MAV) Power
AF06-145 Innovative Fuze Technology Research
AF06-146 Electro-Explosive Effects (E-Cubed, E3)
AF06-147 Micro Damage Mechanisms
AF06-148 Biologically Inspired Adhesive Microstructure
AF06-149 Collision Avoidance
AF06-150 1.6 Hazard Class Detonator
AF06-151 Synthetic alternative binder systems for melt castable explosive fills.
AF06-152 Telemetry and Flight Termination System Technologies
AF06-153 Novel Thermal Management Solutions for Confined Electronics
AF06-162 Identification of Integrally Bladed Rotor (IBR) Damping
AF06-163 Thermal Barrier Coatings (TBC) Lifing Technologies
AF06-164 Development of Hydrocarbon-Based Solid Oxide Fuel Cells (SOFCs)
AF06-165 Low-Weight, Low-Cost Sensors and Low-Overhead Processing Algorithms for Damage Detection in Aircraft Disk and Blade Propulsion Turbomachinery
AF06-166 Accessory Health Management Based on Very High Frequency (VHF) Characteristics
AF06-167 Sensor and Control for Active Combustion Pattern Factor Systems
AF06-168 Thermal Barrier Coating (TBC) Process Condition Monitoring
AF06-169 Smart Ceramic Matrix Composite (CMC) Technologies
AF06-170 Energy Harvesters/Storage System for Onboard Power for Remote Micro-electromechanical Systems (MEMS) Sensors/Devices with Long Mission Times
AF06-171 Health Management for Gas Turbine Engine Accessory Components
AF06-172 Probabilistic Analysis of Military System Development Program
AF06-173 Exploration of Lithium-Ion (Li-Ion) Battery for Space Application
AF06-174 Power and Aeropropulsion
AF06-175 Nanoparticle Synthesis and Coating for Exchange Coupled Permanent Magnets
AF06-176 Combustion Evaluation Device for Hypersonic Propulsion

AF06-177 Reduced-Order Stability Model for Combustion Systems
AF06-178 Prognostics for Switch-Mode Power Supplies (SMPS)
AF06-179 Advanced Composite Analysis Capability for Advanced Manufacturing Methods
AF06-180 Long-Endurance Power Systems for Small Unmanned Aerial Vehicles (UAVs)
AF06-187 Advanced Composite Blade Design
AF06-188 Ignition and Efficient Combustion of Alternative Scramjet Fuels
AF06-189 Electrical Contacts and Packaging for Diamond and Diamondlike High-Power Devices
AF06-190 Development of Computed Tomography (CT) Software Techniques for Detecting Aging of Rocket Motors
AF06-191 Improved Computed Tomography(CT) Imaging of High Z Materials
AF06-192 Small Launch Vehicles Providing Responsive and Affordable Spacelift
AF06-193 Advanced Rocket Propulsion Technologies
AF06-194 Innovative Rocket Propellant Ingredients
AF06-195 Electrically Conducting Polyhedral Oligomeric Silsesquioxane (POSS) Kapton Polyimides.
AF06-196 Propellant Ingredients for Solid Rocket Motors
AF06-197 Navigation-Grade Microelectromechanical Systems (MEMS) Inertial Measurement Unit (IMU)
AF06-198 Network-Centric Warfare Connectivity for Electronic Attack
AF06-199 Real-Time Digital Receiver Rapid Prototyping Testbed
AF06-200 Digital Receiver Geolocation Technology Simulation
AF06-201 Simulation Technologies to Rapidly Evolve EA Sensor Resource Management Concepts
AF06-202 Integration of Risk Analysis into Acquisition Cost, Schedule, and Performance Evaluation Tools
AF06-203 Automatic Self-Tasking for Dynamic Sensor Management
AF06-204 Long-Duration, Eye-in-the-Sky Monitoring for Airfield Threat Detection
AF06-205 Multiband Array Radiators
AF06-206 High-Efficiency Extremely High-Frequency (EHF) Power Amplifiers
AF06-207 Ground-Based Radar Performance Improvements
AF06-208 Adaptive Signal Processing to Counter Jamming
AF06-210 Hyperspectral Algorithms for Anomaly Detection
AF06-211 Two-Color Infrared (IR) Simulation Tools
AF06-212 Indium Antimonide Substrate Growth for Affordable Large-Format Mid-Infrared (IR) Imagers
AF06-213 Low-Cost, High-Performance Inertial Rate Sensors
AF06-214 Low-Profile Tamper Detection Sensors
AF06-215 Lightweight, Miniature Sensor Payload for a Mini-UAV
AF06-216 Coatings for Millimeter Wave (MMW) Electronics
AF06-217 Signature Prediction and Uncertainty Analysis for Recognition Applications
AF06-218 Hyperspectral Identification for Collaborative Tracking
AF06-219 Signal Processing and Exploitation for High-Dimensional Synthetic Aperture Radar (SAR)
AF06-220 Passive Three-Dimensional (3-D) Imaging and Ranging
AF06-221 Low-Cost Day/Night Imaging Sensors for Micro/Mini-Uninhabited Aerial Vehicles (UAVs)
AF06-222 Hyperspectral Detector Enhancement Using Auxiliary High-Resolution Imagery
AF06-223 Multi-Phenomenology Sensing and Sensor Control in Unmanned Intelligence Vehicle (UIV) for ATR and Tracking of Dismounts and Vehicles
AF06-231 Load Bearing Antenna Structure for Small Unmanned Air Vehicles (SUAV's)
AF06-232 High-Speed Valves for Smart-Material Based Electrohydrostatic Actuators (EHAs)
AF06-233 Automating Error Quantification and Reduction for Computational Fluid Dynamics (CFD)
AF06-234 Innovative Structural Joining Concepts and Analysis Techniques
AF06-236 Sense and Control for Efficient Aerostructure
AF06-237 Rapid Mission Planning and Operation for Space Access Vehicles
AF06-238 Unmanned Aerial Vehicle (UAV) Ground Operations Positioning System (UGOPS)
AF06-239 Structural Energy Storage in Air Vehicle Structure
AF06-240 Geometry Manipulation Through Automated Parameterization (GMAP)
AF06-241 Innovative Near Space (High Altitude Air) Platform Technologies
AF06-242 Sensors for Electromagnetic Interference (EMI) Immune Fly-By-Light (FBL) Systems
AF06-243 Surface Measurements – Flow Field Correlations Resulting in Applicable Cavity Flow Field Control
AF06-244 All-Surface Landing Capability Development

AF06-245	Accurate, Stable Clock for Small Low Power Anti-Jam GPS User Equipment
AF06-246	Sensing of Upper Atmosphere
AF06-248	Real-Time Specification of Battlespace Environment
AF06-250	Radar Ionospheric Impact Mitigation
AF06-251	Electro-Optical (EO) Sensor Management
AF06-252	Advanced Algorithms for Exploitation of Space-Based Optical Spectral Imagery
AF06-253	Low Power GPS Signal Acquisition Using Asynchronous Logic
AF06-254	Home-on-Jam Technologies
AF06-255	Optical Jitter Control for Laser Communications
AF06-256	Next Generation Programmable Gate Array
AF06-257	Advanced Transmitter and Receiver (T/R) Module Technology For Space Radar
AF06-258	Electronically Scanned Array (ESA) Performance Prediction Model
AF06-259	Space Radar Reflector Producibility
AF06-260	Satellite Programmable Frequency Transceiver
AF06-261	Standardized Satellite Electrical Internal Interface
AF06-263	Space Object Characterization with Space Based Hyperspectral Imagery
AF06-264	Prognostic Models for Cryo Cooling (Heat Transfer and Heat Dissipation) Systems
AF06-265	Advanced Prognostics Technology for Digital-Based Electronic Systems and Their Components
AF06-267	Tunable Spectral Response in Space-Based Systems
AF06-268	New Sensing Capabilities for Space Situational Awareness
AF06-269	Cold Atom Optical System for Space
AF06-270	Autonomous Flight Termination & Satellite Based Telemetry System for Launch Vehicles
AF06-271	Lightweight Hybrid Radio Frequency (RF) and Optical Instrument
AF06-272	Satellite Design Automation (SDA) for Responsive Space
AF06-273	Plug-and-Play Structures for Satellite Applications
AF06-274	Next Generation Solar Cells Based on Nanostructures
AF06-276	Combining Remotely Located GPS Antennas
AF06-277	Reliable, Lightweight and Volume Efficient Electrical Harnessing
AF06-283	Threat Detection, Validation, and Mitigation Tool for Counterspace and SSA Operations
AF06-284	Miniature Frequency Agile RF Beacon Receivers for Ionospheric Effects Monitoring
AF06-292	Intumescent Material Passive Fire Protection Technique for Aircraft Engine Nacelle
AF06-293	Electronic Virtual Thermal Mapping Device
AF06-294	Mutil-mode Sensor Characterization
AF06-297	Develop Flow-Field Seeding for Large Tunnels
AF06-298	Non-Invasive Model Attitude and Deformation Measurement
AF06-299	Aeropropulsion Test Facility Diagnostics
AF06-300	Hypervelocity Projectile Position, Angle of Attack, and Velocity Detection System
AF06-301	Gas Turbine Particle Matter Emission Characterization
AF06-302	Volatile Particle Condensing Chamber for Turbine Engine Emissions
AF06-303	Telemetry for Testing Applications
AF06-306	Optical /Technology for Cryo-Vacuum Mirrors
AF06-311	Directed Energy Targets with Un-hardened Electronics
AF06-312	Threshold-capable Multi-wavelength High Energy laser Protection
AF06-313	Optimization of Parameter Identification for Flutter and Flying Qualities
AF06-314	Aeroservoelastic Predictive Analysis Capability
AF06-316	Noncoherent Telemetry Demodulator
AF06-317	Automated Analysis of Datalink Transmissions (AADT)
AF06-318	Identification and Tracking of Juvenile Desert Tortoises
AF06-320	Ground Loads Predictive Analysis
AF06-325	Automation of Analysis of Digital X-Ray Images
AF06-326	Environmentally Friendly Cleaning for Titanium Welds and Brazing
AF06-327	Dielectric Measuring Tool for Radome Checkout
AF06-328	Coating Application using Liquefied Powder
AF06-329	Next Generation Supply Chain Management Practices, Processes and Systems
AF06-330	Advanced MRO Multi-Echelon Planning and Scheduling
AF06-331	Filtration of Used Non-destructive Testing Fluids

AF06-332	Use of Environmental Forensics for Trichloroethylene (TCE) Plume Delineation
AF06-338	Noninvasive Pressure Measurement of Aircraft Pressurized Lines
AF06-339	Advanced Frangible Composite Structure
AF06-340	Tiled Ultra High-Resolution Light Engine
AF06-341	Advanced Rigid Composite Tower
AF06-342	Thermoplastic Large, Ground-Based Radomes
AF06-344	Multi-spectral Physics-based Projector
AF06-345	Blast-Resistant Composite Panels for Composite Tactical Shelters
AF06-346	Delamination and Water Intrusion Detection
AF06-347	Low Cost Wear Resistant Surfaces for Composite Shelter
AF06-350	Medium Caliber Gun Barrel Bore Coatings
AF06-351	Eliminating Legacy Performance Barriers Imposed on New Systems
AF06-353	High Efficiency Flexible Photovoltaic Modules
AF06-354	Noise Suppressor (Hush House) Fire Suppression
AF06-355	Damage Detection and Identification in Composites
AF06-356	Damage Detection and Identification of Adhesive Bonding in Metal Components

AirForce SBIR 06.1 Topic Descriptions

AF06-001 TITLE: High Power Optical Amplifier

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative designs and concepts to enhance reliability and output power of High Power Optical Amplifier (HPOA) for SATCOM Laser Communications

DESCRIPTION: Tomorrow's warfighters will require significantly greater battlefield bandwidth to access all of the information required to maximize mission effectiveness. Historically, SATCOM (Satellite Communications) has played a key role in providing bandwidth to remote battlefield locations, and laser communications based SATCOM offers more than a three order of magnitude increase in communications capacity over existing RF (Radio Frequency) based SATCOM. Since High Power Optical Amplifiers (HPOAs) are an enabling technology for laser communications, the availability of HPOA's promotes warfighter's mission effectiveness. Given that the useful operating lifetime communications satellites can exceed twenty years, HPOA reliability is crucial to cost effective delivery of bandwidth to the warfighter. This topic seeks to advance the state of the art of HPOA, particularly with respect to reliability and output power. Goals include optical bandwidth of 1450 and 1500 nm [TBR], minimum gain of 20 dBm [TBR], minimum output power 500 mW[TBR], noise < 3 dB[TBR], output power variation < .5 dB[TBR], isolation > 30 dB[TBR], optical input power (typ) 4 dBm[TBR], operating temperature range between –40 degrees C and +80 degrees C, weight < 2 lbs. The HPOA should be capable of withstanding 300 krads total dose, heavy ions to linear energy transfer (LET) 60, and dose rate to 108 rads/sec.

PHASE I: Evaluate HPOA design options leading to enhanced reliability. Design HPOA and simulate operation over a broad range of environmental and temperature ranges.

PHASE II: Fabricate a minimum of eight prototype HPOAs. Characterize for power output, wavelength, mean time to failure, operating temperature range, and radiation tolerance.

DUAL USE COMMERCIALIZATION: High power optical amplifiers have numerous commercial and military applications, including transmission of data over fiber optic lines.

REFERENCES: 1. S.G. Lambert and W.L. Casey, "Laser Communications in Space", Norwood, MA: Artech House, Inc., 1995

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KEYWORDS: High Powered Optical Amplifier, Satellite communications, Wavelength,. Bandpass, Laser communications, Output power

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AF06-002 TITLE: Spatial Resolution and Conformal Boundaries Within EM-PIC Simulations

TECHNOLOGY AREAS: Information Systems, Weapons

OBJECTIVE: Develop a strategy for handling complex features within an electromagnetic - particle-in-cell (EM-PIC) model which maintains at least second order global accuracy. Convergence should be demonstrated.

DESCRIPTION: Many of the numerical tools which are used in the design and testing of HPM sources are built upon FDTD techniques and rely on a tensor product grid with stair stepped boundaries. This combination requires globally a very fine resolution grid to accurately predict the effects of small scale features. Furthermore, due to the stair-stepping boundary approximation, the global order reduces to first order for sufficiently high resolution. Even on todays massively parallel computers, it is unfeasible to solve this problem with resolution alone. Traditionally for pure electromagnetics these issues are overcome with one of the three techniques; body fitted coordinates [1], fractional cell or mixed boundary elements[2,3] or fully unstructured mesh techniques[4]. These techniques have various advantages and disadvantages which are very problem dependent. Currently none of these techniques have been shown to be feasible for a large scale EM-PIC codes, which implies not only do these techniques need to maintain a high level of accuracy, they also need to be energy conserving, scale to large numbers of processors and support particles.

PHASE I: The goal of Phase I is threefold: first, a survey of techniques which are capable of solving the complex geometry problem; second, identification of a solution technique; third, prototype implementation into either a test code or AFRL provided model. Prototyped implementation should be verified.

PHASE II: The goal of Phase II is implementation of the algorithms into fully functioning codes, complete with particle emission and propagation. Algorithm should be shown to be scalable, stable and globally second order accurate for problems defined in Phase I. Issues such as self force, grid heating, non-physical radiation and self heating should also be mitigated.

DUAL USE COMMERCIALIZATION: As well as electromagnetic generation, a conformal PIC code would also help in the simulation of the following defense related technologies; plasma opening switches, ion propulsion, and hypersonic drag reduction. A conformal PIC code would also help in simulating plasma processing (etch and deposition) and fluorescent lamps, which would have industrial impact. In addition, conformal boundaries would help many areas of basic plasma research such as dusty plasmas, particle accelerators, Q-machines, Malmberg-Penning traps, magnetic fusion plasmas and laser-plasma interaction.

REFERENCES: 1. Karmesin, S.R., P. C. Liewer, and J. Wang, "3D Electromagnetic Parallel PIC in Nonorthogonal Meshes", Plasma Science, IEEE International Conference on June 5, 1995. http://sciserv er.lanl.gov:80/cgi-bin/sciserv.pl?collection=confs&journal=ieee1912& issue=v1995i0506&article=138_3eppinm.

2. Railton, C. and J. Schneider, "An Analytical and Numerical Analysis of Several Locally Conformal FDTD Schemes," IEEE Trans. on Microwave Theory and Tech., Vol. 47, 1999, pp. 51-66.

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4. Hesthaven, J. and T. Warburton, "Nodal High-Order Methods on Unstructured Grids, I. Time-Domain Solution of Maxwell's Equations," J. Comp. Phys., Vol. 181, 2002, pp. 186-221.

KEYWORDS: microwaves, electromagnetic, PIC, FDTD, non-conformal boundaries,

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AF06-003 TITLE: Traveling Wave Marx Generator

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Development of a fast, repeatable, high rep rate Marx generator system using traveling wave triggering techniques.

DESCRIPTION: This effort will develop and demonstrate design concepts for a compact, lightweight pulsed power generator system capable of delivering pulse repetition frequencies (PRFs) of several kilohertz (kHz) at voltages ranging from 50-300 kilovolts (kV) into an approximately 100 ohm load. Present pulsed power generators are generally centered around two primary technologies: resonant transformers and Marx generators. Whereas resonant transformer technology is capable of producing voltages on the order of 1 Megavolt (MV) and PRFs of several kHz, they are generally heavy due to the large volume of insulating oil required. Marx generators, on the other hand, can be made very compact and lightweight, especially when designed to drive impulsive sources. However, their performance is usually limited to <100 Hz and exhibit large erection jitter. For future DoD applications, it is desirable to develop lightweight pulsed power technology that will deliver consistent, low jitter performance at higher PRFs. Precision triggering and low erection jitter are keys to performance. The use of traveling wave switches is a possible solution to this problem.

PHASE I: Perform innovative research on available or completely new pulsed power generator concepts. Phase I will build and test a working model capable of at least 30 kV and 1 second bursts of fast, low jitter, pulses. Develop an initial commercialization concept and plan.

PHASE II: Develop and demonstrate a prototype high-PRF Marx generator capable of delivering the required output. Develop a business and commercialization plan for the Phase II engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military application: Military uses of this technology include airborne and ground-based pulsed radar systems and high power microwave systems. Civilian sector applications include pulsed radar, counter mine, and numerous manufacturing applications.

REFERENCES: 1. C.E. Baum, “Traveling-Wave Switches and Marx Generators,” Switching Note 33, Air Force Research Laboratory/DEHP, Kirtland AFB NM, March 2005.

2. C. E. Baum and J. M. Lehr, "Parallel Charging of Marx Generators for High Pulse Repetition Rates," Ultra-Wideband, Short-Pulse Electromagnetics 5, P.D. Smith and S.R. Cloude, eds, Plenum Press, New York, 2002.

3. J.R Mayes and W.J. Carey, “Sub-nanosecond Jitter Operation of Marx Generators,” Proc. International Pulsed Power Conference, 2001.

4. F.E. Peterkin, et al., “Modular Compact Marx Generator,” Proc. AMEREM 2002 Conference, Annapolis MD, June 2002.

KEYWORDS: Marx Generator, Pulsed Power, High Voltage, High Repetition Rate, High Power Microwave

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AF06-004 TITLE: Radio Frequency Effects on Electronics Algorithm

TECHNOLOGY AREAS: Information Systems, Electronics, Weapons

OBJECTIVE: Develop and demonstrate time-dependent, multi-conductor, transmission line (MTL) algorithms for analyzing the electromagnetic coupling effects on cables and active electronics due to unwanted, ultra-wideband, radio-frequency wave exposures based on the electromagnetic topological decomposition formulation.

DESCRIPTION: The key aspects of modeling the electromagnetic coupling effects on cables and active electronics deal with: 1) the treatment of electromagnetic (EM) coupling between chaotic, ultra wideband (UWB) signals and shielded MTLs, and 2) the process involved in decomposing a complex electromagnetic network system into smaller and manageable modular pieces by developing detailed electromagnetic coupling models for different modular pieces. The intent of this work is to come up with electromagnetic coupling effects software, which is based on the MTL formulation for analyzing the electromagnetic coupling effects of packaged, linear and nonlinear electronic circuit boards, located inside semi enclosed cavities, such as personal computers, buildings, vehicles and aircraft. To date, all known transmission line software have very limited capabilities. One such code developed commercially in 1990, the CRIPTE code, is limited to analyzing linear electromagnetic network systems because of the use of the frequency domain approach. Another transmission line code, called NULINE, was developed back in 1996, and it uses either the frequency domain approach or the time domain approach; however, the time domain approach is limited strictly to a single wire over a perfectly or imperfectly conducting ground plane. These limitations came about mainly because these codes are written more than 10 years ago with limited computational power available at that time. With advent of more powerful computers, it is now possible to develop time-dependent, MTL software that can investigate computationally intensive electromagnetic coupling effects on not just shielded cables but on large apertures and re-radiation off the cables by coming up with more sophisticated lumped circuit models in dealing with the overall response of active linear and nonlinear electronic elements excited by UWB signals. The frequency band of interest for this project is 200 megahertz to 10 gigahertz.

PHASE I: Perform survey of the physics behind UWB coupling on cables and active printed circuit boards in the open literature. Apply innovative mathematical/numerical techniques for EM topological decomposition modeling for solving complex electromagnetic networks of shielded cables and active electronic components under chaotic UWB exposure to perform transient EM effects analysis.

PHASE II: Develop and demonstrate the time-dependent, shielded, MTL algorithms. Come up with a software package, consisting of the MTL coupling effects software and the graphic user interface (GUI) program, which can be tested with existing UWB systems. The GUI program shall be developed specifically for the purpose of decomposing a complex electromagnetic network that can be interfaced directly with the MTL coupling effects software. Will require a business and commercialization plan for marketing this technology.

DUAL USE COMMERCIALIZATION: Military uses of this technology combined with other Maxwell solvers to carry out the susceptibility and vulnerability analysis of complex electronic systems due to unintentional high power microwave irradiation. Civilian applications include methods to harden and protect commercial electronic systems from unwanted strong radio-frequency wave exposure.

REFERENCES: 1. F. M. Tesche, M. V. Ianoz and T. Karlsson, "EMC Analysis Methods and Computational Models," A Wiley-Interscience Publication, John Wiley & Sons. Inc., New York, 1997.

2. C.E. Baum, “Some Simple Formulae for Transient Scattering,” Interaction Notes 558, Air Force Research Laboratory, Kirtland AFB, NM, February 2000.

3. ESI Group, http://www.esi-group.com/SimulationSoftware/, CRIPTE code.

4. J. P. Parmantier and P. Degauque, “Modern Radio Science 1996,” pp. 151-177, “Topology Based Modeling of Very Large Systems,” J. Hamelin (ed.), Oxford U. Press, 1996.

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KEYWORDS: High Power Microwave, Ultra-wideband, Electromagnetic Transient Analysis, Computational Electromagnetics, Electromagnetic Coupling, Telegrapher’s Equation, S-Parameter Analysis

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AF06-005 TITLE: Transportable Ultrashort Pulsed Laser Systems and Technology

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Demonstrate novel concepts for generating and amplifying ultrashort (fs-TW) laser pulses using architecture amenable to mobility.

DESCRIPTION: The Air Force is interested in promoting and conducting innovative research on promising new technologies relevant to the development of femtosecond Terawatt (fs-TW) laser systems that have a minimal number of optical elements, high average power, excellent beam quality, and are easily portable. Ultrashort pulsed laser technology has advanced rapidly in the last 10 years. Numerous domestic & international programs have demonstrated pulsed laser systems with peak powers in the Terawatt and even Petawatt ranges and average powers approaching the kilowatt (kW) level. These high intensity ultrashort lasers have been shown to have interesting propagation and materials interaction properties. Unfortunately, traditional ultrashort laser systems are complex and not particularly well suited for applications which require maintenance-free and mobile operation because they typically incorporate complicated optical trains with many reflective surfaces. The ideal fs-TW system is one in which the oscillator and amplifiers are monolithic - a single solid state material engineered to incorporate all of the optical elements necessary to generate and/or amplify an ultrashort laser pulse. In particular, the pulse stretching and compression techniques require complicated optical elements with large gratings. Potential oscillator candidates include mode-locked semiconductor lasers, fiber lasers, and solid-state laser oscillators. Potential amplifier candidates include semiconductor amplifiers, diode pumped fibers, diode or fiber laser pumped thin disks, and laser pumped gases (contained within a hollow core fiber). Candidate concepts must be capable of producing very high peak energy pulses, with high average power (that is high repetition rate) and excellent beam quality. Furthermore, the overall system must have a high degree of reliability, require minimal maintenance, and have a variable pulse frequency and operational mode (eg. kHz, sub-kHz, and burst mode operation). Finally, high overall energy efficiency is a critical consideration for mobility. System integration issues must be considered. For example, the individual components within the overall system must be compatible with one another and produce an efficient and conveniently packageable ultrashort pulsed laser system.

PHASE I: Identify, model, and/or demonstrate a promising fs-TW system or components. Although laboratory demonstrations at the TW power level are likely to be beyond the scope of a Phase I effort, a clear scaling path including component demonstrations and modeling to the desired power is essential.

PHASE II: Model, build, and demonstrate a suitable fs-TW system that meets the notional requirements identified above. If appropriate, build and demonstrate a portable prototype version of the system. Initiate system studies to determine packaging, size, and weight requirements for the overall system.

DUAL USE COMMERCIALIZATION: Possible applications include industrial welding, beacons and illuminators for upper atmosphere remote sensing, and as a portable source for material interaction studies.

REFERENCES: 1. Koechner, W., "Solid-State Laser Engineering," 5th ed., Springer Series in Optical Sciences, ed. A.L. Schawlow, A.E. Siegman, and T. Tamir, Vol. 1. 1999, New York: Springer-Verlag.

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KEYWORDS: ultrashort lasers, fs-TW lasers, pulsed lasers, lasers, atmospheric propagation

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AF06-006 TITLE: Aero-Optics Research and Development

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Develop optical or flow control technologies to compensate for high-energy laser degradation suffered when a high energy laser (HEL) beam is propagated through aircraft-induced optical turbulence.

DESCRIPTION: High performance HEL aircraft must incorporate large fields of regard in order to enhance mission capability and to provide for greater missile self-defense coverage. Unfortunately, aircraft motion perturbs the refractive index field over most of the field of regard near the HEL exit aperture. As a result, the outgoing HEL undergoes extreme disturbances due to shock waves, turbulent shear layers, and regions of separated flow. The net effect of the large, rapidly-varying wavefront turbulence on the HEL beam produces degraded beam quality and decreased HEL energy-on-target. Since aero-optical turbulence contains a significant high frequency content, current state-of-the-art adaptive optics (AO) systems cannot adequately compensate for their effects. The purpose of this effort is to develop advanced AO technologies to permit high bandwidth (>2 kHz closed loop) HEL compensation of aircraft boundary layer-induced turbulent flow fields. The end product of this effort shall be the development of new high bandwidth laser wavefront sensors, adaptive optics components, near-field laser beacons, etc., as well as, means to mitigate or suppress aero-optical turbulence. In addition, this effort may explore novel turret designs to minimize flow field effects and approaches that utilize electro-optical mechanical hardware (the current standard), all optical, or hybrid concepts. Some approaches may seek to mitigate, reduce, or shift the frequency spectrum of the turbulence flow itself while other approaches may seek to increase the bandwidth of AO system components including sensors, laser beacons, deformable mirrors. In addition, other approaches may culminate in entirely new approaches to solve the aero-optics HEL problem.

PHASE I: The offeror shall develop a concept for a subsystem or component in lieu of a complete AO system. Phase I shall encompass a preliminary design of at least one of the following: a conceptual hardware/software design of the strawman AO concept, control system architecture, sensor design, a conjugate mirror design, flow control devices, or turret design, etc. Performance analysis and modeling shall establish concept feasibility.

PHASE II: Demonstrate, in a cost effective way, the enhanced adaptive optics component and/or flow control hardware based on the approach developed in Phase I. The offeror shall propose a cost-efficient Phase II proof of concept hardware demonstration that will realistically test the utility and performance of the concept.

DUAL USE COMMERCIALIZATION: It is expected that an adaptive optic or flow control subsystem based on the hardware developed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for atmospheric compensation through turbulent media and from moving platforms to moving targets such as the Airborne Laser, the C130 Advanced Tactical Laser, Laser Strike Fighter, Relay Mirror, UAVs, aircraft surveillance systems and the like. Inasmuch as optical turbulence affects the commercial or civilian areas such as astronomy, laser communications, and power beaming, the AO components developed under this SBIR will likewise have a high commercial potential.

REFERENCES: 1. Gilbert, K. G., (1982) “KC-135 Aero-optical Turbulent Boundary Layer/ Shear-Layer Experiments” in “Aero-Optical Phenomena”, Progress in Astronautics and Aeronautics, Vol 80.

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KEYWORDS: adaptive optics, turbulent flow, aero-optics, coherent flow structures, separated flow, shear layers, aerodynamic boundary layers.

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AF06-007 TITLE: Increased Range Neutron Response High Explosives Detection

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Nuclear Technology

OBJECTIVE: Development of ability to detect sealed containers of high explosives at greater ranges. For this topic, this means develop improved gamma ray diagnostics, with better combined spatial, spectral, and temporal resolution, and improved detection algorithms, in order to improve background rejection.

DESCRIPTION: Develop design concepts for increased range neutron (n) response detection system for high explosives (HE). This requires both higher yield, re-usable, reliable 14 million electron volt (MeV) neutron sources (for which there are already good ideas), and greatly improved neutron return radiation diagnostics (which is the goal of this SBIR topic). This is in order to discriminate against nitrogen (N) background in the atmosphere, ~ a kilogram per cubic meter (m). Background: Neutron induced gamma emission is an established technique for detecting HE at short range (~ 3m). This can be done by the use of thermal neutrons for activation analysis, or by the use of fast neutrons (14 MeV from Deuterium-Tritium (DT) fusion reactions) to cause prompt gamma emission from inelastic scattering or other nuclear reactions. Detecting HE at large distances (>/~ 100 m) is extremely desirable and difficult. A possible way to detect HE at distances ~ tens of meters to perhaps 100 m. is the second approach. Inelastic neutron scattering by 14 MeV neutrons has cross sections of 25 millibarns (mb) for producing 5.1 MeV gammas from N, 100 mb for producing 4.4 Mev gammas from C (carbon)and 100 mb for producing 6.1 MeV gammas from O (oxygen). This can be used to determine the stoichiometric ratio of N, C, and O in neutron bombarded samples. Analytic estimates, using the cross sections for prompt gamma production by 14 MeV neutrons incident on C, O, and N indicate that a dose of 100 millirem (2 x 10^6 n/cm^2) on a 50 kg block of typical high explosive will produce ~ 3.0 x 10^7 5.1 MeV gammas from the N, ~ 1.3 x 10^8 4.4 MeV gammas from the C, and ~ 1.3 x 10^8 6.1 MeV gammas from the O. This will result in ~ 250 of the 5.1 MeV gammas/m^2 , and ~ 1,000 each of 4.4 MeV and 6.1 Mev gammas/m^2 at 100 m distance (sample to detector). These numbers (of gammas/m^2 at the detector versus dose or fluence at the sample) will scale inversely with distance (sample to detector) squared. If the source to sample distance equals the sample to detector distance, the required source strength scales as inverse fourth power of distance. This ignores atmospheric attenuation. The size and use of detector(s) determines how many neutrons and gammas/m^2 are required for identifying and locating the HE. Diagnostic development would be as important as source development, and may be quite difficult. The ideal gamma diagnostics would have combined high energy resolution, short time resolution, and good directional resolution with wide directional coverage, operable over a wide dynamic range of incident gamma flux. Simpler schemes using arrays of detectors with just good energy and time resolution, such as triangulation, could work in non-terrestrial environments, where there is no nitrogen atmosphere and virtually no nitrogen in the soil. In the terrestrial environment, background likely requires directional resolution as well as energy and time resolution to overcome it. The existing gamma ray telescopes used in astronomy (on satellite born systems) are very low flux systems. Developing higher flux versions is a possible approach to solving this problem.

PHASE I: Requires innovative R&D of diagnostics for detecting sealed explosive containers at ranges of tens of meters or greater in earth atmosphere environment. This may require simultaneous spectral, spatial, and temporal resolution to greater extent than present radiation detector technology provides. It may also require new analysis schemes.

PHASE II: Develop a feasible detection concept, implement a significant part of the new detection concept. Develop a business and commercialization plan for the Phase II engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military uses of this technology include fixed and mobile high explosive detection systems for force protection. Civilian sector applications include more efficient and increased throughput screening of vehicles and cargo containers for Homeland Defense, law enforcement, public safety, and counter mine systems.

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KEYWORDS: detection, high explosives, neutron response, radiation detector technology, gamma emission, gamma production

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AF06-008 TITLE: <u>Transient Wave Based Command and Control Systems</u>

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: To develop and demonstrate a transient wave based command and control system.

DESCRIPTION: A transient wave based command and control system would have several advantages over the carrier wave based command and control systems currently being used. Carrier wave based command and control systems have limitations. They have a high probability of intercept and a high potential for jamming. They are also limited in bandwidth and therefore limited in data transmission rates. Therefore, we are interested in developing a transient wave based system which would have virtually zero probability of intercept, a low potential for jamming and would be able to achieve very high data transmission rates, on the order of 100 kB/second or better.

PHASE I: Provide a feasibility concept to determine if it is possible to modify existing carrier wave controlled systems so that they can be controlled by a transient wave based system. Develop a prototype to demonstrate this capability. Develop an initial commercialization concept and plan.

PHASE II: Develop and demonstrate a working transient wave based command and control system with a working range on the order of 10's of meters. Investigate antennas to be implemented in the system to transmit and receive wideband signals with minimal dispersion. Develop a business and commercialization plan for the Phase II engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Phase III will require the commercial development of the transmit and receive chip sets to be integrated into transient wave based command and control systems. Size and type of packaging should be designed for substitution into existing carrier wave based systems.

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KEYWORDS: Command, Control, Wideband, Transient, Remote Control, Ultra wideband

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AF06-009 TITLE: Turbulence Inner Scale Sensor

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop a simple technique to estimate the inner scale of turbulence along arbitrary atmospheric paths. Final deliverable would include a sensor package to measure inner scale.

DESCRIPTION: Atmospheric turbulence generally degrades performance of imaging & laser propagation systems because the wave propagates through a region with non-uniform index of refraction. Typical effects resulting from this turbulence are beam broadening, jitter, and irradiance fluctuations. Often simulation results for such systems are compared to experiments where light propagates through the atmosphere, but suffer from the lack of atmospheric turbulence information along the propagation path. To understand such cases the power spectral density (PSD) of the refractive index field is important. The PSD is a function of the spatial wave number, and depends on the refractive index structure constant Cn2, the inner scale and the outer scale. In most cases the outer scale can be considered infinite without deleterious effect. Cn2 is usually not measured at the same time and along the same path as the light in propagation experiments. However, moments of Cn2, like the coherence length r0, the log amplitude variance, isoplanatic angle and the Greenwood frequency are often measured and give some information on the refractive index structure constant. This leaves the inner scale. Often knowledge of the inner scale of turbulence would benefit the comparison, but usually the inner scale isn't measured at the experiment, so in the simulation the inner scale is assumed to be zero, although it becomes the grid size by default. If available, average values of inner scale from similar locations can be used. Having a simple way to measure or even estimate the inner scale along the propagation path would give the analyst a much better idea of the turbulence spectrum and enhance comparison to experiment. Typical scenarios of interest include vertical and near-vertical paths starting at ground level going to an altitude of 24 km and the reverse path. In the most stressing cases the log amplitude variance could be as large as 0.3, and the coherence length as small as a few centimeters.

PHASE I: Perform a study to identify a technique for estimating the inner scale of turbulence that is easy to implement and can be used along arbitrary propagation paths. Provide a preliminary design for an inner scale sensor based on that technique.

PHASE II: Develop and build the sensor and demonstrate on a wide range of propagation problems using the technique developed in Phase I. Typical problems would include measurements with both cooperative and non-cooperative sources, possibly laser guide stars. Final deliverable would include a sensor package for measuring inner scale along an arbitrary atmospheric path.

DUAL USE COMMERCIALIZATION: It is expected that an inner scale sensor based on the concepts proposed under this research would have both commercial and military applications. The military applications include all those with requirements for laser systems propagating through turbulent media such as ground based lasers, tactical laser weapons and laser communications. Commercial markets include areas such as astronomy, laser communications, and power beaming.

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KEYWORDS: adaptive optics, atmospheric turbulence, turbulent media, inner scale

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AF06-010 TITLE: Electric Oxygen Iodine Laser Diagnostics

TECHNOLOGY AREAS: Air Platform, Sensors, Weapons

OBJECTIVE: Design a suite of turn-key diagnostics that produce quantitative data about species generated in electrically driven oxygen iodine lasers.

DESCRIPTION: Instead of using a chemical reaction to produce single delta oxygen (SDO), electric oxygen iodine laser (EOIL) devices rely on direct electrical excitation. The excitation process does not produce a single clean product but a variety of excited state oxygen molecules, O atoms and various other radicals. Currently O atom scavengers, such as NO2, are also used in these experiments and the by-products of these reactions must be known. Sensitive diagnostics are needed to probe what species are produced and in what concentrations.

PHASE I: Conduct research on how to quantify concentrations of O atoms and species, including NO, produced during scavenging. The methods of analysis should rely on spectroscopic methods. Diagnostics should be compact and not require extensive calibration. Prototype apparatus should be designed for Phase II.

PHASE II: The prototype designed in Phase I (including software)should be built and tested. Actual minimum detectable yields and operating conditions should be reported. Designs for streamlining the apparatus to make it rugged and turn-key operational should be pursued. Run-time and pathlengths must be addressed and incorporated into the design to make it compatible with current experimental hardware.

DUAL USE COMMERCIALIZATION: Military application: Build the new diagnostic product and field test it in the appropriate lab environment. Civilian application: Final product can be used for environmental monitoring of these species. Upper atmosphere chemistry would be relevant.

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KEYWORDS: EOIL diagnostic,oxygen-iodine-laser,nitric oxide,O atoms,quantitative spectroscopy

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AF06-011 TITLE: Synthetic/Sparse Aperture Imaging Techniques

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Space Platforms

OBJECTIVE: Utilize active lasing with sparse and/or synthetic aperture techniques to characterize Resident Space Objects (RSOs).

DESCRIPTION: Space Situational Awareness (SSA) requirements include the need to remotely characterize RSOs. Sparse/synthetic aperture imaging techniques can provide a cost effective means of obtaining highly resolved target imagery from long stand-off distances. On-going efforts in the astronomical community have primarily focused on passive ground and space-based interferometry techniques (e.g. NASA's Space Interferometry Mission and Keck Interferometer). This goal of this project is to develop ground-based active (laser) imaging techniques utilizing sparse apertures. Pupil-plane imaging techniques do not require high quality optics and are scalable to very large apertures. The challenge is to develop small-scale test systems that can be scaled to very large apertures, such as 10 to 30 meters.

In order to image Low Earth Orbit (LEO) satellites, the system will also need to be able to track the satellite (which orbits the earth in a period of approximately 90 minutes), so will need to be able to slew rapidly. Significant innovation will be required for such a system.

A significant advantage of pupil-plane imaging techniques is that they do not require hardware to phase the apertures and atmospheric compensation is accomplished using software algorithms. The proposed systems should be designed consistent with existing and/or small (0.53um) advances in laser technology. As an example, a 40-joule to 100-joule solid state (1.0 um) Nd:Glass laser has been demonstrated by Lawrence Livermore National Laboratory.

PHASE I: The Phase I product will be developing concepts for active (laser) imaging, synthetic/sparse aperture techniques, scalable to ground-based 10 to 30 meter apertures.

PHASE II: The phase II product will be to build and demonstrate (in a laboratory) a small-scale prototype system scalable to ground-based 10 to 30 meter apertures.

DUAL USE COMMERCIALIZATION: Military applications of these concepts include improved space surveillance capabilities, for which the ability to image objects at great distances is critical. Private sector commercial applications could include determination of satellite health, such as after collisons with space debris during launch (e.g., the Space Shuttle). Imaging techniques could also be applied to astronomical objects such as near Earth asteroids or other solar system objects.

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KEYWORDS: SSA, RSO, characterization, active imaging, interferometry, sparse aperture, aperture

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AF06-015 TITLE: Wearable Computer for Enhanced Situation Awareness

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a high performance wearable computer system to enhance target detection, recognition, and situation awareness.

DESCRIPTION: What is needed to bring the next generation of day/night vision enhancement systems to life is a powerful, light-weight, efficient, wearable computer optimized for image processing. The desired system will take sensor data from one or more sensors and process the video streams to perform tasks such as: image enhancement, target detection, target recognition, and as such would improve situation awareness. The system will also be required to interface internal or external databases to enable the overlay of additional information on the enhanced imagery and provide a thorough literature review of the current state-of-the-art in wearable computing. In addition, the contractor shall plan what steps need to be taken in order to develop a wearable computer system that will perform real time video processing of sensor data and display the augmented information to the user. The contractor shall develop one or more viable, high-level designs that could be built and tested in Phase II.

PHASE I: Perform an analysis of alternatives and document the strength and weaknesses of competing platforms due to processing power, power consumption, battery life, weight, network bandwidth, and video input/output capabilities.

PHASE II: Build and demonstrate a wearable computer system that can process video streams in real time. The system would be lightweight, energy efficient for long battery life in the field, and powerful enough to process video streams in real time. In addition, the system shall be robust enough for laboratory, limited field testing, and concept demonstrations.

DUAL USE COMMERCIALIZATION: Wearable computers and augmented reality technology is envisioned to help in many tasks where users are presented with a large amount of information and where performance would be enhanced by having additional information overplayed on the real world. Air-traffic controllers could use such a system to automatically overlay the information about the flight number and destination merely by looking at a plane. The training and simulation industries would reap great benefits from high-performance image processors and generators. Finally, the technology developed in this program would also lead to great enhancements in the computer and entertainment industries.

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KEYWORDS: Wearable computer, augmented reality, sensor fusion, image processor, image enhancement

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AF06-016 TITLE: Decision Support Technologies for Weapon System Logistics Investment Decisions

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop support technologies for establishing a repeatable, structured, and integrated decision-making process providing insight into existing and new technology weapon system logistics decisions.

DESCRIPTION: The development of a sound, structured and integrated simulation model to assist in investment decision analyses for existing and future weapon systems is critical. The availability of a consistent, effective evaluation process which includes logistics considerations will ensure the technology and system initiatives for our weapon systems can be evaluated, documented and developed into an integrated investment strategy that provides the greatest return on our limited investment dollars. The goal of this research is to provide a product that incorporates current technologies for use in developing and justifying these weapon systems investment decisions.

This research and methodology development is relevant to Department of Defense weapon systems and technologies because credible engineering and logistics analysis tools and methods are needed to assess the realistic performance benefits of proposed investments. This decision support technology will provide decision-makers with improved insight to the most beneficial investment strategies. Credible logistics models such as the Logistics Composite Model (LCOM) are an important enabling technology for this capability to ensure data input from all levels of the organization can be integrated effectively and used to understand the system performance and affordability of various logistics support options. Proposed methodologies should consider enhancements to legacy simulation tools and must be capable of executing on commercial-off-the-shelf desktops or workstations. Any graphical depiction and output should comply with industry or international standards. Methodologies implementing the collaborative environment should be open and standards-based to support interfaces to other analysis, simulation and modeling tools.

PHASE I: Develop new analytical capabilities/requirements of the structured approach. Develop an integration concept for the model's graphical input interface, the simulation engine itself, output tool module, and proof-of-feasibility demonstration of key enabling concepts.

PHASE II: The researcher will design, develop, and demonstrate a structured, collaborative, integrated approach for evaluating system/technology investment information to provide an assessment of weapon system performance given a specific logistics scenario/concept. The researcher will also detail the plan for Phase III effort.

DUAL USE COMMERCIALIZATION: The desired product of Phase III is a robust, off-the-shelf collaborative, integrated methodology for evaluating system/technology investment information for use in defense and commercial product development and manufacturing. Investment decision methodologies that incorporate community-accepted data and engineering/simulation evaluations for logistics performance effectiveness are applicable to all manufacturing industries, and to communication and information systems. Industry and service organizations that strive to obtain the greatest return for their investment dollars can benefit from this capability.

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KEYWORDS: Modeling and Simulation, Mission Capable (MC), Sortie Generation Rate (SGR), Supply Chains, Logistics, Maintenance

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AF06-017 TITLE: Laser Eye Protection Field Evaluation Device

TECHNOLOGY AREAS: Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a device to measure the optical density of LEP spectacles, goggles, and visors for use by operational military units.

DESCRIPTION: Advances in laser component technologies have lowered the cost and increased the capability, and therefore applications, of lasers by military forces. These advances have put lasers on the vanguard of revolutionary change in modern warfare. The use of lasers for precisely guiding smart bombs, illuminating targets, range finding, aircraft self-protection, laser weapons, and secure communications is extensive and expanding. On the other hand, these lasers create a unique potential for ocular injury of military members as both hazards (buddy lasing) and threats (use by hostile forces). Aside from avoidance, the principal countermeasure against eye injury is laser eye protection (LEP) in the form of goggles, spectacles, and visors. There is not currently, nor will there be in the near future, a single LEP device that can protect eyes against this myriad of laser systems, while minimizing negative impacts on vision, in a format that is compatible with all of the various Air Force missions. As a result, numerous types of LEP will be required to properly protect our personnel. The Air Force currently has three LEP devices in the field, each with a distinct spectral and optical density profile, and three more are scheduled to become available within the next one to two years. The existence of multiple protection configurations presents the opportunity for operators to select the wrong LEP for the laser threat(s) or hazard(s) they will face. Also, since the technologies used in these LEP are new, we have very little experience with field use and operational lifetime of these devices. So, even though the leading-edge technologies used for these high-performance LEP devices are thoroughly tested in the laboratory, we cannot be certain the devices will "perform as advertised" throughout their projected lifetime. The ability to "field check" the protection levels of LEP would be very beneficial because it would: (1) cultivate confidence of personnel in their laser-protective equipment; (2) verify that the LEP on hand (or selected) is the proper protection against the anticipated threat(s) and/or hazard(s); and (3) provide some opportunity for scientists and engineers to collect information on the useful operational lifetimes of new LEP technologies. Therefore, the goal of this effort will be to design, develop, and fabricate a user friendly, self- contained, moderately priced device capable of evaluating the protection levels of LEP out in operational flying squadrons. This will be a relatively small device (e.g. a floor-standing copier or small refrigerator) that can be used by Air Force Life Support Equipment technicians in a non-secure shop environment to verify that any given piece of LEP meets its specifications. It will operate in either a scanning mode or a single wavelength check mode. One must be able to place the LEP into a light tight chamber, enter an identification code for the article to be evaluated, select a scan or single wavelength evaluation, enter the wavelength (if that's chosen), and hit a "start" button. The unit would then either scan through the region of 400 nm to 1400 nm and measure the optical density (OD) as a function of wavelength, or measure the OD at the selected wavelength for any LEP format (true spectacle, clip-on spectacle, mini-visor, visor, and side shields) fabricated using absorptive technology, reflective technology, or a combination of the two with a precision of ± 0.1 OD over the range of 0 OD to 5 OD. The device would then provide the technician with the results according to a means of their choosing. Since OD as a function of wavelength in fielded LEP is generally clasified SECRET, the security of the data output/display must be safeguarded commensurately. Because OD as a function of wavelength will be classified SECRET for many LEP articles, the reference database of spectra must also have hardware and/or software protections against unauthorized alterations or theft.

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

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

DUAL USE COMMERCIALIZATION: There is likely to be solid interest throughout the military community since directed energy is one of the DoD Key Technology Areas. Self-protection against lasers is already becoming an issue for some new systems going to the field. In addition to the Air Force, the Army and Navy are also developing and fielding LEP for their unique requirements. In the Air Force, this product would probably be deployed at the wing level, but could find its way to the squadron level depending upon the price and demand. In the Army and Marines, it would probably be deployed at the battalion or company level, and in the Navy it would be deployed on all ships any part of whose company is at risk of laser exposure. Reserve and Guard units may also have use for this device, depending upon the concepts for LEP deployment and use by these organizations. The commercial market is difficult to predict, but companies specializing in design, development and fabrication of high performance laser protective eyewear have estimated that up to one-third of the cost of a laser eye protection device is attributable to labor costs for the tedious, yet precise, manual process of verifying protective performance. Automating this process holds forth the prospect of increasing the throughput of the inspection process by up to a factor of ten, significantly reducing this cost component for future LEP acquisitions. However, to be most useful to industry the device needs to be able to measure power, prism, haze and distortion, in addition to optical density, and to provide a variety of data output options ranging from very simple (good/bad indicator lights) to complex enough for scientific or engineering applications, e.g. storing data on a computer disk, or printing of a numerical table (spreadsheet), or a spectrum in graphical format so that the data is amenable to failure analysis applications. It is well within the realm of possibility that the component technologies will find spin-off applications, such as quality control devices, spectroscopy, and other measurement technologies.

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KEYWORDS: Automated Systems,Densitometer,Laser eye protection (LEP),
Optical Density,Spectrum Analyzer,Visual performance,
Quality Control

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AF06-018 TITLE: Network Threat Monitoring, Intrusion Detection and Alert System for Distributed Mission Operations (DMO)

TECHNOLOGY AREAS: Information Systems, Sensors

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) compatible embedded network threat monitoring system to constantly detect and mitigate intrusion attempts across a Distributed Mission Operations (DMO) network.

DESCRIPTION: Current network intrusion monitoring tools are not robust enough to be useful in high fidelity simulation environments in real-time. Moreover, the capacity to identify, track, diagnose and remediate/inoculate a high fidelity network from these attacks without negatively impacting the training that is taking place, does not exist today. Network attacks are rarely known in the DMO environment because identifying them and alerting engineers to the events unfolding has not been done to date. An innovative tool is needed which will allow continuous monitoring and intrusion detection of the DMO network. The tool should be compatible with the current DIS and HLA standards, and be able to display entity attributes and specific threats to them. The tool should also be able to diagnose the threat and its potential impact on the DMO training event and to inoculate the network against the attack. The developed tool must enable system threat assessments to be displayed while the simulation is running so that remediation can occur in real-time. In some cases, the identification of a network attack or intrusion attempt could result in a graceful degradation of capabilities while minimizing the impact on the training experience. The

Air Force is seeking development of innovative tools and techniques that can efficiently monitor high fidelity networks in real-time and permit the identification, targeting and remediation of threats and attacks to the network, ideally without impacting the performance of networked real-time simulations in DMO using both DIS and HLA.

PHASE I: Phase I will develop a prototype Intrusion detection, alarm and mitigation tool for a DIS/HLA DMO environment and provide a demonstration and report.

PHASE II: Phase II will result in a fully integrated intrusion detection and attack mitigation capability which is useable in real-time DMO environments and provides the capabilities outlined above. It will also result in test and evaluation of the developed tool and will provide documentation of results in a technical report.

DUAL USE COMMERCIALIZATION: The capability to provide real-time network intrusion and attack detection, diagnosis and inoculation of ongoing network threats in an interactive DIS/HLA simulation environment does not exist today. Phase III Dual Use potential is significant since both the military and commercial sectors actively participate in distributed simulation environments. Distributed simulation events can include participants from all over the world. The need is for the development of a DIS/HLA compatible embedded network threat monitoring system to constantly detect and mitigate intrusion attempts across a distributed simulation network.

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KEYWORDS: Distributed Mission Operations, Network Threat Assessment, Network alert, DMO training effectiveness, DMO Network Security, Distributed Interactive Simulation, DIS Standards, High Level Architecture, HLA Standards

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AF06-019 TITLE: Photosensitive Visor for Flight Helmets

TECHNOLOGY AREAS: Electronics, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and apply variable-transmittance technologies that can be incorporated into a single day/night visor for the aircrew HGU-55/P Helmet.

DESCRIPTION: With the advent of Helmet-Mounted Displays (HMDs), the pilot no longer has the option of raising the visor when transitioning from high to low light level conditions; therefore, a variable-transmittance visor is required. Previous efforts have developed continuously variable transmissivity visors using liquid-crystal shutter technology and visors consisting of relatively thick base/cap pairs. This approach increases the cost, adds distracting secondary reflections, and complicates manufacture and customizing/trimming the visor’s fit to prevent light leakage around the nose/oxygen mask area. A simpler, low-cost approach to providing this variable transmissivity capability that will also allow the curved visor to be customized (trimmed) for individual pilots is required. The technology design goals include: spectral neutrality, fail clear, have fast transitions with no irising and be compatible with polycarbonate helmet visors. These additional goals for visor attributes are listed as design parameters that must be considered during development in order to ultimately have a successful commercialized product.

PHASE I: Identify and develop material technologies for a curved, low-cost, customizable, variable-transmittance visor. Determine required drive electronics. Identify system level/device requirements and program high-risk areas. At the end of Phase I, provide a report of accomplishments and lessons learned.

PHASE II: Develop a prototype into a functional, rugged visor with drive electronics that will be able to undergo testing (flight trials, integration and compatibility assessments, environmental, etc.) when mounted onto a standard Air Force HGU-55/P helmet. The new device must interface and be compatible with systems which are used with existing day and night time visors, i.e., prescription spectacles, laser eye protection spectacles, and oxygen masks. The prototypes will undergo testing and operational assessment to insure aircrew/equipment compatibility.

DUAL USE COMMERCIALIZATION: Low-cost, variable-transmittance technology can also have civilian sector applications in the areas of space suit helmet visors, race helmets, welding, eyewear, windows, automobile/aircraft/spacecraft windows, non-emissive displays.

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KEYWORDS: helmet-mounted display, HMD, tint, shutter, visor, variable transmittance, electro-optical, customized trimming, ambient light, illumination, illuminance

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AF06-020 TITLE: Aircrew Personnel Lowering Device

TECHNOLOGY AREAS: Air Platform, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and apply technologies that can be incorporated into an improved aircrew personnel lowering device.

DESCRIPTION: The current aircrew personnel lowering device (PLD) was developed during the Vietnam era to help parachutists extricate themselves from trees. The PLD, integrated with the bail parachute, is large and bulky. The PLD case contains approximately 140 feet of 0.75 inch tubular webbing folded 140 times. Multiple elastic straps sewn in the PLD case on each side are used to secure the webbing. While this system has served its function, modern day aircrew require an improved streamlined version of this system to provide extraction capability. The desired system is small and compact (fits in flight suit pocket), incorporates manual activation of slow (2-3 ft / second) controlled descent, and accommodates a load of up to 350Lbs. Technological challenges are foreseen with the control descent mechanism. This device will have to be miniaturized and withstand the applied load forces. Component stress, heat management, resistance, degradation and structural integrity are critical challenges that must be addressed. The USAF is seeking innovative technological solutions to address the requirement for a modern PLD.

PHASE I: Identify and develop material technologies for a compact PLD. Identify system level/device requirements, components, and program high-risk areas. At the end of Phase I, provide a report of accomplishments and lessons learned with technology demonstrations of a breadboard and model or PLD prototype.

PHASE II: Develop a prototype into a functional PLD that will be able to undergo laboratory and government tests to demonstrate performance. Laboratory tests will be performed to validate component and system level performance. Operational assessments will be performed to asses aircrew/equipment compatibility.

DUAL USE COMMERCIALIZATION: Military application: This technology can be utilized by climbers and emergency rescue teams such as firemen.

REFERENCES: 1. Multi-Command Operational Requirement Document CAF-MAF-AETC 319-93-I-A, "Aircrew Protection/Support/Escape Systems," Jan 99.

KEYWORDS: Lowering Device,Escape Systems

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AF06-022 TITLE: <u>Next Generation Architecture for Night Vision Imaging</u>

TECHNOLOGY AREAS: Sensors, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a new device architecture for enhancing vision under low illumination conditions

DESCRIPTION: Image intensifier (I2) tubes are commonly used in head-mounted devices that are designed to aid vision at night. I2 tubes are analog devices that integrate the sensor, light amplifier, and display. The amplifier within the I2 tube is a microchannel plate, which must be suspended in a vacuum, thereby complicating fabrication and permitting certain image defects. Many I2 tubes employ a coherent fiber optic bundle to re-invert the image after amplification, adding weight, size, and complexity. Further, I2 tubes do not lend themselves to the use of digital image enhancement techniques or the display of images produced by outboard sensors or computers.

Advances in technology now make possible the fabrication of solid-state micro displays and near infrared imaging arrays. A next logical step is to combine these technologies, perhaps even integrating them on one substrate, along with addressing and control structures, into a sensor/display package similar to the I2 tube. Further, it may be possible to incorporate digital computing devices on the substrate. This architecture would enable real time digital image enhancement and could ultimately outperform and replace the I2 tube. This program will develop candidate architectures based on the preceding ideas and produce a demonstration device.

It is envisioned that the next generation system can be built with smart three dimensional packaging of multiple Complementary Metal Oxide Semiconductor (CMOS) subsystems, and a micro display matrix. The CMOS based image sensors must deliver very high frame rates, and permit parallel readouts. The computing stage would follow a Single-Instruction Stream Multiple-Data Stream (SIMD) architecture such as Geometric Arithmetic Parallel Processor TM. Though the know how of individual stage synthesis is well known and proven in the market place, off-the-shelf products do not exist for system integrators to build the envisioned next generation night vision system. Identifying high performing candidates for each stage, synthesizing each individually, fabricating each by standard micro fabrication process and integrating them by a robust and inexpensive 3D packaging would be necessary.

Thermal isolation between the CMOS sensor plane and the computing planes would have to be addressed. Phase I efforts will include an analysis of alternatives, examining at a minimum: imaging array technology, miniature display technology, onboard computing, image processing, approaches for inserting information (symbology and imagery), weight, size, and power consumption. A recommendation of the best alternative should also be identified in a detailed technical report, written at the end of this phase.

PHASE I: Develop candidate architectures for the construction of a solid-state sensor/display package similar to the I2 tube.

PHASE II: This phase will involve the construction of a prototype device using an appropriate approach as determined by the Phase I effort. If necessary, multiple paths should be pursued. The Phase II prototypes will be robust enough to undergo laboratory and limited field-testing and function as concept demonstrators.

DUAL USE COMMERCIALIZATION: Solid-state imaging devices will significantly improve the quality of low light and infrared imagery, when coupled with on-chip image processing and eliminate several problems inherent in image intensifier tube based systems. The resulting improved image quality and capability will lead to advances not only in the military and law enforcement communities, but also in other fields where high quality low light images are required from compact systems, such as head-mounted devices or in the automotive industry. This technology will be a great advancement over current methods for imaging as it is adaptable to a broad range of wavelengths in the electromagnetic spectrum.

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KEYWORDS: Night vision goggle, Micro display, Solid-state imaging, Near Infrared, NVG, NVD, Image processing

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AF06-023 TITLE: Advanced Sensor to Identify and Quantify Contaminants in Cockpit Air

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop and demonstrate sensor capable of detecting, identifying, and quantifying smoke, debris, and pollutants in cockpit air.

DESCRIPTION: Future aircraft will use a Prognostics and Health Management (PHM) system to provide a comprehensive assessment of aircraft systems, including detection of system performance degradation. For example, the aircraft environmental control system could be monitored to determine if the pressurized air delivered to the cockpit is free of pollutants. Cockpit pollutants might be fuel vapor, hydraulic fluid, heat exchanger fluids, carbon monoxide, particle debris, and smoke. The presence of these pollutants may indicate the environmental control system performance is degrading. For example, toxic heat exchanger fluids could enter the cockpit, if an environmental control system heat exchanger was leaking. Sensing the presence of a cockpit contaminant could provide a method for early detection of a potential system problem before complete system failure occurs. Further, the sensor could warn the pilot of these pollutants before their concentration reachs a level that might lead to pilot incapacitation. The cockpit air sensor must be small, lightweight, low power, reliable, low maintenance, accurate, affordable, and very responsive. The sensor must detect, identify, and quantify pollutants. Preferred approach would use solid state technology or nanotechnology.

PHASE I: Develop and demonstrate a breadboard sensor showing the feasibility of detecting, identifying, and quantifying pollutants in cockpit air.

PHASE II: Develop and demonstrate a prototype system consisting of cockpit sensor and software/algorithms (if required). Demonstrate the capability of the prototype system to detect pollutants under simulated laboratory conditions. Determine approach for integrating sensor with a military aircraft prognostics and health management system.

DUAL USE COMMERCIALIZATION: The technology could be used on military and commercial aircraft to detect smoke, debris, and pollutants in aircraft cabins. Technology could be used at various ground locations to detect pollutants.

REFERENCES:
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KEYWORDS: aircraft prognostics, cockpit air pollution, smoke detection, cockpit contaminants, chemical sensor, particulate sensor, environmental control system, aircraft chemical hazards

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AF06-024 TITLE: Enhanced Transmission Control Protocol/Internet Protocol (TCP/IP) for Distributed Network Applications

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Define an enhanced TCP/IP protocol for reliable and complete communication transmission in deployed environments to support live and virtual distributed entities.

DESCRIPTION: The TCP/IP protocol is the de-facto standard for commercial and government web data transfer under normal operating conditions. However, not all commercial and government information systems are connected to stable modes of transmission. This problem is most relevant in situations where communications equipment must be deployed in areas where a reliable infrastructure is not in place. Further, aircraft increasingly rely on data transmission between aircraft and ground stations. Since the variations of in-flight connectivity quality is often high due to flight dynamics, electromagnetic interference, and weather, critical data can become corrupted or dropped. While some loss can be tolerated, the loss rate utilizing the current TCP/IP standard can be unacceptable. Other challenging applications include distributed live simulations. The enhanced protocol will overcome the limitations of systems using the current TCP/IP protocol under less than ideal situations (i.e. deployed communications/simulations, ad-hoc mobile networks, etc.). These systems must be able to reliably interface with virtual and live entities located throughout the world. In this case, neither the loss of data nor a significant amount of packet latency can be tolerated. Hence, there exists a need to define a standard that can better tolerate high bit error rates and low or varying data rates, and be able to prioritize traffic under high volume situations.

PHASE I: Develop a framework on which to base the enhance TCP/IP standard from inputs generated by interested commercial and military parties and appropriate standards organizations and demonstrate its applicability to the modeling and simulation community, also commercial and military aviation applications.

PHASE II: Refine the enhanced TCP/IP through continuous interaction with interested parties and standards organizations to create a viable model with the potential of becoming an industry standard. Deliverables for this phase include a thoroughly documented model capable of addressing the issues stated in the description of this topic and a proposed methodology for implementation.

DUAL USE COMMERCIALIZATION: Monitor standard through its adoption by commercial industry and the government. Respond to comments presented by the user community.

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KEYWORDS: TCP/IP, deployed networks, challenged internets, internet protocols, mobile communications, adaptive networks.

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AF06-025 TITLE: <u>Sensor Fusion Tactics Trainer</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a high fidelity sensor fusion tactics trainer for developing and enhancing strategic and tactical knowledge and mission readiness.

DESCRIPTION: There is currently no capability to adequately train and rehearse decision makers in the tasking, processing, exploitation and dissemination (TPED) process. While there are numerous automated tools for gathering data from sources and getting those data to the "fuser", there is no training and rehearsal capability to teach personnel how to interpret taskings, what assets are available and capable of providng data for the tasking, how to obtain data from the various sources, what the quality (in terms of such things as freshness and reliability) of the data are and their relevance to the tasking, what form the fused data should take, and how best to get the fused data to the battlestaff for their use. There is also no mechanism in current ops to provide feedback to the "fuser" on the usefulless of the fused products produced for battlestaff decision making. This effort will develop a training and rehearsal capability for sensor operators that addresses these shortcomings. The capability we envision is one that includes developing and validating intelligent agents as actors that can role play tasking enties and sources of data to support a variety of taskings that replicate real world activities in support of current operations. Our proposed target training audience are the operators of such systems as the Distributed Common Ground Station (DCGS), a TPED Intelligence, Surveillance, and Reconnaissance (ISR)system. The training and rehearsal capability will also help to improve the selection process of the operators in terms of developing better understanding of the capabilities and the quality of data from various sensor sources. This understanding should lead to better development of products for taskings and help sensor operators anticipate data requirements in advance of taskings such that better products can be made available more quickly. In other words, the operator becomes a more informed consumer of the source data and a better producer of fused information derived from it. This type of understanding existis only in the most senior sensor operators who have been on the job for a number of years. Current ops are such that we need to train less experienced operators to this level of understanding much sooner. We plan on conducting a detailed functional and information flow analysis of ISR tasks for an example system like the DCGS. the analysis will identify key expert and non-expert decision paths and solutions as well as examine lessons learned from successful and unsuccessful recent ISR TPED activities and develop approaches to train and rehearse for more successful ISR TPED decision making proccesses and develop an after action capability to provide feedback on the products for the battlestaff. The end state will be a training and rehearsal exemplar for a cognitively complex area of need.

PHASE I: Phase I activities include the identification of sources of data of relevance for a system of choice (e.g., DCGS), identification of typical and unique data requests and the idenficiation of experienced and non experienced operator performance and gaps. Phase I will develop the specifications and example scenarios for the training and rehearsal exemplar which will be fully elabroated in the Phase II effort.

PHASE II: Phase II will fully develop test, refine, and validate a TPED ISR training and rehearsal capability, develop and test S/W and H/W interfaces between environment and tactical information systems and conduct evaluation studies of interfaces and interoperability environment. It will also develop a first-ever feedback and after-action review capability for TPED ISR activities.

DUAL USE COMMERCIALIZATION: This effort will provide an integrated suite of tools, technologies and a general architecture for developing and enhancing the mission readiness of Intelligence, Surveillance and Reconnaissance operators and teams, as well as affording training and rehearsal for those elements identified as gaps in the gathering, packaging, delivery and evaluation of fused information products. A capability like this has been highlighted as a critical need for intelligence analysts in the Department of Homeland Defense and in the commercial space imagery sector where a variety of source data are available, each with a cost associated with its availability and use. Gathering the "wrong data" or misunderstanding data requests, sources, and desired products, is time consuming and expensive. Targeting gathering, fusing and delivery of classes of data is a shortfall that exists today for all. There is strong US and International commecial interest in a training capability like the one to be developed in this effort.

KEYWORDS: Affordability, Criterion development, Intelligence Surveillance and Reconnaissance, Knowledge assessment, Performance measurement, Readiness evaluation, Team effectiveness, Workgroup effectiveness.

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AF06-026 TITLE: Linguist's Ambiguity Tutor and Rehearsal System (LATARS)

TECHNOLOGY AREAS: Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Improve capability to rapidly produce linguist training material and demonstrate approaches to train linguist how to easily process ambiguities and slang in foreign languages.

DESCRIPTION: Military linguists are faced with a rapidly changing environment in today's Global War on Terrorism (GWOT). One challenge is the extreme diversity of the languages currently and potentially spoken by terrorists and their supporters. Our current ability to deal with foreign languages rests on the availability of human translators or on automatic translation systems. In order to be successful, linguists must correctly understand semantic meaning when presented with ambiguities, double meanings, and slang phrases. The ability to correctly understand hidden semantic meaning in a slang or duplicative phrase has a critical mission impact. There is an urgent need for an ambiguity tutor and rehearsal capability to train linguists to rapidly understand ambiguities, slang, and double meanings for a foreign language. There is a need for source material to be processed and distributed as fast as possible to ensure linguists can quickly adapt to new contexts and changing strategies. The ability to dynamically load new source material and then rapidly identify new ambiguities, new slang, and new double meaning phrases would be a transformational improvement in foreign language training.

PHASE I: Phase I will identify an approach, define an architecture, and demonstrate a prototype capability.

PHASE II: Phase II will develop a fully functional system capable of use and will result in a prototype capability for three languages other than English including at least one low-density language. This phase will also fully develop a system with advanced features for data input, semantic processing, usable user interfaces, and improved performance.

DUAL USE COMMERCIALIZATION: The application developed for the Department of Defense is equally applicable for use in training environments for federal agencies, commercial businesses, and academia.

REFERENCES: 1. The State of Foreign Language Capabilities in National Security and the Federal Government: Hearings before the International Security, Proliferation, and Federal Services Subcommittee of the Committee on Government Affairs, United States Senate (2000, Sept. 14 & 19). [Transcript]. Retrieved from http://www.access.gpo.gov/congress/senate/senate12sh106.html

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KEYWORDS: Linguists, Language, Training, Rehearsal, Semantic Analysis

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AF06-027 TITLE: Gaming and Training Environment for Counter Space Operations

TECHNOLOGY AREAS: Space Platforms, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and demonstrate a game-based approach to training, rehearsal and exercise for offensive and defensive counterspace (OCS/DCS) operations.

DESCRIPTION: Recently there has been a growing recognition of the potential role that interactive games may have as environments for training and rehearsal for military personnel. The growth of the military’s interest in gaming is exemplified by the Defense Advanced Research Project Administration (DARPA) DARWARS initiative and the US Army’s collaboration with the University of California Institute for Creative Technology. Games, however, are not typically designed with either a research or training focus. This effort will explore the potential for applying gaming technology to the training of counter space tactics, techniques, and procedures (TTPs). At the present time the USAF Space community in particular and the US space community in genral does not have a capability to examine alternative TTPs for offensive and defensive counter space (OCS/DCS)operations in a realistic environment. OCS/DCS is conceptualized as four key tasks: detect, identify, track, and disrupt activities from space vehicles. This effort will explore the training utility of developing a gaming environment where these tasks can be trained and rehearsed in a realistic set of scenarios and simulations. The environment will need to have object models to simulate interactions between satellites and ground stations, model track data, display raw sensor data, and have the capability for multiple players to participate and to provide command and control and other tactical and operational information and interaction to the game. By using a gaming approach, access to any classfied data would be eliminated, but the training that is provided could be conceptually valid and of sufficient fidelity to support the key OCS/DCS tasks. In addition, this effort could permit a number of other, more research- and training-centric issues, to be examined in detail as they relate to gaming environments and to future commercial applications. First, develop specific model representations (objects) for the people, places, and things associated with OCS/DCS tasks; Second, identify and validate training strategies and scenarios that support the development and refresher of skills associated with OCS/DCS performance in the environment. Specifically, what are characteristics of strategies and scenarios embedded in the game that support development and refresh of critical knowledge and skills; Third, develop specifications for performance measures and protocols for assessing proficiency and decay for the gaming environment; Fourth, what are some preliminary guidelines for refresher training intervals for different "classes" of OCS/DCS skill. Fourth, examine team-level assessments and the mechanisms for gathering these in a multiplayer gaming environment. One interesting area here would be the extent to which "multiplayer" could include connecting the gaming environment with a distributed mission training environment; Finally, demonstrate real-time scenario authoring and skills tracking that can be integrated into other gaming/training environments.

PHASE I: Develop specifications for using gaming approaches to train, rehearse, and exercise OCS/DCS type operations.

PHASE II: Demonstrate a game-based approach to training, rehearsal and exercise for OCS/DCS operations. Develop and validate authoring methods, event management, tools and trainee performance tracking capabilities inside the gaming environment. Explore connectivity feasibility among the gaming environment and a distributed mission training simulation environment. Conduct a field evaluation of the gaming environment with operational space personnel.

DUAL USE COMMERCIALIZATION: The areas to be examined in this effort will have a prodfound impact on gaming and training activities in the future. Several of the activities in this effort represent true "firsts" for a game and increase the potential future implementation of games as training environments with military/civilian applications. The key tasks for OCS/DCS operations (e.g., detect, identify, track, and disrupt) are general enough to be applicable to a variety of commercial training requrirements where gaming is also a plausible environment choice. The key components of the gaming environment developed in this effort would have application in homeland security, first responder rehearsal, and police force training and rehearsal.

KEYWORDS: Training, simulation, countermeasures, satellites, ground stations

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AF06-029 TITLE: Untethered Datalinks for Use in Simulation Environments

TECHNOLOGY AREAS: Information Systems, Electronics, Human Systems

OBJECTIVE: Development of a means of wirelessly conveying high-bandwidth data simultaneously to and from multiple participants on an individual basis in immersive simulations.

DESCRIPTION: In immersive simulation environments, information is presented to participants in a number of different ways, the primary stimuli being visual and auditory but other possible stimuli including tactile and even olfactory cues. Such information in its various possible forms is presented to simulation participants via various transducers, be they graphics or image display systems, speakers or headphones, vibration platforms or artificial G-seats, or scent aerosol dispensers. Some transducers, such as headphones, binoculars, helmet-mounted displays, radios, or simulated night vision goggles, may be individually worn or employed. All such transducers require an electrical signal of some sort to drive or actuate them. In current simulation environments involving participants that perform and move around independently of vehicles (e.g., soldiers operating on the ground), the participants typically receive stimuli from transducers built into the simulator environment in which they are operating. In future actual combat environments, individuals will function as discrete nodes or entities in a large network, each receiving and transmitting information via wireless data links. In immersive simulation environments a high-fidelity simulation of the same data communication capabilities will be required for training realism sake. In actual vehicle-independent combat environments, individuals will not be tethered via cables to any fixed point. In immersive simulations, participants transmitting and receiving information similarly should not be tethered via any cables that would limit or restrict their movements, nor should the devices they use be tethered in a manner not duplicative of the devices they use in the real world. Some large vehicle-based simulator designs are not conducive to users being tethered by cables, as the users may need to get up and move around inside the vehicle during training exercises.

Due to unavoidable physical limitations of some simulation environments, some stimuli may necessarily need to be presented to participants via individually-worn transducers (as previously defined) which would not be present in an actual combat environment. For realism sake the fidelity of visual and auditory stimuli must be very high, and for visual stimuli in particular this corresponds to high resolution, wide field of view, and a correspondingly high bandwidth.

The Air Force is seeking means of wirelessly conveying high-bandwidth data simultaneously to and from multiple participants on an individual basis in immersive simulations. Such means of data transfer must have sufficient bandwidth to support full-color, wide field-of-view, high resolution (2000 x 2000 pixel minimum) dynamic imagery at a 60 Hz update rate for individual helmet-mounted displays. Such means of data transfer must support individually different security levels, must support high-fidelity auditory communications, and must provide means of triggering other discrete sensory cues for each participant. For the participant(s) in a simulation equipped with the necessary measuring equipment, such means of data transfer also must support external real-time monitoring of biometric or physiological parameters (e.g., respiration, pulse, skin conductivity, eye tracking data, etc.) for each individual.

PHASE I: Identify and document effects of high fidelity stimuli on data bandwidth requirements. Define and document technical options, design a tetherless datalink concept capable of meeting all requirements in "Description" for multiple individual participants in various immersive simulation environments.

PHASE II: Prototype the proposed Phase I design concept, and demonstrate it using GFE simulated binocular NVG, supporting two individuals simultaneously. Durability and operating duration are considerations. Also demonstrate system maximum transmitting and receiving bandwidth capability. Submit a complete technical report documenting all work under the effort.

DUAL USE (MILITARY AND COMMERCIAL) APPLICATIONS: Military: Any training simulation system requiring realistic untethered high-resolution data transfer to/from dismounted trainee participants. Examples: USAF JTACT Simulator; US Army Dismounted Soldier Simulator. Commercial: Entertainment industry, also education, training or maintenance applications which would benefit from continuous roaming access to high-resolution reference materials.

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KEYWORDS: Simulator, Immersive, Datalink, Cable, Tether, Wireless, Bandwidth, Multiplexing, Security, Encryption, Decryption, High resolution, High fidelity, Sensory cues, Stimuli, Helmet-mounted display, Night vision goggle, Visual display, Auditory

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AF06-030 TITLE: <u>Knowledge Assessment System for Evaluating Performance in Dynamic Environments</u>

TECHNOLOGY AREAS: Air Platform, Human Systems

OBJECTIVE: Develop interactive knowledge assessment tool that provides realistic vignette examples and assesses pre- /post- performance in Distributed Mission Operations (DMO).

DESCRIPTION: This effort will develop an automated, psychometrically sound, vignette-based tool which will assess pre- and post- performance of individuals in a dynamic environment. Efforts will focus on tailoring the tool to diagnose knowledge and skills, identify gaps, and outline training areas which can be addressed in a Distributed Mission Operations (DMO) environment. Currently most assessment methods for DMO events involve subjective pen-and-paper critiques of observed performance and do not allow the players to receive immediate feedback in the fast-paced, complex, critical decision making environment. It is difficult to asses how well an individual or group of individuals is performing in real time, subjective assessment. This tool will provide psychometrically valid assessment of an individual's performance based on their responses before and after participating in a DMO event. It will also assess knowledge and measure mission effectiveness and performance in military training and rehearsal environments. Air Weapons Controllers operate in a fast-paced, quick thinking decision-making environment and it is critical that they perform to the highest level at all times. Training challenges faced by Air Weapons Controllers include reduced flexibility of mission training needs and little opportunity for repetition of specific mission elements. Controllers need realistic continuation training that centers on job specific critical skills. Currently, it is difficult to cater training missions to their needs as they play a supporting role in training missions with pilots. This interactive tool will initially focus on the Air Weapons Controller community due to the complexity of their environment and their relation to air combat, however, this tool will have the capability to generalize to other air combat areas. This vignette-based assessment tool will supplement training by providing controllers targeted mission element examples that cover a broad scope of mission types, scenario variances, and best practices. Due to the critical role communication plays within the Air Weapons Controller community, this tool will also allow for audio assessment and feedback. The tool will provide repetition of mission elements critical to maximizing their performance capability both in theater and in simulated operations. The developed solution will leverage innovative training strategies to demonstrate quantified improvement in performance on critical skills in the DMO environment.

PHASE I: Provide proof-of-concept vignette-based technology for assessing pre- and post- performance of individuals within a DMO environment.

PHASE II: Fully develop, apply, test, refine, and validate the knowledge assessment system of pre- and post-performance of individuals training within a distributed manner which includes an interface able to adjust to changing mission requirements and a scoring function to measure increases in performance after structured training interventions.

DUAL USE COMMERCIALIZATION: This effort will produce a cost-effective capability to evaluate pre- and post- performance within a dynamic environment. This system will have wide application within the command and control arena and will be extensible to combat environments throughout the military services. Commercialization of the toolset may include other domains that require fast-paced, quick thinking, accurate decision-making as well as repetition and flexibility in training protocols (air traffic control, emergency personnel)

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KEYWORDS: Distributed Mission Operations, Training Effectiveness Evaluation, Weapons Controllers, simulation performance measurement, effective communication, performance assessment

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AF06-031 TITLE: Intelligent Information Decluttering for UAV Displays

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate intelligent information decluttering software that enhances UAV operator decision making by reducing distractions and improving situation awareness.

DESCRIPTION: Unmanned Air Vehicles (UAVs) are at the forefront of current battles and future thinking (OSD UAV Roadmap, 2002). Several projects are underway to increase the level of autonomy for future unmanned systems, so as to increase the number of UAVs that one crew (or one operator) can simultaneously control. Besides supervising multiple UAVs, operators will be challenged to maintain situation awareness as the availability of real-time net centric information updates drastically increase, cluttering displays even more. Information overloaded displays can have several deleterious effects: 1) important information may be obscured, 2) irrelevant information may receive undue attention, 3) decisions may be delayed, 4) decision accuracy may be compromised, and 5) cognitive workload may escalate needlessly. Current declutter mechanisms are limited and only offer discrete predetermined solutions, based on simplistic classification rules. With the increasing levels of data available, it is vital that the control station intelligently highlight critical and timely information to maximize UAV operator situation assessment and decision making. Intelligent information decluttering should also help UAV operators manage their attention and concentrate on the most critical and/or threatening information. The key challenge is determining which information elements should be decluttered, based on the task at hand. With decision-aiding knowledge-based tools and advances in modeling/neural networks, innovative solutions for automatically tailoring information presentation in response to real-time algorithmic mission assessments are now plausible. However, the extreme complexity of situation and threat evaluations within the "fog of war" precludes the development of a single, foolproof decluttering algorithm. Therefore, the development of several ‘heuristic’ automation declutter algorithms, even though imperfect, may be more desirable to guide the operator’s attention. With the goal of being a “decision-support tool” this decluttering approach should guide the operator’s attention to what the automation thinks “matters most” via decluttering/symbology highlighting, while also allowing the operator to verify the algorithms’ accuracy. This will help ensure operators still have all the needed information to serve as the final authority in judging the appropriateness of decisions/actions made by the automation system and assessing their impact on overall mission objectives. Additional challenges in developing this intelligent information decluttering model/simulation software is ensuring that it enhances overall situation awareness while it simultaneously reduces distractions and ensures that the intelligent information decluttering is sophisticated, following operationally relevant criteria. The decluttering must take into account real-time task assessment and prioritization of threats/information as well as information reliability and capabilities of the automation system. This is especially critical in light of operators’ entirely new supervisory tasking, driven by the capability of future UAVs ‘to decide’ autonomously. The goal of this SBIR is to provide a real-time decision-aiding knowledge based information management system, based upon the development and validation of several heuristic automation declutter algorithms, which will reduce UAV operator workload and improve situation awareness, threat response time, and overall UAV mission effectiveness.

PHASE I: For a representative net-centric control UAV application and mission, develop a real-time decision-aiding visualization software prototype that enables intelligent information decluttering and attention management.

PHASE II: Perform spiral design/evaluation/refinement iterations on the intelligent decluttering model/simulation. Expand technology to multiple UAV applications and several realistic network centric enabled information sources.

DUAL USE COMMERCIALIZATION: This effort directly supports the goals of the UAV program. The intelligent information decluttering technology will also be generalizable to unmanned ground and sea systems as well as numerous civilian supervisory work domains.

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KEYWORDS: unmanned systems, UAV, clutter, display, neural network, human factors, automation, situation awareness

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AF06-033 TITLE: Instrumented Anthropomorphic Prototype for Non-Lethal Weapons Effects

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical, Electronics, Human Systems, Weapons

OBJECTIVE: Investigate Physiological Effects of Non-Lethal Weapons

DESCRIPTION: The current proliferation of non-lethal weapons (NLWs) is occurring despite a vacuum of data on their human physiological effects. Literature review and animal testing supplies data of limited fidelity on these human effects. Data based upon human testing is extremely difficult and rare due to ethical concerns, and when they do exist, such data are based upon experimental manipulations of low intensity and may not generalize well to operational intensities. Thus, there is a need for a human surrogate more accurate than animal models. Suggested here is an anthropomorphic test dummy prototype that is instrumented to collect data on the quality, intensity, and duration of human sensory performance as a function of the physical output of a variety of NLWs. However, neither the current state of physiological modeling nor sensory instrumentation for recording sensory responses are sufficiently advanced to provide this capability. Basic research and development are required in sensors, material technology, and most importantly, in functional modeling of human sensory capacities. The sensory mechanisms most relevant to the mediation of NLW effects must be identified and quantified in a manner that can be approximated with sensors. It is unknown whether commercial off the shelf (COTS) sensors will suffice for full instrumentation, thus custom materials and sensor development may be necessary to model certain human sensory capacities. Ultimately, such a prototype will pave the way for rapid and safe collection of high fidelity human physiological effects data as a function of existing and prototype NLWs, as well as provide design guidance on probability of effectiveness and risk for future NLWs. At a minimum, such a prototype will be instrumented to collect data regarding visual and auditory sensation, and blast overpressure effects to the lungs, central nervous system, and other major organs, with expanded capabilities to include toxicological effects of riot control agents (RCA), and dermal and optical effects of directed energy.

PHASE I: Review and quantify sensory mechanisms most relevant to the mediation of NLW effects. Design a promising prototype based upon test comparisons between COTS and/or experimental sensor characteristics and sensory mechanisms most relevant to the mediation of NLW effects.

PHASE II: Build the prototype and validate its capabilities against human effects data gathered through computer models, animal models, and extant human experimentation.

DUAL USE COMMERCIALIZATION: This test bed will measure human effects of NLWs for both the DoD and CONUS law enforcement agencies.

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https://www.jnlwd.usmc.mil/default.asp

KEYWORDS: Non-lethal weapons, human effects, physiological effects, anthropomorphic modeling, human sensation, sensors

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AF06-034 TITLE: <u>3D Image Conversion to Editable Voxelized Anatomical Model</u>

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop software to generate and edit a voxelized 3-dimensional anatomical models.

DESCRIPTION: Voxelized anatomical models are widely used to simulate exposure of biological systems to directed energy. Most 2D and 3D models are only concerned with surface generation. The research community is concerned with the complete volume and retaining the integrity of the internal structures within the voxelized model. Developing the models currently is a completely manual process of converting MRI data into voxelized models. The manual editing is done one slice at a time in two dimensions which makes maintaining continuity in the third dimension difficult. The goal of this project would be to create an automatic method of converting medical scanning data into a voxelized model including an editor to over come the stated difficulties. An open source development model is preferred. Convert a 2-dimensional image dataset such as the Visible Man (National Library of Medicine) or a magnetic resonance imaging (MRI) dataset to a 3-dimensional voxelized anatomical model. The voxelized model will have automatic segmentation of tissue types that represents each tissue type by a color during visualization and as bytes in an output file. Develop an interface that allows accurate dual visualization of both the original image data and the voxelized model for comparison of tissue type choices. Provide the ability to edit the 3-dimensional voxelized model tissue types by moving a boundary line. Final editing will permit changes to individual voxel color/byte assignment. The user must be able to visualize each organ continuity and relationship between organs.

PHASE I: Conduct research to identify software requirements and then initiate the development of software that will generate a voxelized anatomical model and complete automatic segmentation of tissue types. Design layout and planned functionality of the interface for viewing and editing the voxelized model while comparing to the original 3D image. An Open-Source business model would be preferred. Software should be capable of operating on LINUX and Microsoft Windows operating systems.

PHASE II: Conduct research to refine the 3-dimensional image conversion with automatic tissue segmentation and implement the 3-dimensional interface to edit the voxelized model. Software should be operated using Graphical User Interfaces (GUI).

PHASE III DUAL-USE COMMERCIALIZATION: The final product will be useful to government, industry, and academia. The ability to obtain cost-effective anatomical 3-dimensional voxelized models of humans would be advantages to groups designing non-ionizing medical equipment or communication systems. The voxelized models can be used in most human research that requires very detailed internal structures. Understanding directed energy absorption is critical for equipment design and operation. Anatomical 3D voxelized models of animals could be used for Food and Drug Administration (FDA) efforts.

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KEYWORDS: voxelized editor, voxelized models, anatomical models, editable 3D models, 3D image conversion, 3D model continuity

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AF06-035 TITLE: Development of a Deployable Biomarker-Based Health Biomonitor (DBHM)

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a fieldable biomonitoring device, operable by nonmedical personnel, which allows biomarker detection in body fluids.

DESCRIPTION: The DBHM will incorporate innovative, versatile platform and capture elements to assay multiple biomarkers in a hand-held, field deployable device. Size and weight are important objectives: the DBHM will be small and lightweight (about the size of a PDA or less). Unlike currently available point of care units, the device and its capture/detection elements must be robust to withstand battlefield conditions, including temperature and humidity extremes. The biomonitor will sample microliter amounts of body fluids (blood, urine, saliva) in a noninvasive or minimally invasive manner and provide quantitative results for multiple biomarkers in near real time. In anticipation of the development of future militarily relevant biomarkers, the biomonitor must incorporate a multi-channel design to streamline uptake of new assays. Capture/detection elements should be designed with the ability to be reused a minimum of four times, with reagentless or near reagentless operation. The device will include any mechanism required for sample collection and will not require external power sources. The emphasis in concept and design will be on the flexibility of the device to not only test multiple biomarkers, but multiple biomarker types (protein, DNA, RNA) in extreme conditions.

PHASE I: Develop the initial components and key elements capable of completing the objectives in both the analyzer (mechanics and software) and the sampling platform. The sample assay chamber must demonstrate the potential for multiple assay capabilities as demonstrated by the incorporation and simultaneous detection/quantitation of two independent biomarker assays. Biomarker assays used in development in both Phase I and II may be selected by the performer and obtained by commercially available means and/or independently developed.

PHASE II: Based on Phase I design and concepts, advanced prototype development will progress to miniaturization of the computer analyzer to the objective size and weight. Software will be updated and refined. Required Phase II deliverables will include a prototype with multi-analyte detection ability as demonstrated by the incorporation and simultaneous quantitation of four independent biomarker assays, to include biomarkers to both protein and DNA. Additionally, the device detection/quantitation element must demonstrate statistically insignificant variation on four different testings of the same sample using the same assay chamber from temperatures ranging from 10 degree to 48 degree C.

DUAL USE COMMERCIALIZATION: As previously stated, the development of a deployable biomonitor will give the warfighter the capabilities to monitor health in ‘real time’ in the field, allowing for detection and intervention. Once such a health monitor platform is developed, its use is limited only by the identification and validation of biomarker assays by other sources, either DoD or commercial. The DBHM will be valued for application in Homeland security through rapid evaluation of health status in emergency situations requiring the rapid testing of large numbers of personnel by field staff. Additionally, with the development and incorporation of animal biomarkers to the early stages of exposure to such bioterrorist agents such as anthrax and hoof and mouth disease, this device could be used on site by veterinarians to quickly detect and contain an agriculture bioterrorism act. The civilian use DBHM may also contain additional internet connectivity abilities to allow assay data to be sent to a central location for further evaluation and data comparison/storage.

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KEYWORDS: biomonitor, biomarker, immunoassay, ELISA, POC, chemical agent testing, biological agent testing, low level dose, force protection, early intervention, health assessment

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AF06-036 TITLE: Remote Personnel Assessment

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: The objective of this research effort is to develop microwave/laser based technology to measure heartbeat, respiration and galvanic skin response in moving and non-cooperative subjects. It will also investigate methods to extend the standoff distance of the microwave/laser system to 35m. Furthermore, it will explore the possibility of using this system to detect and characterize personnel in severe urban clutter or in buildings (through walls) with a probability of detection threshold goal of 95%, with a 2% false positive rate.

DESCRIPTION: Recent research has supported the belief that active combatants will in general have heart, respiratory and galvanic skin responses that are outside the norm with respect to rate and rate variability. Therefore being able to perform real time physiological monitoring from a distance using a microwave/laser based system may provide for early detection and identification of terrorists, suicide bombers, and other personnel posing a threat. Such a device would also be useful for detection of subterfuge or deception during prisoner interrogation, and remote detection and targeting of life signs through obstructions and severe urban clutter.

PHASE I: Researchers will perform computational investigation/analysis of laser and RF based technologies for a single system to monitor/interrogate heart rate, respiration and galvanic skin response (GSR) in human subjects in a lab setting. The effort will emphasize small sized (easily man portable) sensors with low power requirements. This effort will trade laser against radiofrequency capabilities and define preferred system configuration. Technical challenges in this phase are expected to include: integration of laser/RF technologies, signal to noise optimization and statistical interpretation. Preliminary designs will be provided.

PHASE II: Researchers will investigate methods to extend the range of the system to 35 m with a probability of detection threshold goal of 95% and false positive rate of 2%. Researchers will also investigate methods to detect and characterize personnel in severe urban clutter and through external and interior building walls. During this phase the researchers will provide a detailed prototype design and will complete fabrication and testing of a prototype. Technical challenges in this phase are expected to include process optimization.

PHASE III DUAL USE APPLICATIONS: This device would be useful for military applications such as (1) Counter-terrorism: Remote/non-intrusive monitoring of the physisiological functions of adversaries that may predict hostile behavior and give advance warning of hostile acts. (2) Force protection: Remote/non-intrusive detection of human life forms in concealed/battle damaged areas. (3) Intelligence: Remote/concealed "lie detector" analysis of individuals. The device would also have multiple commercial applications such as emergency patient monitoring, prisoner suicide prevention, disaster recovery operations, medical image processing, airport surveillance, etc.

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KEYWORDS: Physiological Monitoring, Behavioral Monitoring, Physiological Sensors, Remote Detection, Doppler Shift.

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AF06-037 TITLE: Quantitative Assessment of Influence Operations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Establish approaches to quantitatively predict the results of influence operations on military outcomes using existing market research statistical models.

DESCRIPTION: Influence operations as defined here are activities that consciously attempt to influence the mental state and behaviors of adversaries or potential adversaries. Specifically included in these activities are PSYOP, military deception, counterintelligence, and public affairs. Currently there are no universal processes to predict the results of influence operations. Being able to predict the results of influence operations would save countless lives and provide a great advantage to friendly forces. We seek novel exploitation of concepts, encouraging the use of modeling and simulation, to guide the development of an approach to quantitatively predict the results of influence operations using existing market research statistical models.

PHASE I: Identify and define how market research statistical models can interact in a positive manner with military operations. Design a mechanism for fitting statistical models to after action reports, as a function of influence operations.

PHASE II: Using the results from Phase I modeling, design, demonstrate and validate a prototype quantitative or semi-quantitative influence operations predictive capability that is analogous to market research as it is practiced today.

DUAL USE COMMERCIALIZATION: Military application: Being able to predict how an adversary would react to influence operations would bring about a decrease in casualties and material loss. Commercial application: Findings of this effort would be of great interest to current market researchers in explaining and predicting outcomes as it relates to target product or service.

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KEYWORDS: Modeling and Simulation, Influence Operations, Market Research, Operations Research, Discrete Task Event Analysis Tools, Hybrid Models, Mathematical Economics and Econometrics, Model-data Fitting, Learning Theory

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AF06-038 TITLE: Innovative Tools for Information to Decisions in Biosciences

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

OBJECTIVE: Create and demonstrate an innovative automated intelligent tool set for managing, analyzing, and producing new knowledge, based on large bioscience-based research data sets.

DESCRIPTION: Developments in computer science, sensors, electronics, biomechanics, biotechnology, nanotechnology, cell-like entities, anthropometry, medical imaging, visualization, biochemistry, automated laboratory analysis, digital human modeling, the internet and other research areas have made it possible for ever-increasing amounts of data to be collected. Some of these data are analyzed, published, and readily available worldwide. This rapidly growing body of information is not organized in ways that would allow a quick response to “What If” questions, nor are the disparate pieces of information linked in a way to foster leaps in understanding. An example of an accessible database that could benefit from the application of intelligent tools to convert information to knowledge and decisions can be viewed at: www.biodyn.wpafb.af.mil. Similar data sets exist in the areas of altitude physiology, anthropometry, acceleration physiology, and human performance. Areas of immediate application include: biotechnology, bioinformatics, protection science, biomechanics, anthropometry, nanotechnology, remote identification and state assessment of humans, and digital human modeling.

PHASE I: Research & define innovative tools to automate & facilitate the intellectual process of transforming information from the literature and from experimental data sets to knowledge, understanding, and decisions. Perform an initial feasibility demonstration of the intelligent tool concept

PHASE II: Finalize and demonstrate the tool set from Phase I. Phase II will be the continuation of the development of the tools proposed from Phase I. This information system will be validated by demonstrating how a research question can be answered through use of these intelligent tools for a practical application.

DUAL USE COMMERCIALIZATION: The tool set developed and demonstrated in Phase II would be widely applicable in the Human Effectiveness Directorate of the Air Force Research Laboratory. These tools would find wide application in government, academic, and industrial laboratories where researchers face the need to process increasing amounts of information and quickly make decisions based upon that information. With these tools it would be possible to organize and analyze the information from many different fields in order to make significant leaps in understanding.

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KEYWORDS: intelligent software tools, database, computer science, sensors, biomechanics, biotechnology, nanotechnology, cell-like entities, anthropometry, medical imaging, data visualization, automated laboratory analysis, digital human modeling, the internet, bioinformatics

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AF06-039 TITLE: Desalinator for One-Man Survival Kit

TECHNOLOGY AREAS: Biomedical, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a lightweight, compact, rugged and reliable system that can filter salt water into safe drinkable water.

DESCRIPTION: Aircrew members ejecting over salt water carry limited drinking water reducing the time they can survive pending rescue operations. Current procedures/equipment for supplying aircrew members with drinking water following an ejection over salt water are not adequate. Available water includes water in soft packets and cans which are placed in the ACES II ejection seat survival kit and aircrew survival vest. While desalinators are available to produce drinkable water, there is no desalinator suitable for storage in the ACES II survival kit. The current desalinator (RMOD-06) used by the USAF is hand-pump operated and used on multi-man survival kits. The product water to effort ratio of the current desalinator is very small, producing only 1 cup of drinking water for 16 minutes of continuous effort or nearly 1000 hand pumps from the operator. The current desalinator can be made inoperable by biological or chemical degradation, fouling and scaling, or by supply water bypass, which are common problems with current technology. For this effort, the contractor shall research technologies that can be applied to a new desalinator to reduce size and weight, and increase reliability and product to effort ratio. A desalinator one-third the size and weight of the RMOD-06 is desired for storage in the ACES II survival kit or survival vest pocket. The weight and volume of the current device is 2.5 lbs and 100 in3 (5in x 8in x 2.5in). A novel method will also be investigated to minimize or eliminate aircrew physical activity/exertion, while increasing product output. The contractor shall also investigate methods to introduce electrolytes into the water to reduce the potential for hyponatremia or water intoxication caused by electrolyte loss. Objective for water production is 2 gallons per day with a salt rejection of 98.4% average (95.3% min.).

PHASE I: Identify/develop technologies which can be integrated into a desalinator suitable for aircrew use in the ACES II survival kit or survival vest. Perform requirements identification, analysis, program risk assessments and trade studies for recommended solution(s) to address size, weight, water production, reliability, salt rejection and electrolyte addition. At the end of Phase I, provide prototype(s) or demonstrate technologies which could be applied to a desalinator system.

PHASE II: Continue to develop/refine the Phase I system. Finalize system requirements and verification methodology. Prepare test plan and perform laboratory tests to ensure components and system are biological and chemical resistant, fouling and scaling resistant, temperature shock resistant, and pressure shock resistant. Assemble prototype systems for integration and compatibility assessments with AF equipment, survival vests/kits.

DUAL USE COMMERCIALIZATION: This technology could provide affordable drinking water conversion from brackish or sea water sources. This technology has broad commercial applications for emergency equipment for fisherman, particularly the commercial fishing industry, cruise vessels, boating, etc.

REFERENCES: 1. Multi-Command Operational Requirement Document CAF-MAF-AETC 319-93-I-A "Aircrew Protection and Life Support/Escape Systems" dated Jun 99

KEYWORDS: desalinination, desalinator, portable, sea water, salt water

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AF06-040 TITLE: Distributed Methods for Assessing the Readiness of Coalition Workgroups, and Teams

TECHNOLOGY AREAS: Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop collaborative real-time performance assessment methods for evaluating the impact of training, rehearsal, and human factors engineering interventions.

DESCRIPTION: Challenges with distributed team performance assessment have been demonstrated recently during a multi-national coalition high-fidelity simulation training event. Current assessment methods of such events rely on subjective pen-and-paper critiques and reviews of after-action reports which are labor intensive, time sensitive and ineffective for assessing workgroup and team performance. There is a need to develop comprehensive, psychometrically valid assessment tools for not only individuals, but workgroups and teams who interact within a dynamic environment. Team members will often respond to specific situations in different ways depending on their position and role. In previous, non-collaborative assessments, each member’s response could not be evaluated within the context of the aggregate performance of the team. This effort will conduct research to develop distributed, collaborative methods and criteria to systematically assess the performance and readiness of individuals, and individuals as participants in workgroups, and teams. This will include conducting studies to develop real-time distributed performance assessment methods and criteria for use in evaluating the impact of a variety of training, and design interventions on individual, workgroup and team performance and effectiveness. The resulting technology and criterion measures may employ text-, digital video-, animation-, and/or simulation-based situations for performance assessment. Using this developed technology, all members of the team can respond as individuals and can observe the responses of all other members. Some members may actually respond differently based on the given responses of other members. Also, the criterion performance measures will be situationally-based assessments from which actual test scores would be obtained. This same performance assessment approach can also be used by dispersed members of a workgroup who must share information about a situation and arrive at a group response or decision. A distributed, collaborative approach for performance assessment not only provides critical information about how all members would perform in the given situation, but the data on their responses can be used to identify innovative solutions, misconceptions about the appropriate solution, and incorrect information that could be addressed in future collaboration or in follow-on education and training programs. Similarly, workgroups and teams can be identified, assembled, and assessed more readily if relevant, objective performance measures are developed and used. Also, exemplary criterion measures and data collection methods will be developed for four domains. Two of the domains will be related to Joint or Coalition military workgroup and team performance and two will be related to non-military domains such as regional sales teams or product development teams.

PHASE I: Provide proof-of-concept technology for evaluating and modeling learning and for conducting real-time performance assessments in a distributed, collaborative environment.

PHASE II: Fully develop, apply, test, refine, and validate the distributed, collaborative learning modeling and real-time performance assessment technology and develop tools to permit criterion measures to assess workgroup and team performance and readiness.

DUAL USE COMMERCIALIZATION: This effort will produce a cost-effective capability to evaluate individuals and teams. The results from this effort are of considerable interest to the Private Sector as a means of gathering team productivity and performance assessments from dispersed workgroups for use in identifying areas of high performance, areas of potential problems, and additional education, training, or management requirements. Phase III Dual use potential is significant as no assessment capability such as the one described herein exists. The benefits from such a capability to Government and Private Sector agencies could help organizations save considerable time and expenditures by targeting measurement to address specific areas of performance and productivity.

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KEYWORDS: Coalition training,Collaborative learning,Distributed simulation, Joint training and rehearsal,Performance measurement, Program evaluation,Readiness evaluation,Individual and team effectiveness

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AF06-043 TITLE: Developing Crew Resource Management (CRM) Skills for Combined Air Operations Center (CAOC) Teams

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The objective for this effort is to identify CRM skills required by AOC crews, develop training interventions to improve these skills and evaluate the impacts on AOC crew performance.

DESCRIPTION: Military and commercial flight crew training programs have invested considerable resources in Crew Resource Management (CRM) training, and general CRM concepts are currently being applied to a variety of other high risk environments such as medicine (Helmreich, 2000) and industrial settings such as off shore oil operations (O'Connor and Flin, 2003) and nuclear power plants and refineries (Helmreich, Wilhelm, Klinect, & Merritt, 2001). Despite its widespread adoption as a training intervention, researchers have documented a lack of agreement on several fundamental issues, including which CRM skills are needed for effective mission performance, how CRM behaviors can be most productively trained, and even the effectiveness of CRM training (Salas, Rhodenizer, & Bowers, 2000).

For Air Force aviators, CRM skills are defined in terms of six core areas--situational awareness, crew coordination/flight integrity, communication, risk management/decision making, task management, and mission planning/debriefing (Air Force, 2001). Statistically significant correlations between these CRM areas and mission performance were documented for both special operations and tactical airlift crews during annual simulator refresher training (Nullmeyer and Spiker, 2003; Nullmeyer, Spiker, Deen, and Wilson, 2003), and key CRM behaviors of the most effective crews were identified. Consistent with trends identified from real world mishap reports, specific CRM shortfalls were associated with weak mission performance. On the opposite end of the performance spectrum, a consistent set of exemplary CRM behaviors characterized the most effective crews.

Helmreich (1999) documented a clear evolution of CRM training from seminars covering general interpersonal dynamics toward aviation-specific content that includes hands-on simulator scenarios. Recent generations of CRM focus on error management (avoiding errors, identifying and correcting errors before they become consequential, and mitigating the consequences of errors that do occur). With this focus comes a requirement for an accurate understanding of error in the community being trained. Smith (2002) used the Air Force CRM taxonomy to analyze events leading to the 1994 Black Hawk fratricide and concluded that "CRM-type concepts were applicable." CRM-type errors were evident in this real-world incident, and CRM-type skills were evident in analyses of several CAOC Offensive Operations Team Time Critical Targeting processes. Both suggest the need for effective CRM training.

Smith's detailed analyses of CRM behaviors in CAOC crews and lessons learned from aviation CRM training both suggest the need to identify the areas of greatest need upon which CRM instruction can be focused. Smith found evidence that most, but not all elements of the Air Force taxonomy were relevant. In addition, several CRM-like behaviors that are not specifically addressed in the Air Force taxonomy emerged as important elements. Similarly, aviation CRM programs have clearly evolved from generic to audience-specific content (Helmreich, 1999). Smith's initial analyses are encouraging, but they are focused on one event that occurred a decade ago. An early requirement is to determine those areas of greatest need based on a broader analysis of current CAOC performance.

PHASE I: Review the scientific literature and interview AOC experts to identify crew performance areas that are particularly sensitive to CRM skills. Conduct cognitive task analyses to identify training objectives. Develop a concept design for CRM training interventions to include training media.

PHASE II: Based on the Phase I concept design, produce a functional prototype CRM instructional package for AOC crews, including both courseware and media. Test and evaluate the resulting instructional package to demonstrate impacts on the specific CRM skills identified in Phase I and on the overall performance of AOC crews.

DUAL USE COMMERCIALIZATION: Prepare detailed plans for implementing demonstrated team training capabilities for applications in the domains of homeland defense, law enforcement, medicine, business, or aviation industries. Phase III proposals must include a detailed market survey and letters of interest / commitment from potential commercial partners for evaluation of Phase III consideration.

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KEYWORDS: crew coordination, situation awareness, decision making, communication, air and space operations center, distributed mission operations

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AF06-044 TITLE: Immunity from Threat Based on Measured Injury Causation

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a new class of small sensors for routine wear by military, police & sports personnel that record the magnitude & duration of exposure to impact, electromagnetic radiation, blast waves & bullets. The particular focus should be on sensing energy from blast waves (e.g from Improvised Explosives Devices) and bullets that accelerate the helmeted head to dangerous levels causing traumatic brain injury.

DESCRIPTION: An increasingly important issue in force protection is the ability to quantify injury causation resulting from various weapons effects and to design appropriate protection strategies. Today's weapons range from kinetic weapons, blast waves, thermal pulses, optical/electromagnetic beams and secondary sources such as shrapnel, and crash. What is not always known is the relationship between the local insult and the resulting injury. This is especially true of traumatic brain injury caused by blast waves from Improvised Explosive Devices (IEDs). In order to design effective protection systems knowledge of this cause and effect relationship is critical. What is envisioned are very small sensors that can be worn by all military personnel without encumbrance during all operations. These totally new sensors built using MEMS and or Nano technology would require no power or recorder but could be calibrated to permanently change in some way to capture a p record of the energy and direction of the blast or accleration of a helmet caused by a bullet. A small step in this direction has been taken by instrumenting race car drivers in the Indy Racing League and Champ cars with earplugs containing miniature accelerometers. More than sixty crashes have been documented thus far showing how the drivers' heads accelerate during the impacts while the resulting injury in documented by the medical staff. Boxers at the Air Force Academy have also been instrumented with earplugs containing accelerometers. However, both these current systems require batteries and a recorder that raise cost and require the wearer to put them on and other wise take care of them. With the new sensors very comprehensive prospective epidemiological studies could be carried out in all military and police operations and in helmeted sports where the recorded insult could be correlated with the resulting injury documented by medical staff. The resulting data could then be used to optimize protection through changes in protective equipment and tactics.

PHASE I: Conduct research leading to the development of very small, inexpensive, unpowered sensors that physically capture the magnitude and total energy of acceleration events. Results must demonstrate that practical components are possible, and that such components would have wide application (hence low price).

PHASE II: Phase II would consist of developing, testing and validation of a prototype system of sensors for a helmet and demonstration of its use in a blast wave environment (provided by the government).

DUAL USE COMMERCIALIZATION: Wearable monitoring sensors could be a highly marketable item to the military, police, sports and the automotive industries. In all areas it will provide critical information linking physical insult to resulting Traumatic Brain Injury. Design of new protection concepts requires such understanding. Groups that have already expressed interest include, National Rodeo Association, National Football League, Olympic Ski Team, Military and Civilian Fast Boats, Champion Aerobatic Pilots and FIA - Racing Go Karts and Rally Cars.

REFERENCES: 1. Knox, Ted, Validation of Earplug Accelerometers as a Means of Measuring Head Motion. SAE Paper 2004-01-3538, Proceedings of the SAE Motorsports Conference and Exhibition (P-392). Nov. 30 – Dec2, 2004, Dearborn, MI

KEYWORDS: force protection, warfighter, battlefield stressors, real injury criteria, epidemiology of injury, sanctuary, immunity from threat, wearable sensors, nanotechnology, MEMS, unpowerd sensors, traumatic brain injury

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AF06-045 TITLE: Networked Electronic Warfare Training System (NEWTS)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: To develop a synthetically Electronic Warfare threat training system for tactical aircraft flight training for the Next Generation Threat System & proven Imbedded Electronic Warfare System.

DESCRIPTION: The Imbedded Electronic Warfare System (IEWS) was a highly successful AFSOC project (02-028) designed by the Air Force Research Lab Warfighter Training Research Division to simulate threat parametric data in the AN/ALR-69 Radar Warning Receiver (RWR). IEWS was developed with commercial off-the-shelf (COTS) personal computers installed in a rack in the cargo area of aircraft IWES interfaced with the AN/ALR 69 signal processor through the MIL-STD-1553 EW bus, creating an onboard simulation of the AN/ALR-69 with threat parametric data. Aircraft airspeed, altitude, and position data were also fed into the simulator from the MIL-STD-1553 navigation bus, allowing the imbedded simulator to provide fully correlated threat parametric data to the AN/ALR-69 azimuth indicator and indicator control unit in the cockpit. With IEWS, aircrews were provided a realistic simulated threat environment for training anywhere and anytime without the additional cost and need of an EW training range or dedicated air and ground threat assets. Today's small tactical aircraft do not have the physical space for an IEWS equivalent imbedded system. Although such a system could be packaged in a pod that would be hung from a weapon station, doing so would require Seek Eagle testing for each platform type on which the system was used. Additionally, funding for dedicated training systems on every small tactical aircraft cannot compete with funding for essential combat equipment. The proposed NEWTS addresses these issues by utilizing existing EW and data link equipment on small tactical aircraft to pass the "hard-wired" commands utilized in the IEWS system over "wireless" channels between a common ground simulator and participating aircraft. For initial validation of this concept, certain fighter aircraft are ideal because of their AN/ALR-69 RWR and Situational Awareness Data Link (SADL) capabilities. Additionally, fighter aircraft possess the AN/ALQ-213 EW Management System with proven AN/ALR-69, MIL-STD-1553 bus, and data link interface capabilities. After successful validation of this concept, the NEWTS could be extended to all small tactical aircraft with RWR and data link capabilities. Essential air and ground EW threat training opportunities would no longer be limited to EW training ranges with expensive emitters or pod-required training systems.

PHASE I: Design a feasible technical solution to provide networked electronic warfare training via datalink. Document inadequacies of current fighter EW training. Propose system architectures able to transmit data, aircraft airspeed, altitude and position data over time, and process this data in NGTS.

PHASE II: Demonstrate generation of a threat symbol on an AN/ALR-69 RWR. The threat symbol will correlate in azimuth and range to a fixed ground location relative to a flying fighter aircraft. Airspeed, altitude and position data over time will be processed in NGTS to assess the maneuvering against the simulated threat. Countermeasure actions will be identified for assessment.

DUAL USE COMMERCIALIZATION: This effort will produce a cost-effective capability to maximize critical combat training opportunities. It will fill an identified shortfall in realistic threat reaction training, especially for smaller dislocated operation units and ultimately improve combat effectiveness. High fidelity EW scenarios and training could be executed at the unit level, without external contractor support or cumbersome aircraft mounted pod systems. Contractors supporting Air Force DMO systems can integrate NEWTS into current and future aircraft. Additionally, civilian organizations supporting Homeland Defense and Air Traffic Control can leverage networking applications developed for NEWTS for use in civilian training or live systems.

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3. OPERATIONAL REQUIREMENTS DOCUMENT (ORD) CAF ORD 330-88-II-B For Joint Threat Emitter (JTE)

KEYWORDS: Electronic Warfare Training,Live Virtual Constructive, Distributed Simulation,Combat Mission Training

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AF06-047 TITLE: Semantic Interoperability of C2 Tools and Technologies

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology for information discovery and reasoning to facilitate information sharing between decision aiding tools to efficiently perform planning and execution management functions.

DESCRIPTION: The current Command Control Communications Computers Intelligence, Surveillance Reconnaissance (C4ISR) infrastructure is not seamless and vital pieces of information are not passed in a timely manor or critical pieces of data are not linked to entities that require it. In addition, many of the current systems lack compatible tool/process interoperability, which results in slower processing and action on information. Operators spend a tremendous amount of time identifying relevant, required and missing information across the boundaries of the AOC Divisions.

The purpose of this effort is to develop tools and techniques that will enable personnel to utilize information discovery technology to connect semantically meaningful information to automated AOC systems. The goal is to create reasoning capabilities to provide executable, decision-quality knowledge to the commander in near real-time from anywhere, thereby enabling force application in single-digit minutes from the decision to engagement

Demonstrate the interoperation of decision aiding tools and technologies utilizing semantic like integration and information infrastructure technology for such areas as collaborative planning, scheduling, and execution analysis capabilities. For a military environment this could be the complete Joint Air Operations Plan (JAOP) and execution Air Tasking Order (ATO) within the Air Operations Center (AOC). Semantic linkages between the information/data and various tools should also be explored.

PHASE I: Analyze information sources and need of prospective processes within the Air & Space Operations Center for maximizing machine interoperability. Develop an approach to assist AOC personnel and demonstrate the initial design for a prototype application.

PHASE II: Research and develop the required technologies and prototype, per Phase 1 design. Develop and demonstrate a prototype system which semantically marks up information across the AOC tools. Demonstrate that the information can be used to support other applications.

PHASE III DUAL USE APPLICATIONS: The ability to understand information constructs through the definition of relationships would enable timely passing of needed and relevant information. This would also be of primary benefit to Homeland Defense and law enforcement for situation understanding.

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2. The Semantic Web, Tim Berners-Lee, James Hendler &Ora Lassila, Scientific American, May 2001

3. Joint Publication 3-30 (2003), “Command and Control for Joint Air Operations”

KEYWORDS: Semantic Markup, Air Operation Center, AOC, Interoperability, Information Exchange

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AF06-048 TITLE: Mission Rehearsal Capability for Feasible Dynamic ISR Tasking in Support of Effects Based Assessment

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Provide the Air Operation Center (AOC) with a capability to simulate and assess alternative air intelligence collection tasking methods in support of dynamic effects based assessment.

DESCRIPTION: The dynamic and evolving hyper-operations-tempo battlespace of the future will require rapid adjustment of the location and timing of intelligence and surveillance collection assets. This effort will result in a mission rehearsal and analysis capability for use by the AOC Combat Plans division to “fly-out” ISR (Intelligence, Surveillance and Reconnaissance) collection plans. Algorithms, simulations and/or modeling techniques will be investigated and developed for use in optimizing the ISR plans in relation to their support for effects-based assessment. Exploration of the application of modeling and simulation technology such as system modeling, discrete event simulation, numerical simulation, multi-perspective modeling, performance evaluation, etc. should be proposed. The capability will assist the ISR planners to optimize alternative paths, layouts of assets, and alternative collection resources, and de-conflict ISR collection plans with other mission plans (Attack and Electronic Combat). The ISR Division of the AOC could also utilize the technology developed to adjudicate between JFACC (in-house) vs. national ISR collection asset and assist in dynamically adjusting these asset collection mission paths.

Inherent in the capability will be insight into the effects-based course of action and Joint Air Operations Plan, especially the assessment plan developed by the Operational Assessment Team. The final product will allow ISR planners to adjust their plans to meet the dynamic nature of the battlefield. The ISR plan can then be focused on how their assets will contribute to the overall operational (effects-based) assessment. The capability will answer such questions as: When should the ISR assets be at a specific location and time? What are the collection requirements that need to be met in support of assessing the effects-based plan? Can the assets see and collect relevant intelligence that will give indications of the attainment of an effects based dynamic plan at a given location? When should collection of intelligence be performed? What is the best orbit, location and orientation to collect info to meet the effects assessment needs? What is the most meaningful time to employ assets in support of assessment? Proposals can focus on one or more of the numerous aspects of the ISR tasking for effects-based assessment challenge without trying to solve the entire problem.

PHASE I: Research the applicability of proposed M&S technology for a mission rehearsal capability oriented to optimizing the ISR collection plan for effects based assessment. Investigate operational utility. R&D technology application and conduct a concept demonstration of the prototype capability.

PHASE II: Research and develop the required technologies and prototype, per Phase 1 design. Develop and demonstrate a prototype baseline system to assist with optimizing air intelligence collection tasking in support of effects based assessment. Develop capabilities to incorporate dynamic and continuous planning for assessment into the intelligence and surveillance collection process.

DUAL USE COMMERCIALIZATION: The ability to conduct mission rehearsal is very important in the military domain as discussed above as well as for first responders during a crisis response such as hurricanes, terrorist attacks, earthquakes, etc. Algorithms developed under this effort should be flexible enough to apply to these events.

REFERENCES: 1. Air Force Instruction 13-1, Operational Procedures - Aerospace Operations Center

2. Joint Publication 3-30, Command and Control of Joint Aerospace Operations

3. Air Force Doctrine Document 2-5.1, Intelligence, Surveillance, and Reconnaissance

4. EBO References: “Effects Based Operations”, www.sci.fi/~fta/EBO.htm

KEYWORDS: Mission Rehearsal, Optimization Algorithms, Air Operation Center, AOC, ISR Plans, electronic combat plans

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AF06-049 TITLE: Real-Time Effects Assessment Management System

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology to conduct continuous real-time effects-based assessment across all levels of war. Include techniques for correlating and matching observables to indicators from the EBO plan.

DESCRIPTION: Current combat assessment practices are not adaptable to the complexity of a dynamic and evolving hyper-ops-tempo battlespace. The DoD lacks a comprehensive assessment architecture and current approaches focus on assessing actions rather than effects. In addition there is currently no generally accepted framework (rating scale, update method, etc.) for conducting rapid battle damage assessment. Effective real-time assessment is required to assess actions in light of their progress towards achieving commander’s desired effects, so that air tasking processes can be dynamic and highly responsive to changes in guidance, resources and situation. This effort will explore new ways to achieve effects-based assessment in real time. Inclusive with assessing desired effects is the need to assess the impact of blue actions on enemy system models. This will assist in determining if indirect, cascading and unintended effects are being achieved. Technology is needed that can derive or infer attributes from intelligence data for the purpose of correlating effects indicators with evidence. Applications such as case-based reasoning, assessment templates with wizards, success indicator ontologies, data matching and correlation methods, and on-board decentralized assessment could be considered for exploration. The technology will enable the rapid assessment of tasks, effects and objectives based on observed actions, observed and predicted results, intelligence information, and other disparate forms of evidence. The resulting capability should address the aggregation of assessment from lower levels such as enemy target system battle damage assessment, up through assessment of component operational and strategic campaign objectives and effects.

PHASE I: Develop initial technology for automated effects based assessment using accrued multi-int sources, mission reports, battle damage assessment, intelligence summaries, platform video, real-time reporting links, etc. Design a capability for real-time and continuous effects based assessment. This might include exploring new frameworks for rapid battle damage assessment and the ability to parse the BDA reports to extract appropriate evidence for higher level EBA.

PHASE II: Develop a prototype effects based assessment management capability. This product will assist in planning and conducting effects based assessment. It will address the rapid aggregation of battle damage assessment and engagement level task accomplishment to determine higher level effects and objectives at the operational and strategic levels of war.

DUAL USE COMMERCIALIZATION: The ability to conduct real-time assessment could benefit sectors of industry that are involved with dynamic tasking processes such as express mail services, rental car companies, and airline agencies. Other Government agencies such as FEMA that are involved with emergency relief operations could also benefit from a real-time assessment technique.

REFERENCES: 1. JP 2-01.1, “Joint Tactics, Techniques, and Procedures for Intelligence Support to Targeting”

2. JP 3-60, “Joint Doctrine for Targeting”

3. ACC White Paper and ACC/XPS briefing “Effects-Based Assessment: Closing the Loop”

4. "The Current Battle Damage Assessment Paradigm is Obsolete", Lt. Col. Hugh Curry, Air and Space Power Journal - Winter 04

5. EBO References: “Effects Based Operations”, www.sci.fi/~fta/EBO.htm

KEYWORDS: Effects Based Assessment, Effects Based Operations, Combat Assessment, Battle Damage Assessment, Dynamic Tasking, Campaign Assessment, Operational Assessment,
Correlation and Matching, Indicators, Observables

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AF06-050 TITLE: Exploiting Dynamic Text Sources (e.g., Chat) for Improved Battlespace Awareness

TECHNOLOGY AREAS: Information Systems, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology to extract information from dynamic text sources (chat) for improved Battlespace Awareness, particularly in support of Dynamic Targeting.

DESCRIPTION: Time-Sensitive Targets (TSTs) require an immediate response because they pose danger to friendly forces, or are highly lucrative fleeting targets of opportunity. Examples may include tanks, troops, leadership, Command and Control facilities/nodes, and surface-to-air missiles. Because TSTs require an immediate response, a key goal is to reduce the time it takes to prosecute TSTs from hours to minutes. This need to speed up Dynamic Targeting has driven a demand for faster, more dynamic Battlespace Awareness. This has resulted in the operational use of friendly chat and other dynamic textual sources (e.g., e-mail) as alternate/contributing sources of information for Dynamic Targeting. However, critical parameters such as accuracy, latency, format, and actual value have yet to be assessed for Dynamic Targeting applications.

The objective is to develop technology to automatically extract information from dynamic text sources like chat, pertinent to Dynamic Targeting of TSTs. The goal is to provide high-quality structured information to processes involved in Dynamic Targeting (those involved in the Find, Fix, Track, Target, Engage, Assess cycle), to help automate, speed-up, and improve those processes. Note that for fast moving targets, such as missiles, chat has insufficient accuracy and update rates for use in actual targeting, but may be useful as an indicator for a launch event, or for confirmation of general trajectory or type.

Of particular interest is the use of chat by two groups that play key roles in Dynamic Targeting: Air Operation Centers (AOCs) and the AF Distributed Common Ground Station (DCGS-AF). E.g., AOC Time-Sensitive Targeting Cells do the planning and decision-making for targeting and prosecuting TSTs. Automated tools are being developed to speed-up these processes, but they need timely inputs, in a structured form their tools can exploit.

Developing technology that successfully extracts information from chat for this purpose would be a major accomplishment. For Combat Assessment, extracting information on the status of a TST targeted during a previous mission could help determine if it needs to be re-targeted.

The DCGS-AF, a major provider of information to AOCs, will provide worldwide Tasking, Processing, Exploitation and Dissemination of AF air and ground Intelligence, Surveillance and Reconnaissance (ISR) sensors and systems. This includes multi-INT Fusion. Could information extracted from chat be used by any of these processes to speed-up/improve Dynamic Targeting?

Numerous research challenges are associated with extracting reliable, high-accuracy information from dynamic textual sources like chat. Chat is non-grammatical, and is full of acronyms and abbreviations. Chat is similar to dialogue in nature; certain knowledge is assumed to be shared between participants vs being explicitly stated. Extracting useful information from chat will require: inferring information across lines/sentences, performing co-reference resolution; time-stamping information, and disambiguating/normalizing locations. Because chat is so domain-specific, the capability must facilitate domain-customization by users to improve performance. Information that is subjective, uncertain, or negated must be accurately captured and represented. Since chat/email traffic may be erroneous or intentionally false, sensitivity analysis is important.

Because of the operational nature of this SBIR Topic's requirements and data, offerors are required to have at least Secret clearances.

PHASE I: Perform research to ID concept-of-operations, specify requirements and assess potential approaches. Develop the most promising solution approach and assess its feasibility. Develop the initial design for a prototype and demonstrate its application. AFRL is pursuing chat data for analysis.

PHASE II: Research and develop a prototype baseline system for extracting info from dynamic text sources like chat, per the Phase 1 design. Use real data, if possible. Demonstrate how the capability improves a specific Dynamic Targeting process (e.g., in the DCGS or AOC). Show how it would be used along with DBs within and outside of the Theater Battle Management Core System for immediate application.

DUAL USE COMMERCIALIZATION: The ability to extract information from dynamic textual sources such as chat would be very useful to analysts and investigators in both Homeland Defense and Law Enforcement, who need to be apprised of potentially relevant information in these textual data sources, but have limited resources, in terms of time and manpower, to do so in a manual fashion. An automated capability, that could keep them apprised of potentially critical new information as it becomes available, would be an invaluable assistant to shorthanded analysts and investigators.

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2. AF Chief of Staff General John Jumper, "Future Force: Transforming Operations", http://www.af.mil/speech/speech.asp?speechID=67, Remarks to the National Defense Industrial Association, Arlington, Va., April 1, 2004.

3. Cummings, M.L., "The Need for Command and Control Instant Message Adaptive Interfaces: Lessons Learned from Tactical Tomahawk Human-in-the-Loop Simulations", http://web.mit.edu/aeroastro/www/people/missyc/pdfs/Cummings_AA.pdf, July 23, 2004.

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KEYWORDS: Information Extraction, Natural Language Processing, AOC, DCGS, Chat, Dynamic Targeting, Time-Sensitive Targets, TST

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AF06-051 TITLE: Track Type Prediction Algorithm

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology, based on branch prediction algorithms for pipelining processors, to predict track types of emerging, potential dynamic targets.

DESCRIPTION: Positive Identification (PID), which is a step in the dynamic targeting process that determines the intent and target type of an emerging target, is a bottleneck for prosecuting time sensitive targets (TST) in the Air Force Air Operations Center (AOC). PID often involves tasking multiple sensors to gather intelligence on the track report of a potential target, analyzing the intelligence from the multiple sensors, and concluding if the target is a valid target. This could take 30 minutes to several days depending on the availability of sensors and human analysts. Once PID has determined the target as hostile, the AOC may continue the planning process of assigning which asset to strike the target; however, with a very small window of time to work with. By alleviating this bottleneck in the dynamic targeting process, more time would be available for planning and more strike options would be available, resulting in more TST opportunities taken.

Although several approaches are currently being researched, including automatic target recognition and dynamic sensor management, results have been slow to solidify. Instead of just waiting for results, something needs to be done to address this problem in the near-term to more rapidly support the warfighter. One completely different approach is to accept that PID will take a long time, but make predictions about the PID outcome so that the planning process may commence prior to PID completion. This approach exists today in the computer engineering domain for streamlining instruction evaluation for pipelined computer processors. It could be applied to any pipelined serial process, including the dynamic targeting process.

Modern computer processing architectures employ pipelining to cost-effectively approximate parallel processing. In other words, a single N-stage pipelining processor at steady-state is theoretically equivalent to the throughput of N parallel processors. In reality, the pipeline processors must contend with data, control, and structural hazards, which stall out the pipeline causing degradation in throughput.

The utilization of branch prediction algorithms significantly reduces stalls caused by these control hazards resulting in an increase in instruction throughput. The algorithm predicts the outcome of the branch condition, which is a condition where the location of the next instruction is not known, before it is actually evaluated. The postulated outcome is assumed true until the actual branch condition is evaluated. In the event that the outcome is incorrect, the next instruction will have to be aborted and reissued, causing a penalty equivalent to normal penalties in the absence of a branch predictor. If the postulation was correct, then the next instruction is left alone to continue execution, resulting in the avoidance of a stall. Modern branch prediction algorithms make predictions based on global and local histories of previous outcomes of branch evaluations. Low overhead approaches such as this have been shown to have prediction accuracies ranging from 80% to 95%.

PHASE I: Develop an automated track type prediction algorithm based on the most promising approaches. Given a track, the algorithm will make predictions on the intent and type of entity based on a variety of information sources, which will also be identified in this phase. The algorithm should focus on providing computationally inexpensive solutions at the cost of accuracy. Assess the algorithm's feasibility. Develop the initial design for a prototype, perform modeling and simulation, and demonstrate its application.

PHASE II: Research and develop the required technologies and prototype, per Phase 1 design. Develop and demonstrate a prototype baseline algorithm in military domain. Plan for Phase III.

DUAL USE COMMERCIALIZATION: At the core technology of the track type prediction algorithm is a low cost prediction algorithm. Business could benefit from utilizing this core technology, allowing their processes to be streamlined. For example, an event prediction algorithm could be employed at a bank in the loan process, specifically at the point of pre-approval. The algorithm could predict whether the applicant will be approved or denied based on the applicant's historical data and the bank's historical data on the applicant's classification. After pre-approval, if the outcome was different than the prediction, then the loan officer could easily adjust. This may be faster or cheaper than existing pre-approval methods. Industry would also benefit as most manufacturing processes in industry use an assembly line, which is a form of pipeline. Inspection points may be choke points in the process, where each item must pass some test before proceeding to the next process down the line. The prediction algorithms could predict whether or not a batch of items should be rejected or accepted based on historical data of the batch as well as historical data on all of the batches.

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KEYWORDS: PID, TST, PBA, Set Prediction, Branch Prediction Theory, Statistical Inference, Information Fusion

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AF06-052 TITLE: Semantically Correct Interoperability of Executable Architectures

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop a methodology for providing semantically correct interoperability of executable models of system/operational architectures of complex information systems

DESCRIPTION: Architecture design tools for complex information systems are in increasing use in government and industry. The DOD Architecture Framework lacks semantically correct interoperability of compliant tools. Current commercial and DoD tools are not interoperable and output from one tool cannot be read by other, different tools. Interoperability among tools is of high concern to government users and many in the commercial sector. New trends in system design have led to the creation of executable models of system and operational architectures, but many different tools are in use, and the value of executable architectures is diminished without interoperability. An executable model of an architecture is a mathematical representation of the architecture traceable to the data contained in the DOD Architecture Framework artifacts and products. Current commercial efforts are developing tools for architecture design and analysis but not establishing an underlying foundation that allow tools to exchange data that has both correct content and meaning.

The objective of this research is to define and develop new and innovative methodologies for both syntactically and semantically correct interoperability of executable architecture models. There is a major deficiency in the ability to address semantic interoperability. While many tools export and import content in a tagged-data format, typically Extensible Markup Language (XML), tool interoperability is not achieved since the XML nomenclature for each tool is often proprietary. The development of language translators that convert one XML format to another often leads to subtle translation errors related to seemingly insignificant semantic differences between two nearly identical objects. The Defense Department has developed a central repository, the Defense Architecture Repository System (DARS), to foster interoperability between complex system architectures developed with different tools. DARS is compliant with the Department of Defense Architecture Framework (DODAF), which does not currently specify how executable architectures are expressed. The purpose of this research is to create a general DODAF/DARS compliant methodology (taxonomy, terminology, and ontology) for representing executable architecture content. The end product of the research will be a methodology that can be used to extend the Department of Defense Architecture Framework and commercial applications to include architecture execution by providing a common set of fully-expressed data descriptions related to architecture execution. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. If any graphical output is employed for visualization, industry or international standards such as OpenGL, Java libraries, etc. should be used in lieu of proprietary products.

PHASE I: 1) Develop specifications and design for a methodology to express executable architecture content that is DODAF/DARS compliant, 2)proof-of-feasibility demonstration of key concepts for preserving semantically correct interoperability executable architectures across 2 or more existing modeling tools

PHASE II: The researcher shall design, develop, and demonstrate a prototype tool that implements the Phase I methodology. The researcher shall also detail the plan for the Phase III effort.

DUAL USE COMMERCIALIZATION: The desired product of Phase III is a robust, off-the-shelf engineering tool capable of preserving syntactical and semantic interoperability for executable models of operational/system architectures for use in defense and commercial product design, development, and manufacturing for large and complex systems. Design and engineering tools are applicable to financial and manufacturing industries, biotechnology, healthcare, transportation, communications, and information systems.

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KEYWORDS: Model architecture, executable architectures, UML, XML, CPN, IDEF, color Petri nets, GIG, DARS, DODAF

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AF06-053 TITLE: Knowledge-based Technologies to Support Predictive Mission Awareness

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop algorithms and architectures using knowledge-based technologies to support real-time battlespace non-intrusive data collection and autonomous networking of theatre platforms for rapid predictive awareness.

DESCRIPTION: Decision makers in the defense and commercial sectors must assimilate a tremendous amount of information, make quick-response decisions, and quantify the effects of those decisions in the face of uncertainty. Advanced information technology will enable new decision-making tools, decision support systems, and future predictive oriented simulations that will assist decision makers in making better decisions. For military operations, Predictive Mission Awareness is the understanding of the operational environment that allows the commander and staff to anticipate future conditions, analyze adversary and friendly courses of action, formulate plans, and forecast specific events where decisions are required. An example of Predictive Mission Awareness is Predictive Battlespace Awareness as define by General John Jumper is his paper on the Global Strike Task Force.

The purpose of this research is to define and develop new algorithms, methodologies and architectures using real time knowledge-based technologies to support the collection and aggregation of situational information and the processing of predictive mission awareness across a range of applications. In general predictive mission awareness can be carried out by the human analyst , an intelligent system, or a mixture of both, and is very data intensive. The data are usually distributed across several command and control systems and in various formats. The researcher shall investigate new approaches for accumulating relevant data from distributed and heterogeneous data sources so that minimal amount of time is spent in learning individual data formats. The researcher shall consider intelligent agent and other knowledge-based technologies that could enhance data retrieval efficiency by automatically locating and retrieving data based on user queries. The researcher shall also consider the concept of a continuous, serendipitous, automated on-board ISR function while the aircraft is already out on the ATO-directed mission supplying situational data over autonomous data link operations. This function would automatically monitor all sensor events and direct additional sensors coverage of the events along its flight path so that ISR data can be sent back immediately to the CRC/AOC for up-to-date predictive evaluation. Once the specific data sources have been located and retrieved, they need to be fused based on some standard ontology to support rapid situation and threat assessment and prediction.

The amount of relevant data that are being accumulated has become overwhelming. A manual process to look for indications and warnings of threats into such data is highly time consuming. Intelligent techniques therefore need to be employed that can automatically assess and predict threats in a timely manner. Such techniques should be robust in order to deal with uncertain and incomplete data. New research is needed for rapid retrieval of data from voluminous and distributed heterogeneous data sources based on agent technology; fusion of accumulated information; advanced situation and threat assessment based on artificial intelligence techniques that can deal with uncertain data, such as influence nets and Bayesian belief networks; and prediction of adversary activities taking into account spatial and temporal dimensions.

A predictive mission awareness environment should include components for information retrieval, fusion, situation assessment and prediction. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. If any graphical output is employed for visualization, industry or international standards such as OpenGL, Java libraries, etc. should be used in lieu of proprietary products. Methodologies implementing the predictive awareness environment should be standards based to support interfaces to other analysis and simulation and modeling tools.

PHASE I: Phase I activity shall include: 1) development of a framework, computational approaches, architectural concepts and communication protocols for implementation of real time knowledge-based technologies for autonomous ISR data collection and predictive awareness; 2) a proof-of-feasibility demonstration of key enabling technologies .

PHASE II: The researcher shall design, develop, and demonstrate a prototype tool that implements the Phase I methodology. The researcher shall also detail the plan for the Phase III effort.

DUAL USE COMMERCIALIZATION: The desired product of Phase III is a robust, off-the-shelf tool for predictive awareness for use in the defense and commercial sectors. Commercial applications include law enforcement, financial industry, biotechnology, healthcare, transportation, and telecommunications. On the commercial side, this research can be applied to detecting credit card and telecommunication fraud by collecting data from multiple corporate data sources or to generate business intelligence by collecting and analyzing data available over the web. Additionally, the use of distributed intelligent nodes, communicating and handling processes in a closed domain without human intervention, could have many uses in industry, business and DoD. Space applications were the first to use this concept in a limited manner, by necessity. Nuclear, biological and other locations dangerous to humans would be conducive to this approach. Homeland defense is another application where drug or terrorist interception could be aided by many civilian aircraft with additional sensors and data inks. Conservationists could use this large area coverage for plant disease, animal migration and erosion control surveillance.

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KEYWORDS: Knowledge-based modeling, predictive awareness, mission space, predictive battlespace awareness, intelligent agents, knowledge-based technology

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AF06-054 TITLE: Argumentation-based Approaches to Enhance Dynamic Time Critical Decision-Making

TECHNOLOGY AREAS: Information Systems, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop an argumentation-based approach to support dynamic time critical activities such as prosecution of air campaign targets

DESCRIPTION: Many time sensitive and time critical processes exist in commercial and military activities.

In the military, prosecution of time sensitive and time critical targets within a command and control environment imposes significant workload and processing challenges. The compressed timeframes for addressing dynamic targets, combined with the uncertainty of battlespace information and the desire to elicit specific effects, impose severe limitations on command and control personnel. There is a significant need in military and commercial applications for a robust methodology to support decision making in time critical situations.

The purpose of this research is to define and develop argumentation-based approaches with agent-based system to support dynamic time critical activities such as the Aerospace Operations Centers for military and emergency planning centers in commercial applications. The argumentation formalism provides a form of reasoning that can account for uncertainty, ambiguity, and incomplete knowledge in decision factors.

The researcher shall address these issues with innovative methodologies to construct arguments for and against alternative options then aggregating what support information there is for each. The method must be robust and versatile but formalized in a way that is theoretically sound and computationally practical. Argumentation theory allows reasoning explicitly with negation of the candidate decision options; allows various forms of a dictionary of evidence which may be more psychologically intuitive than probabilities; provides a simple rule-based structure of knowledge that is easier to understand for non-technical end-users; and requires very few parameters for processing information. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. If any graphical output is employed for visualization, then industry or international standards such as OpenGL, Java libraries, etc. should be used in lieu of proprietary products.

PHASE I: 1) Develop specifications and design for an argumentation-based agent framework for use in a dynamic Aerospace Operations Center scenario; 2) a proof-of-feasibility demonstration of key enabling concepts.

PHASE II: The researcher shall design, develop, and demonstrate a prototype tool that implements the Phase I methodology for an air campaign scenario. The researcher shall also detail the plan for the Phase III effort.

PHASE III: The desired product of Phase III is a robust, off-the-shelf decision support tool capable of decision-making within time critical environments. Time sensitive and time critical decision support tools are applicable to financial and manufacturing industries, biotechnology, healthcare, transportation, communications, and information systems. Within the military community, an automated means for response recommendation has tremendous implications for the development of next-generation command and control systems. Within the commercial domain, example applications include equity and money market trading.

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KEYWORDS: Argumentation-based reasoning, decision support, time critical decisions, decision theory

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AF06-055 TITLE: <u>Uncertainty Visualization for Modeling and Simulation of Complex Systems</u>

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research, develop and evaluate methods for visualizing uncertainty in simulations of complex military systems

DESCRIPTION: Data visualization technology has made significant gains in its ability to rapidly, and with high resolution, render two and three dimensional graphics. But visualization needs to advance dramatically from data to information to knowledge visualization. In complex commercial and military information systems, there are many significant spatial and temporal uncertainties that must be depicted in an understandable fashion to the decision support personnel. There is a compelling need for providing a way for analysts and decisionmakers to assess uncertainty in the data they are exploring and for new methodologies to visually represent uncertainty. The objective of this research is to address current deficiencies and inability to portray uncertainty in military decision support systems and accompanying models and simulations.

Modern military simulation systems employ a variety of models to provide realistic representations of friendly and adversary warfighting capabilities (e.g., models of specific weapon systems) and the environment in which these capabilities exist (e.g., models of weather phenomena). These models and simulations attempt to capture the key elements needed to support training, mission rehearsal, decision support, acquisition, deployment, and tactics/strategy development. To achieve high degrees of realism, these models and simulations must also represent inherent uncertainties. For example, a commander deciding to deploy a specific weapon system may check the current and predicted turbulence at the target's location. In the real environment, the commander would use a weather forecast that has some degree of uncertainty in predicting turbulence. In the simulation, the model of the weather must also represent that degree of uncertainty so that the decision aid can correctly respond. Despite the fact that there are many methods to model uncertainty, uncertainty and data confidence levels are not typically incorporated into battlespace displays shown to the decision maker. This is due, in large part, to the fact that it is yet unclear how best to portray uncertainty in military decision support systems and that uncertainty visualization is an active area of research. Ill-timed or ineffective presentation of uncertainty information, in addition to other critical decision information, can result in information overload and interfere with decision making in rapid-response situations. Also, the user's trust that a simulation is realistic will depend on the representation of the same uncertain information found in real combat situations.

The researcher shall develop innovative methodologies of uncertainty depiction and consider aspects such as identification of key types of uncertainty and the situations where uncertainty information is critical to decision making; development of a system for exploring visualization techniques for representing uncertainty within simulations of complex systems such as military weapons; and the evaluation of visualization techniques using established metrics (e.g., response time, accuracy, user trust, improved situation awareness). Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Graphical output should comply with industry or international standards such as OpenGL, Java libraries, etc. in lieu of proprietary graphics products.

PHASE I: 1) Develop specifications, metrics, and design for a methodology to portray uncertainty for military decision-making which is supported by a battlespace simulation such as the Joint Semi-Automated Forces (JSAF), 2) a proof-of-feasibility demonstration of key enabling concepts.

PHASE II: The researcher shall design, develop, and demonstrate a production-scalable prototype that implements the Phase I methodology for a selected battlespace display driven by a military simulation. The researcher shall also detail the plan for the Phase III effort.

PHASE III: The desired product of Phase III is a robust, off-the-shelf decision support tool capable of visualizing information and knowledge uncertainty for simulations of complex military and commercial information systems. Decision support tools are applicable to financial and manufacturing industries, biotechnology, healthcare, transportation, communications, and information systems. Other dual use applications include state and local government emergency response systems for homeland security scenarios where uncertainty information is critical to effective decision-making.

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KEYWORDS: Knowledge visualization, Information visualization, uncertainty depiction, decision aids, Modeling and Simulation, Uncertainty

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AF06-056 TITLE: Tri Band Radome Design for Airborne Antennas

TECHNOLOGY AREAS: Air Platform, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop of a low loss triband radome for airborne antenna terminals.

DESCRIPTION: The radome mechanically protects the antenna and
terminal electronics from the outside environment. Careful trade-offs must be made between the mechanical constraints on the aircraft and the electrical performance. This development effort focuses on the development of a multi band radome and its associated material properties. The frequencies of interest would be Ku, Ka and EHF. The radome could be used on future FAB-T increments such as Global Hawk, U2 and Predator.

PHASE I: Develop conceptual material coupons and radomes designs that relate to the existing FAB-T radome shape. Analyze resistive and reflective losses in the bands of interest.

PHASE II: Fabricate a radome coupon/panel to validate the results predicted from the phase I development effort. Incorporate the results into a radome Design and predict losses as a function of scan angle using a representative FAB-T antenna. Design consideration should include rain erosion aerodynamics.

DUAL USE COMMERCIALIZATION: The contractor will work to produce a similar multi-band radome for the commercial aviation market. The frequency bands of choice for the commercial application will initally focus on 2-way Ku-band service (nominally 12 GHz receive and 14 GHz transmit) and the commercial Ka-band (nominally 20 GHz receive and 30 GHz transmit). The application is for commercial satellite communications on passenger aircraft. Radome sizings will be determined early on in Phase 3 and will address the antenna aperture sizings necessary to support various data rates deemed of interest in the commercial market and the capabilities of the satellites that are being connected to.

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KEYWORDS: 1. Multi band radomes,Airborne terminals,Reflector antennas

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AF06-059 TITLE: Automated Metadata Generation, Indexing and Cataloguing

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Provide a capability that will facilitate tagging and cataloguing of ISR information products for enhanced discovery and information sharing.

DESCRIPTION: Service-Oriented Architectures (SOA) are being developed to support the Air Force’s migration from a Task, Process, Exploit, Disseminate (TPED) toward a Task, Process, Post, Use (TPPU) approach in which Publish/Subscribe mechanisms will play an important role. A critical element of the Pub/Sub approach is the need to create and maintain metadata of information products to be shared within a commonly accessible, shared repository. Metadata, which will play a vital role in implementing the DOD Net-Centric Data Strategy, describes the content, quality and other characteristics of data in a structured manner that facilitates management, discovery and retrieval. This SBIR effort will develop tools that automatically capture metadata as the user is creating the information product using unclassified versions of standard Air Force vocabularies and metadata standards. Standards and vocabularies are crucial in describing the information that producers have and that consumers need to access. Safeguards are needed to ensure that metadata is indexed and cataloged before an approved information product is allowed to be shared within the enterprise to include capturing security dissemination restrictions. It will enable information discovery by known and unanticipated users throughout the enterprise. Automatic generation of metadata during new document creation will be a part of the content authoring and structuring capability that is used during the creation of new document. In addition, there is a need to generate metadata to facilitate the use and exchange of documents produced from legacy systems. Current approaches for leveraging unstructured information products would require extracting metadata though a labor intensive effort which is often error prone. Advances in linguistic analysis may allow for automated tagging by extracting and classifying information.

PHASE I: Perform the initial research necessary to assess potential approaches. Develop a solution approach comprised of the most promising approaches, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application using open sources.

PHASE II: Research and develop the required technologies leading to the demonstration of a limited prototype. The prototype will demonstrate the creation of metadata during the generation of candidate ISR products consisting of textual and imagery data from unclassified sources to the extent possible.

DUAL USE COMMERCIALIZATION: This software-based tool will prove useful throughout the retail marketplace (e.g. Wal-Mart, Target, etc). It will augment their current efforts to assemble large, dynamic data warehouses, conduct data mining and facilitate business-to-business commerce.

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KEYWORDS: Interoperability, Metadata, Data Discovery, Content Analysis, Information Retrieval

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AF06-060 TITLE: Enabling Monitoring and Analysis of Concept-Based Event Information in Text.

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop technology for extracting concept-based event information from unstructured text, for operational-quality monitoring, retrieval and analysis of events.

DESCRIPTION: Information analysts need to effectively exploit event information for their area of responsibility from unstructured textual data sources (open source, HUMINT, etc.). E.g., analysts studying missile proliferation may want to monitor textual data sources for all procurement events involving certain types of missile delivery systems, with certain characteristics, and involving certain known (or unknown) participants (persons, organizations or countries).

However, current technology has a number of shortfalls. First, it is difficult to find events of interest from large volumes of text. Keyword searches typically result in either a lot of irrelevant information (high recall, low precision) or a small subset of highly relevant documents (high precision, low recall). Even after documents containing relevant events have been found, the event information is not in a structured form exploitable by analysis and visualization tools. So analysts must manually input event information into DB records. Analysts need a faster, more effective means for exploiting event information in unstructured text. Information Extraction (IE) technology holds promise for meeting this need.

Considerable research has advanced IE technology over the past several years. DARPA-led efforts like TIPSTER, EELD, TIDES and GALE have made substantial contributions. Benchmark Evaluations have also helped advance the state-of-the-art, providing the methods and resources to objectively measure IE performance and to assess progress in the field. These include the DARPA-led Message Understanding Conference (MUC), NIST's Automated Content Extraction (ACE) Evaluations, the Time Expression Recognition and Normalization (TERN) Evaluations, and SENSEVAL. Finally, linguistic resources, such as those made available through the Linguistic Data Consortium (LDC), have been invaluable in nurturing extraction research.

As a result, simpler IE capabilities have matured and are now available commercially. This is exemplified by the wide-spread use of commercial products for Named Entity (NE) extraction that extract the names of people, organizations, locations, etc. Somewhat more complex capabilities, like relationship extraction, are also available, but do not perform as well as NE tools, and often require customization by the developer.

However, concept-based event extraction is a much more difficult challenge. Most operational IE systems that do event extraction typically perform shallow event extraction. I.e., the actions they extract are typically based on a verb that has not been disambiguated (has multiple meanings). In addition, many do not extract all essential information associated with a given event type. E.g., for a procurement event, such information as: who is the buyer, who is the seller, what was sold, at what cost? Finally, many operational systems are still limited to extracting information within a sentence's boundaries. So while promising research that can contribute to domain-customizable concept-based event extraction is being performed, such a capability is still beyond the state-of-the-art.

The focus of this SBIR Topic is to research and develop a capability for high accuracy, concept-based event extraction from unstructured text. Desirable features include domain-portability, and capturing all essential information associated with event types of interest from across a document (disambiguated, normalized, and consolidated). While determining time and location is also desirable, this is not a primary focus of this research.

PHASE I: Feasibility concept. Develop an innovative approach to meet the SBIR Topic requirements, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application.

PHASE II: Research and develop the required technologies and prototype, per Phase 1 design.
Develop and demonstrate a prototype baseline system for extracting and visualizing event information from unstructured text with a high level of accuracy, using candidate actual data from operational systems.

DUAL USE COMMERCIALIZATION: A capability to perform concept-based event extraction has high dual-use applicability. It would be of great benefit to Homeland Defense analysts, who need to be able to monitor large volumes of unstructured text for specific events of interest. A capability to do this quickly, and with high accuracy, would give our people earlier indications of potential threats, thus enhancing Homeland Security. Law Enforcement would similarly benefit, as investigators would have an effective means to search large volumes of text for particular types of events, involving specific suspects, in order to develop or pursue leads. Business Intelligence applications would also benefit, as this would enable near real-time alerts for event types of interest, such as corporate sales or mergers, or changes in product status.

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KEYWORDS: Information Extraction, Natural Language Processing, Events, Homeland Defense, Intelligence Analysis

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AF06-061 TITLE: Multi-INT Ontology Mediation Services

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an information sharing capability that will promote the exchange of information that resides across multiple communities of interest (COI).

DESCRIPTION: A key component to achieving this capability involves discovering and accessing a community's available information products which includes the information content and structure. An illustrative example would involve multi-sensor (e.g. E-O), multi-platform systems that cover the spectrum from ground, air and space deployments. Each community shares a specialized language which has evolved over many years that may be significantly different from other communities. Currently, each sensor type is often processed, exploited and disseminated in isolation and are not used to their utmost potential. Even though this data is easily accessible, integrating this data is not practical. This is primarily due to the fact that each data producer uses his own standards and formats. The main purpose of this research is to enable information sharing in a way that is independent of where and how information is stored. Considerable progress has been made to create and maintain metadata repositories (e.g. DCGS ISR metadata standard) to facilitate information discovery and access. There is an emerging interest in the development of ontologies as a medium for defining metadata categories. As the second step beyond metadata tagging, ontologies will improve discovery and access by revealing the information content and semantic meaning. Although ontologies can be represented in a digital form, the generation of a mapping between two or more COI ontologies can be tedious, time-consuming and manpower intensive. Automated tools that can provide this mapping function would foster greater information sharing and reuse. Under this research, consideration should be given to the application of structure-based, keyword-based, thesaurus-based and namespace-based that takes full advantage of inferencing capabilities enabled by the ontologies. Technologies useful for representing weakly-structured information sources should be considered. For example, XML, RDF and OWL have proven useful in describing syntax and semantics of semi-structured information sources.

Military information systems suffer from the proliferation of standards to represent the same data. Ontology mediation among these community standards will help promote interoperability. Such a capability would enable the Distributed Common Ground System (DCGS) to discover and utilize sensor data from a variety of sources. It will pave the way for more effective information resource discovery, transparent data exchange, and automated integration, re-use of information content from any producers and timely delivery to any information consumers. This underlying capability will facilitate both intelligence information pull and push to meeting dynamic mission planning and execution needs.

PHASE I: Perform the initial research necessary to assess potential approaches. Develop a solution approach comprised of the most promising approaches, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application.

PHASE II: Research and develop the required technologies leading to the demonstration of a limited prototype. The prototype will demonstrate the capability to broker, translate, aggregate and integrate ontologies from multiple ISR products consisting of textual and imagery data.

DUAL USE COMMERCIALIZATION: Commercial enterprises have recognized the importance of ontology to the development of Internet commerce systems. The main barrier to electronic commerce lies in the need for applications to meaningfully share information. This is due to the variety of enterprise and e-commerce systems deployed by businesses and the way these systems are variously configured and used. This capability will prove useful throughout the retail marketplace (e.g. Wal-Mart, Target, etc). It will augment their current efforts to assemble large, dynamic data warehouses, conduct data mining, facilitate business-to-business commerce and dynamic supply chain composition.

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3. Special section on Semantic Web and Data Management: A conceptual architecture for semantic web enabled web services, Christoph Bussler, Dieter Fensel, Alexander Maedche, December 2002 ACM SIGMOD Record, Volume 31 Issue 4

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KEYWORDS: Semantic Processing, Information Retrieval, Semantic Knowledge-based, Interoperability, Semantic Web, Web Services, Peer-to-Peer Technologies

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AF06-062 TITLE: Reprogrammable High Assurance Internet Protocol Encryptor

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a reprogrammable High Assurance Internet Protocol Encryptor (HAIPE) for use in future satellite communications (SATCOM) applications.

DESCRIPTION: As military satellite communication systems continue to evolve, new generations of hardened space qualified and military ground qualified bulk and packet encryption/decryption devices will be required to provide secure transmission of data for the Transformational Satellite (TSAT) program and its successors. HAIPE is planned for use as a means of encrypting data packets for transit across ground to satellite links. Encryption algorithm obsolescence and high 'bulk' encryption data rates are two examples of emerging HAIPE requirements growth. Encryption algorithms obsolescence will lead to more sophisticated algorithms and greater computing speed. Laser communications will drive bulk encryption requirements beyond 10 Gbps. The purpose of this topic is to develop and demonstrate a field programmable gate array (FPGA)-based programmable encryption device capable of meeting projected HAIPE requirements. Goals include reprogrammability, data rate > 10 Gbps, modular design, backwards cryptographic bypass [TBR], field software reprogrammability, operating temperature range –40 to +85 degrees C, and a forward compatibility with emerging algorithms.

PHASE I: Explore FPGA-based encryption/decryption device viability and security issues. Develop FPGA requirements for topology, gate count, speed, memory, radiation hardening and reliability. For the speeds required to be compatible with the military laser communications, this will be very challenging. This effort will not involve classified material for the Phase 1 part of this effort and will not begin to address classified information we are well into Phase 2 of this effort. Phase 2 may or may not become classified. Phase 1 will simply recommend radiation hardened, high speed processing architectures that would be amenable to the reprogrammable HAIPE capability.

PHASE II: Develop a minimum of eight prototype devices, characterize for speed, power, reliability, radiation hardening. Final report documenting. Phase 2 will begin with the verification of high speed processing reprogrammability consistent with the speeds required for the laser communications placed on the Transformational satellites. Toward the end of Phase 2, collaboration with NSA may lead to the instantiation of classified, HAIPE compliant hardware. If this happens, a DD 254 will be submitted for the program and the effort will become classified.

DUAL USE COMMERCIALIZATION: Commercial uses for encryption include financial transactions over the internet and wireless communications. Future commercial satellites will migrate to a processed packet communications. Highly sensitive commercial traffic traveling over satellites such as banking information, will need to be conducted at high speeds as well. This effort will directly benefit those commercial requirements.

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KEYWORDS: Field programmable gate array, internet protocol,application specific integrated circuit, information security, reprogrammability, encryptor

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AF06-063 TITLE: Asymmetric Adversary Tactics and Strategy Generation

TECHNOLOGY AREAS: Information Systems, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop the capability to automate the generation of asymmetric adversary tactics and strategies for use in synthetic environments.

DESCRIPTION: Recent events have demonstrated the use of non-traditional tactics to offset US military power. The use of non-traditional tactics and strategies by potential adversaries, i.e., asymmetric warfare, has come into the forefront of national security issues. Rogue nations, with links to trans-national terrorists, in tandem with the rapid proliferation of weapons of mass destruction, have created a highly unpredictable and potentially dangerous environment for homeland security, emergency preparedness, and military operations. Innovative information and human systems technology to assess, generate, and present potential adversary tactics and strategy will improve decision support in these environments. Modeling methodologies and capabilities, which take into account social, cultural, political, economic, religious, ethnic, and ideological aspects of the adversary, are required to assist decision makers in preparing for future adversary actions. The models shall be capable of interfacing with simulation environments and provide realistic adversary tactics and strategy to support a persistent synthetic battlespace infrastructure. The infrastructure is critical for military training, mission rehearsal, and the exploration, design, development, analysis, and testing of new warfighting systems and concepts. This research will define and develop an asymmetric adversary modeling capability that can support synthetic environments. Decision theoretic methodologies to gather data and dynamically build adversary models to describe, assess, and predict the activities of individuals, teams, and organizations shall be developed. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Methodologies implementing the adversary environment should be standards based to support interfaces to other analysis, and modeling and simulation tools.

PHASE I: Research and develop technology to support an adversary environment that generates tactics and strategy for military simulations. Develop the specifications and design for a standards based adversary environment. Develop a proof-of-feasibility demonstration of key enabling concepts.

PHASE II: Research, design, develop and demonstrate a prototype adversary modeling system capable of interfacing with military simulation environments, and assessing an air campaign tactical scenario.

DUAL USE COMMERCIALIZATION: An off-the-shelf asymmetric adversary environment for decision support will increase our ability to conduct military training, mission rehearsal, and the exploration, design, development, analysis, and testing of new warfighting systems and concepts. Improved anticipation and preparation for national emergencies, terrorist activities, homeland defense and military operations will result. The development of automated tactics and strategy generation also has high relevance to the commercial wargaming industry, where applications of asymmetric adversary models would result in more realistic military strategy games. In addition, the commercial Industry relies on predictive simulations for assessing and evaluating strategies related to marketing assessments, business process management, enterprise management and network control. Improved modeling technology could result in higher quality decisions.

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http://www.mors.org/meetings/ebo/ebo_reads/McCrabb_Caroli.pdf

3. Wallace, Jeffrey W. and Judy M. Sollenberger, "Improving the State of Military Modeling and Simulation: The Joint Synthetic Battlespace", http://www.modelingandsimulation.org/MandS0101/Wallace0101.html .

KEYWORDS: Asymmetric warfare, Joint Synthetic Battlespace, Adversary behavior, Cultural modeling, Adversary model

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AF06-064 TITLE: Automated Signal Processing for Information Exploitation

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Design and prototype technologies that provide Signals, Imagery and Measures/Signatures Intelligence, information dominance through innovative signal processing of systems, sensors and data.

DESCRIPTION: The all source analysts’ mission is to provide the maximum amount of relevant information from raw data signals and imagery. Current automated sensors are capable of collecting vast amounts of modern modulation data and exploitation of new systems that provide far more information than can be exploited by today’s analysts. Analysts are at the breaking point in obtaining actionable intelligence information from the data. New, efficient, automated exploitation tools and methods are unavailable and are required to rapidly extract the highest interest information. Research is required to assess the feasibility of new innovative signal processing and technology approaches to exploit the modulation, compression, coding, forensics of modern modulation signals and automate the exploitation processes being employed. Operators and analysts need new tools and concepts now to stay ahead of the information technology being fielded today. The following topical areas represent scientific and technical problem areas requiring innovative solutions:
1) Exploit 'All' the data from the traditional and non-traditional reconnaissance and surveillance sensors
2) Automate the processing to provide actionable intelligence information from sensor data
-Determine the feasibility of the application to RF signal interception, detection, identification, location, demodulation, processing and collection of data
-Determine the feasibility of the application to audio signal processing for user identification including open set speaker, language, dialect, and background detection
-Determine the feasibility of the application to video processing for target identification/target tracking and processing.
-Determine the feasibility of the application for steganography, watermarking, steganalysis and digital data forensics for information exploitation, tracking, protection and assurance

-Determine the feasibility of the application for implementation of measures and signatures intelligence architectures and techniques to exploit unaddressed sensor signals. Assess new approaches to foster equipment interoperability and functionality associated with production

PHASE I: Assess innovative signal processing tools for data collection, information exploitation, intelligence production; propose conceptual proof-of-concept prototypes to address modern modulation signals, new systems/sensors, revolutionary improvements in information analysts' productivity.

PHASE II: Develop working prototypes with sufficient fidelity to: demonstrate the exploitation of heretofore difficult or unexploited modern modulation signals and new systems and sensors; - improve current manual analyst activities with new automated and semi-automated capabilities.

PHASE III DUAL USE APPLICATIONS: Vast opportunities currently exist for innovative information technology (IT) signal processing techniques to be readily melded into fielded commercial IT systems as preplanned-product-improvements. Further, small businesses have previously secured successful commercialization of their work in this IT area through creative contractor teaming arrangement with large contractors on new acquisition efforts. Entrepreneurs will further their commercialization efforts with the start-up of new product line thanks to the risk reduction work accomplished under this SBIR topic. From the government perspective, this work can contribute to the common platform baseline used by all US DoD military intelligence analysts in support of information exploitation missions. Furthermore, this technology has current relevance to support homeland security activities at the local, state and federal government levels and in the commercial and private sector security areas that feed to homeland security.

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KEYWORDS: SIGINT, IMINT, MASINT, COMINT, ELINT, Motion Imagery, Steganalysis, Forensics

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AF06-065 TITLE: Acquiring Probabilistic Knowledge for Information Fusion

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop technology for acquiring uncertain relational knowledge from SME's, and demonstrate the acquisition of probabilistic models to support situation awareness and predictive analysis.

DESCRIPTION: The work performed under this SBIR will focus on the development of technology for acquisition of large probabilistic relational knowledge bases. The probabilistic knowledge acquisition process currently requires deep expertise and is still largely a manual effort. Recent work in knowledge acquisition technology is beginning to support acquisition of models in relatively expressive relational languages. There has also been substantial research on the knowledge engineering aspects of Bayesian networks. However, there are as yet no systems that provide end-to-end support for the acquisition of probabilistic relational knowledge. Intelligent systems capable of performing situation and impact assessment will require the ability to better capture, represent and express probabilities. This knowledge acquisition bottleneck is a critical obstacle to the deployment of these data fusion systems. Such systems will support diverse tactical-level analysis tasks, including behavior-based identification of asymmetric targets, determining adversary force structure and courses of action from GMTI data, and generating timely indications and warnings for force protection.

PHASE I: Develop algorithms and methodologies for the acquisition of probabilistic relational knowledge from subject-matter experts with little or no training in formal knowledge representation or probability theory.

PHASE II: Implement prototype software to acquire probabilistic relational knowledge. Validate the approach by using the prototype to acquire models which could be used to solve a real-world fusion problem.

DUAL USE COMMERCIALIZATION: Develop deployable system for acquiring probabilistic relational knowledge. Applications of this technology include battlespace situation and threat assessment, early detection of indications and warnings of terrorist activity, interpretation of medical imagery, condition-based maintenance complex machinery, and interpretation of business intelligence.

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KEYWORDS: Probabilistic knowledge, Information Fusion, Uncertain Reasoning, Knowledge Acquisition

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AF06-066 TITLE: Systems-of-Systems Data Utilization Patterns

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Space Platforms

OBJECTIVE: Develop the tools and techniques to infer ontology concepts and relationships from data utilization patterns in federated system-of-systems environments.

DESCRIPTION: The need for enterprise information integration is widely recognized in both the commercial and government worlds. DoD's approach, defined in the DoD Net-Centric Data Strategy, aims to make data from multiple, divergent domains visible and accessible

To achieve this goal increasing numbers of new and legacy DoD systems are being integrated into federated systems-of-systems, providing greater access to large volumes of data that span multiple domains. This is true for the DoD space launch and range operations environment. Space launch and range operations at the national ranges involve many different organizations working together to perform complex and technically demanding operations. For example, the 45th Space Wing (45 SW), provides space launch and range support for Department of Defense (DoD), civil, and commercial space launch missions. Support is also provided to DoD submarine launched ballistic missile Test and Evaluation missions. To provide this support the 45 SW operates and maintains the Eastern Range. It includes launch complexes, processing facilities, tracking radar, optical systems, telemetry, command destruct systems, and communications-computer systems. This demanding mission is performed primarily through several major service contracts that provide the multitude of services and functions needed to support launch and range operations. To perform its mission the 45 SW and its contractors must actively work with many other organizations involved in launch and range operations. The diversity of organizations and associated data sources involved in launch and range operations significantly increases the need for and scope of federated systems-of-systems to deliver integrated information. This increase in federated systems-of-systems has created both need and opportunity.

These federated systems-of-systems depend, either explicitly or implicitly, upon ontologies to provide a basis for integrating, searching and using the data. The problem is that ontologies that federate these diverse systems and their information sources are typically incomplete. They are also dynamic, continually changing in response to user needs and the availability of new data sources. The risk is that search, query and analyses based on incomplete ontology semantics will not help us find the specific information we are looking for in a large forest of information, leaving the needle lost in the haystack. One research hypothesis is that information access and usage patterns may provide important heuristics for positing new concepts and relations to the ontology. This will involve monitoring information use across systems, capturing usage patterns, analyzing patterns for potential concepts and relations, and offering assistance to ontology modeler on where to merge newly learned components into the semantic model.

The opportunity relates to the possibility that overall system management based upon understanding of the data will also generate information that can be used to enhance the value of the data itself. A tool for system management that understands the use of the data could also support analysis of patterns for additional insight or to aid specific tasks such as search. An analogy may be found in the use some web search engines make of relative links for determining the relevance of a given page to a search. Data usage patterns in a federated system-of-systems might indicate the value of specific data for specific purposes or even promote collaboration between users.

Research is needed into how federated system-of-systems data utilization patterns can be captured, analyzed, and applied to positing new concepts and relations to the ontology to increase value to the end-user. Solutions must address how such patterns can be acquired without adversely impacting system performance; and how user interfaces can be improved by leveraging the systems-of-systems data utilization patterns. New tools and techniques are needed to grow and optimize the semantics and metadata that support the unifying ontologies in order to obtain semantic models that more closely represent the way these systems and their underlying data sources are used.

PHASE I: Develop the requirements, general usage scenarios and candidate architecture for capturing and applying system-of-systems data utilization patterns. Consideration must be given to performance impacts, security, analytic approaches, and value to the end-user.

PHASE II: Develop a full scale implementation of the federated system-of-systems data utilization pattern capability and employ it in a suitable trial environment. Emphasis shall be placed upon the balance between data and system utilization pattern capture and analysis to infer ontology concepts and relationships and creation of value to the end-user

DUAL USE COMMERCIALIZATION: Military application: Due to the growing use of federated systems-of-systems and the need to effectively manage and use the integrated information from them, a data utilization pattern capability could have wide use in the government and commercial world. PRIVATE SECTOR COMMERCIAL POTENTIAL: A robust implementation of this capability could easily be applied to the many business organizations (medical, manufacturing, etc.) implementing large-scale data integration and systems-of-systems. Candidate commercial partners include firms providing Enterprise Information Integration, Message-Oriented Middleware, or Data Warehouse solutions.

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KEYWORDS: Information Technology, Pattern Matching, Ontology, System-of-System Architectures

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AF06-067 TITLE: Robust Complex Systems

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop tool(s)/toolset(s) for the productive development and deployment of software-intensive parallel application of cognition into military information systems.

DESCRIPTION: Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems employ distributed processing, and make use of mobile code, intelligent process allocation, dynamic multiprocessing and other techniques to create a virtual distributed computing network. These complex hardware/software systems have to satisfy hard real-time performance constraints. The ability to evolve, organize and optimize over their lifetime offers the opportunity to enhance these systems through the introduction of cognitive capabilities. By exploiting the performance advantages made possible with self-organizing morphable hardware and software, cognitive functions may be added which will leverage the parallelism that is inherently available. Since the parallelism in these types of applications is irregular, they will likely take advantage of multithreading. Multithreaded applications present unique challenges to application developers especially during the debugging stage. The requirement that these systems be scalable, modular, verifiable and distributed results in an unprecedented system complexity. Further, cognitive software systems require verification and validation that cognition is correctly performed, unacceptable behavior identified, defects in behaviors that have yet to be learned detected, and prediction of the system performance. This effort will develop tools and techniques to enable, debug, verify, and assure productive implementations of software-intensive parallel applications for cognitive information systems. Possible approaches include but are not limited to cognitive techniques for debugging such as inferring invariants whose violation could correspond to bugs, or techniques for debugging cognitive applications which do not lend themselves to conventional imperative debugging.

PHASE I: Develop a tool/toolset that includes a low fidelity feasibility demonstration of the critical aspects of the design.

PHASE II: Develop and demonstrate the prototype tool/toolset in a realistic environment. Conduct testing to demonstrate the approach is scalable and adaptable to mission objectives.

PHASE III DUAL USE APPLICATIONS: This tool/toolset could be used in a broad range of military and civilian applications which demand that systems evolve and change by ad-hoc and self-adaptive means.

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KEYWORDS: Software intensive systems, cognitive information systems, parallel development

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AF06-068 TITLE: Cyber Operations

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this effort is to develop a defensive “Cyber-Craft” for full-spectrum computer network defense and information assurance.

DESCRIPTION: Today’s philosophy of cyber defense is centered on strong boundary protection (e.g. firewalls) and network intrusion detection systems. While these technologies provide some sound defensive capabilities, if breached these types of systems provide the intruder with full-access to an enterprise network. In a Network-Centric Warfare environment today's defenses will not scale to provide the protection required. We envision a new capability we call the cyber-craft that operates solely within the cyber domain to extend the arm of existing cyber defense and computer network defense capabilities. A cyber-craft can be thought of as a lightweight software agent system that performs multiple computer network defense and information assurance functions. The characteristics of a cyber-craft include the ability to be launched from a network platform, the ability to embed control instructions within the craft, the ability to positively control the cyber-craft from a remote network location or management console, the capability for the craft to self-destruct if attacked and corrupted, the capability for the cyber-craft to operate with minimal or no signature/footprint, and the ability for the cyber-craft to rendezvous and cooperate with other friendly cyber-craft. Small, lightweight cyber-craft agents could monitor a large enterprise network with nearly no performance degradation and cooperate in such a way that collectively they become a smart cyber sensor grid. It is envisioned that a cyber-craft system would augment existing computer network defenses by helping to perform security management, network management, intrusion detection, malware detection and eradication, and digital evidence gathering.

PHASE I: Perform the initial research necessary to assess potential approaches. Develop a solution approach comprised of the most promising approaches, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application.

PHASE II: Develop the required technologies leading to the demonstration of a limited prototype. The prototype will demonstrate the creation of software agents for comprehensive, enterprise-level computer network defense.

DUAL USE COMMERCIALIZATION: Military application: Dual use applications of this technology include industries and critical infrastructures that have networks and enterprises requiring a high-level of assurance and security. In addition, from a military standpoint this technology could be transitioned into any networks requiring an enhanced level of information assurance.

REFERENCES: 1. Secrets and Lies: Digital Security in a Networked World by Bruce Schneier

2. OASIS: Foundations of Intrusion Tolerant Systems Edited by Jaynarayan H. Lala, IEEE Computer Society Press

KEYWORDS: Cyber Operations, Cyber Defense, Computer Network Defense, Information Assurance

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AF06-069 TITLE: Advanced Radio Frequency and Optical Connectivity to support Network-Centric Operations

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This program seeks innovative hardware and/or software technologies that advance radio frequency, optical, networking technologies, reduce transmission requirements, and reliable communications.

DESCRIPTION: There are numerous radio, data link, and RF-based network equipments that are being considered for upgrade or replacement over the next decade. Replacement is done with the intention of supporting future NCO environments, where participants are able to collaborate and cooperate seamlessly through appropriate information-sharing mechanisms. This will require that all communication terminals be capable of providing “internet-like” services, albeit at differing levels of service, speed, and versatility. In addition, the trend is towards smaller unmanned air vehicles in which size, weight, prime power consumption, quality of service, data integrity, interoperability, maintainability, and re-programmability are some of the key requirements. Technologies need to be developed wherein the Department of Defense can insert advanced technologies to these systems or develop new systems for increased throughput or reduced size, weight, and prime power. Develop innovative ideas to reduce the insertion loss, physical size, and increase the power handling capacity of passive RF components, in particular, X-band, Ku-band, and Ka-band diplexers; and the use of digital signaling processing techniques to shape the transmit waveform to minimize the possibility of interference and the need for band-pass filtering. Combining these technologies to accomplish multiple functions simultaneously or readily switching between different technologies to accomplish a number of specific functions are just some of the possible approaches. Increased throughput can also be achieved by operation at higher radio frequencies, use of laser communications technology, combined RF/optical data link technology, more efficient transport, network, link protocols for mobile ad hoc networks, use of multiple paths for data transfer, advanced data/video compression algorithms, etc.

PHASE I: Explore design options to determine the technical feasibility of the proposed hardware or software. Show how the technology option selected has application to one or more of the existing radio/data link/network systems or offers the potential to replace an existing capability.

PHASE II: Fabricate a breadboard hardware feasibility model(s) and/or specify and code the software algorithm technology option(s) selected. Provide a demonstration that validates the proposed technology. The Phase II program shall provide a plan to transition the technology to operational use.

DUAL USE COMMERCIALIZATION: Military application: The proposed technologies shall be applicable to a range of DOD and Homeland Security systems requiring connectivity among a range of wireless and wired platforms and commercial applications including radio, cell phone, network, and satellite applications

REFERENCES: 1. Space & C4ISR Capabilities CONOPS

2. Global Strike Task Force Infrastructure Capabilities Roadmap

KEYWORDS: Radio Frequency Communications, Optical Communications, Free-space Optical Communications, Antennas, Diplexers, Mobile and Ad-hoc Networking, Enterprise Management, Network Modeling and Simulation, digital signal processing, wideband communications

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AF06-070 TITLE: Innovative Command and Control (C2) Technologies to Enable Force Synchronization for Effect

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research and develop advanced information technologies to enable future forces to synchronize their respective capabilities (kinetic and non-kinetic weapons, sensors) to achieve desired effects in high tempo and dynamic environments

DESCRIPTION: DoD transformation initiatives are actively pursuing the development of a Net Centric Environment where information will be pervasive creating new opportunities to better conduct operations in a wide variety of scenarios. The concept of synchronization of forces is a revolutionary concept that could change the way we Command and Control (C2) our forces in the future. Synchronization is defined as “the purposeful arrangement of things in time and space”. From a military perspective, it is the successful orchestration of all forces within the battlespace in both position and time to achieve objectives. This encompasses sequencing the actions of forces (ground, sea, air, and space) to combine their effects to accomplish the mission. C2 elements process information and arrange and continually adapt the relationships of actions in time and space in order to maximize effects and established mission objective(s). Additionally, synchronization must occur vertically from operational to tactical levels, and horizontally across C2 entities and functional areas. Further, shared awareness and shared understanding enable an entity (individual, group, organization) to self-synchronize and to operate in the absence of traditional hierarchical mechanisms for command and control, thus enabling more dynamic responses through more efficient decentralized execution. Self-synchronization represents the full capitalization of network centric operations. It increases force agility to respond quickly to fleeting targets and changing objectives.

PHASE I: Develop an innovative approach that will provide a decision maker with the ability to decisively task and re-task kinetic and non-kinetic weapons and sensing “platforms” to achieve commander’s intent in time and space. Potential solutions could include extending existing weapon targeting pairing algorithms to include information operations and sensors, causal modeling, graph tree analysis, genetic algorithms or hybrids of these or other novel approaches. Solution should be extensible to non-military domains. Develop architecture views of the information sources and human operators combining to synchronize capabilities and actions to accomplish various missions.

PHASE II: Based on the results from Phase 1, define, develop and then simulate (real and virtual) a prototype effects based force synchronization capability. Emphasis should be on commanding and controlling all available forces and then synchronizing those forces to achieve effect.

DUAL USE COMMERCIALIZATION: The ability to conduct synchronize resources in time and space would be beneficial to sectors of industry that are involved with time sensitive dynamic tasking processes such as express mail services, retailers, rental car companies, and airline agencies. This capability also will enable better emergency response to major disastrous events (9/11, Hurricane Katrina) and security of major venues like the Super Bowl and Political National Conventions.

REFERENCES: 1. CCRP Publication Series, “Power to the Edge”, Alberts and Hayes

2. CCRP Publication Series “Understanding Information Age Warfare”, Alberts, Garstka, Hayes, Signori

3. CCRP Publication Series “Net Centric Warfare 2nd Edition”, Alberts, Garstka and Stein

KEYWORDS: Command and Control, Effects Based Operations, Combat Assessment, Self Synchronization, Dynamic Tasking, Net Centric Warfare, Power to the Edge

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AF06-071 TITLE: TACTICAL INFORMATION INTEROPERABILITY & MANAGEMENT (TIIM)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Design and build an innovative information management technology to support peer to peer information exchange, enhancing information collaboration and sharing for manned and unmanned tactical assets.

DESCRIPTION: Today’s tactical warfighter is not unfamiliar with hostile tactical environments. The increasingly non-traditional nature of these environments (urban warfare, IEDs, etc) often means that the veracity, relevance, and timeliness of the warfighter’s information about his surroundings is one of his greatest tactical assets. In this new era of Net-Centric Warfare (NCW), getting such information from the Global Information Grid (GIG) to these tactical environments will become a problem of increasing importance. Unmanned Aerial Systems (UAS), especially the smaller, more agile variety of UAS, will soon pervade these tactical environments. The goal of this topic is to take advantage of the growing presence of UAS in the tactical environment by exploring technologies that will allow for the creation of a peer to peer (P2P) information sharing network over a cluster of small UAS. One aspect of this research includes modifying or creating P2P information sharing technologies that would allow for a "Napster in the sky" capability. Nodes of such a P2P technology would have to provide certain information sharing services and would have to operate on the lightweight, low power, resource starved hardware and disadvantaged links common among small UAS, while at the same time taking into account unreliable connections and rapidly changing node topologies. Another aspect of this research will involve the routing of information through such P2P technologies, as well as the actual physical control algorithms of the UAS themselves. One can envision several different modes of operation for such P2P information sharing networks: in an information "cloud" UAS nodes would organize themselves into a cluster providing an information sharing infrastructure to a local area; in an information "bridge" UAS nodes would line up to transport information from one location to another; an information "airlift" would allow a single UAS node to leave the cloud and physically bring requested information to a specific location. The benefits and feasibility of these and other algorithms should be examined. Research efforts for this topic should culminate in a prototype P2P information sharing network capable of being deployed using clustered, small UAS nodes.

PHASE I: Develop a conceptual design and early prototype of a P2P information sharing technology that specifies software and hardware to be used and incorporates concepts of operation and tactical scenarios.

PHASE II: Develop and demonstrate a full prototype system in a realistic environment. Conduct testing and demonstration to prove feasibility of approach.

DUAL USE COMMERCIALIZATION: Military application: The developed technology could be used in other future commercial UAV/UGV environments where multiple sensors are deployed such as oil exploration, commercial fishing, and environmental monitoring.

REFERENCES: 1. A Reference Model for Information Management to Support Coalition Information Sharing Needs; Linderman et al, ICCRTS 2005.

2. Net-Centric Information Management Challenges; Linderman, Milligan, SPIE Defense & Security Symposium 2005, Conference 5820, Paper 5820-39.

3. UAS Roadmap, http://www.acq.osd.mil/uas/

4. A Survey of Peer-to-Peer Content Distribution Technologies; Androutsellis-Theotokis, Spinellis, ACM Computing Surveys, Vol. 36, No. 4, December 2004.

KEYWORDS: Tactical, UAS, Information Management, Smart Munitions, Non-Traditional ISR Assets, Information Interoperability, Peer to Peer

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AF06-072 TITLE: Locating and integrating members for virtual ad-hoc teams

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To enable the rapid identification of people with the requisite expertise and personal characteristics to effectively participate in ad-hoc virtual teams.

DESCRIPTION: Faced with asymmetric threats and the expanding set of military missions (e.g. humanitarian and police functions), commanders are often confronted with a varying array of situations for which they need expert assistance outside of their immediate staff. In the era of network centric operations, connectivity and bandwidth are increasingly available to the commander so that outside experts can be reached for consultation when a specific situation arises. The goal of this effort is to develop the capability to locate experts and form virtual ad-hoc teams on demand. In order to identify experts, it is envisioned that the documents produced by individuals within the organization (including Word documents, PowerPoint presentations, email, etc) will be analyzed by a machine learning-based text categorization method (e.g. neural network, bayesian classifier, or decision tree) in order to develop an association between individuals and their primary areas of expertise or interest. The results would also be ranked based on a weighting factor or an assigned trust factor, potentially based upon how many times an individual's documents were downloaded or modified and/or utility rankings provided by other users. The capability to suggest potential team composition from a listing of potential candidates and a suitable collaboration environment is also desired. It is envisioned that multidisciplinary teams will be formed in most situations with a mix of internal and external members. In addition to an individual's expertise on a given subject, social network analysis (SNA) may be employed to determine what groups of people are already working together as part of the "informal organization," outside of the standard org charts of the enterprise. SNA can also provide information about how extroverted or focused an individual is. This information could then be considered when suggesting members for the virtual team. More research into automated text categorization, trust networks, and social network analysis would be required to be successful in this SBIR. The end goal of this effort is to assist the commander's ability to foster creativity in the decision making process in instances where expert assistance may be needed outside of their staff.

PHASE I: The desired end product is to have the capability to identify and integrate experts into ad-hoc virtual teams on demand. It is expected that by the end of Phase I a set of applicable technologies to solve the problem are identified.

PHASE II: Develop a prototype capability that can be demonstrated within a controlled environment in order to test the functionality and determine its usability in a controlled operational environment.

DUAL USE COMMERCIALIZATION: The potential exist for the widespread application of this product throughout the world, spanning academic, Government, industrial, and non-government organization (NGO) communities, where people can identify others with similar interests in order to collaborate and develop professional relationships.

REFERENCES: 1. Tom Garvey, Future Command Experience for Intuitive Decision, 23 Sep 2004.

2. Wasserman, Stanley, Social Network Analysis. Cambridge University Press, 1994.

3. R.A. Baeza-Yates and B. A. Ribeiro-Neto, Modern Information Retrieval. ACM Press / Addison Wesley, 1999.

KEYWORDS: Communication pattern monitoring, collaboration environment, team formation, trust networks, social network analysis, virtual teams.

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AF06-073 TITLE: Collaborative Sense Making

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide methods to analyze, represent, visualize and collaborate in order to "make sense" of the contents of large heterogeneous distributed data and document collections.

DESCRIPTION: The objective of this topic is to develop collaborative sense-making technologies to enable individual and team cognitive performance in developing a picture of the situation at any given moment. Intelligence Analysts must excel at performing enormous tasks at uncovering new, potentially suspicious "patterns of activity”; and putting multiple puzzle pieces of information together. Although they typically have both broad and deep knowledge of the subject area, there is still a need for analysts to better coordinate their “sense making” analysis and production tasks with other analysts who are working within the same subject domain or in a highly related subject domain area.

An essential component to sense making is the need for an intuitive integration framework whose foundation includes a large virtually centralized knowledge repository. This "Virtual knowledge base" will be an instantaneously accessible repository in which past historical information and current knowledge is automatically collected and organized. Key here is that the information and knowledge that is stored must be valid, reliable, and immediately accessible from anywhere at anytime by anyone. The Virtual Knowledge Base must also be self-organizing and self-generating in order to accommodate newly gathered information or knowledge. Situational analysis tools will utilize this knowledge in a collaborative environment providing a quantitative evaluation of events that enhance a decision maker's ability to judge, appraise, and determine the relevance of emerging situation's). These tools will help identify what key aspects are needed to verify an existing situation or anticipate a situation and be used to cull through the data and information, discover new knowledge, and provide a real-time situation assessment.

Currently, there are many tools being developed that provides various intelligence products aimed at situational analysis. The potential sources of information associated with these tools include extensive existing databases. Innovative technologies are needed to be able to utilize these databases as a virtual, centralized, knowledge repository in an integrated analysis environment. The primary focus of this topic is to design and prototype such a sensemaking technology integration framework through which these disparate tools and data can be easily brought together allowing individual and team sensemaking activities. The goal is a single "system of systems" that models the process of sense-making (i.e., information gathering, transformation, analysis, interpretation and presentation).

PHASE I: Perform the initial research necessary to assess potential approaches. Develop a solution approach comprised of the most promising approaches, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application.

PHASE II: Research, develop, and demonstrate the prototype designed in Phase 1 for creating decision support capability using information integrated from structured and unstructured sources. Develop and demonstrate the prototype baseline capability using candidate actual data from operational systems.

DUAL USE COMMERCIALIZATION: Military application: Develop deployable system for sense making and understanding. Possible applications of this technology include military situation and threat assessment, indications and warnings of enemy activity, business intelligence monitoring and interpretation, and counterterrorism for homeland security.

REFERENCES:

1. Endsley, M. (1995). Toward a theory of situation awareness in dynamic systems. Human Factors, 37(1), 32-64.

2. Weick, K.E. (1995). Sensemaking in organizations. Thousand Oaks, CA: Sage Publications
Kirlik, A.; Rothrock, L.; Walker, N.; & Fisk, A.D. (1996). Simple strategies or simple tasks? Dynamic decision-making in “complex” worlds. Proceedings of the Human Factors and Ergonomics Society 40th Annual Meeting, 184-188.

3. Lipshitz, R. & Strauss, O. (1997). Coping with uncertainty: A naturalistic decisionmaking analysis. Organizational Behavior and Human Decision Processes, 69(2), 149-163.

KEYWORDS: Information Fusion, Reasoning under Uncertainty, Knowledge Acquisition, Knowledge Discovery, Information Extraction, Social Network Analysis, Pattern Learning

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AF06-076 TITLE: Anticipatory Capabilities for Complex, Dynamic Environments

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: The development of anticipatory tools and techniques to assist command staff in the rapid generation and analysis of adversary and neutral courses-of-action, enabling the rapid diffusion of undesirable military or socio-political situations.

DESCRIPTION: Achieving Predictive Battlespace Awareness (PBA) through the products provided to us by the Intelligence Preparation of the Battlespace (IPB) process require that command staff eventually generate the most-likely and most-potentially-lethal courses of action that our adversaries are capable of taking against U.S. and coalition forces. Currently, this process is largely manual, and depends on the individual creativity of intelligence analysts and strategists, working with limited cognitive resources. The objective of this SBIR is twofold: first, to harness the power of computation for exploring a wide range of potential enemy courses-of-action based on putative adversary objectives and resource considerations (i.e. only having trucks and crude bomb-making materials at hand, rather than a more conventional arsenal). Secondly, we would like to explore extrapolations of these courses-of-action with respect to perceived opportunism on behalf of our foes (i.e. our adversaries knowing that must operate according to a fairly strict code of conduct). The automated tool that we envision will present a number of plausible options to the decision-maker, allowing the human decision-maker to explore skeleton courses-of-action generated in the description of objective #1, while allowing them to selectively explore various extrapolations of the same via the product produced to satisfy objective #2.

The choice of objectives in this topic parallels the classic bias-variance (overfitting-underfitting) tradeoff which must be established when constructing predictive models of any kind. Rapid generation of likely courses-of-action must take historical data into consideration without biasing the model toward certain modes of adversary operations (i.e. using one particular mode of transport in a suicide-bombing), while discovering enough structure to generate meaningful patterns of activity (i.e. the use of an arbitrary mode of weapons delivery in a suicide attack). Knowledge-intensive techniques may be applied to models constructed at these appropriate levels of resolution to generate a plausible set of candidate adversary courses-of-action. Current technologies available for discovering parsimonious models may include mixed-resolution modeling for pruning otherwise unmanageable search-spaces; and the incorporation of adversary plan constraints utilizing adversary readiness, resource requirements, and assumed adversary knowledge of coalition constraints (i.e. rules of engagement, demonstrated thresholds of acceptable risk in coalition plans). Technologies available for plan extrapolation will generally be knowledge-rich, enabling detailed step-by-step explanation/justification for each proposed adversary action within an adversary course-of-action.

PHASE I: Selection of appropriate methodology to induce plan-skeletons, and choice of appropriate heuristics and priors to be incorporated in the inductive method. Selection of technique to facilitate human-in-the-loop plan extrapolation, complete with a mechanism to generate a justification for each adversary action.

PHASE II: Demonstrate a prototype for the system architecture developed in phase I. Identify sources for real-world data (either from exercises, or operational sources), and show compatibility between the architecture developed in phase I, and the data sources used in phase II. Work to identify potential customers for commercialization.

DUAL USE COMMERCIALIZATION: Tools developed in this effort will be of great use to planners operating at all levels of warfare, especially in joint and coalition operations. Industrial applications include generation of appropriate corporate business rules for pre-empting competition with rival corporations.

REFERENCES:

1. Air Force Pamphlet 14-118, Aerospace Intelligence Preparation of the Battlespace, 5 June 2001, pp. 6-7.
2. Christopher M. Bishop (1995), Neural Networks for Pattern Recognition, Oxford University Press

3. “Anticipatory Planning Support”; John R. Surdu, John M. Hill, Udo W. Pooch; Proceedings of the 2000 Winter Simulations Conference.
4. “Dynamic Situation Assessment and Prediction (DSAP)”; Alex F. Sisti Air Force Research Laboratory/IFSB.
5. “Synthetic Cognitive Modeling of Adversaries for Effects-Based Planning”; Paul K. Davis; Proceedings of SPIE Vol. 471 operational anticipation, adversarial modeling, battlespace knowledge

KEYWORDS: Heuristic search, multi-resolution modeling, plan induction, knowledge representation, reasoning

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AF06-077 TITLE: Command Decision Support and Explanation from Fused Structured and Unstructured Information Sources

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop decision support capability that reasons over fused structured/unstructured information sources and explains decision rationale

DESCRIPTION: Commanders are required to make mission-critical decisions based on information that is often distributed, non-integrated, and represented in many structured and unstructured formats (e.g. situation reports, database data, voice, email, etc.). Currently, support staff must read many potentially relevant documents to extract information needed to create a situation report that assesses operational capability or mission risk in order to make go/no-go decisions. Even where data access is automated, information is frequently not integrated into a “single integrated mission picture” to support decision-makers; and where data is integrated, the detailed domain analysis needed to support decision-makers is not automated. At the 45th Space Wing, Patrick Air Force Base FL, for example, knowledgeable staff must analyze an assortment of information to make decisions as to whether or not range systems are ready to support a specific space launch as each launch has different requirements. Significant domain knowledge goes into making these determinations, which is not captured in an automated form. Capabilities are needed that (1) represent integrated information, on demand, from structured and unstructured sources, (2) aggregate integrated knowledge to support high level views of decision issues such as systems or mission status, (3) capture the decision analysis needed to assess those decision issues and related risk, (4) explain the underlying process to those responsible for making decisions, and (5) capture the decision history for after-action review and historical trend analysis. Since decision-makers will never entrust final decisions to software applications, the decision support system must be capable of explaining its own analysis, including the reasoning it used to produce the analysis and the core data/information used in making its decisions. This capability must also support decision-makers, and staff, in drilling down into detailed, semantically relevant information used to make the decisions (or trigger the rules). In short, they must support a complete explanation of the “decision history” that gives commanders confidence that the readiness assessment is accurate, complete and appropriately classified. The overall goal is to help commanders make better, more informed decisions more rapidly and to assess the analysis leading to recommended decisions.

While there are a number of technical areas that need to be addressed in order to achieve a high quality command-level decision support capability, the specific areas of interest for this topic are (1) the representation of decision analysis over semantically relevant information gleaned from fused structured and unstructured sources, (2) traceability/explanation of decision logic sufficient to give human decision-makers confidence in the decisions, and (3) access/visibility into detailed information that formed the basis for decisions. Of particular interest are the problems associated with the integration of structured and unstructured data in a way that can support decision analysis and decision explanation. In other words, the research must show that aggregate decision results can be unraveled down to the logical sequence of decisions made as well as down to the source data upon which that logic operated.

PAYOFF: This research has high payoff in the area of using fused data to support command decision-making. It makes the connection between the fused data and the decision process. It would have high value to any commander with a "single integrated picture" and the need to make decisions based upon that picture. An example could be the 45 Space Wing which is deploying systems to support a "single integrated range picture" of operations at the Eastern Range for the Wing Operations Control Center (WOOC), but has no tools to directly use that integrated view to aid in decision-making. It contributes to the goal of the "Single Integrated Battlefield Picture" which is at the heart of military data fusion initiatives. It will support Homeland Defense by showing how fused data can provide a rich source of knowledge that can be exploited by decision support systems with detailed decision histories tied to detailed data triggering proposed decisions. This capability also offers a foundation for better alignment in command decision-making, since staff and contractors can assess the decision logic and conclusions. Finally, this capability is critical to capturing domain knowledge and transferring it to new staff, since it offers a core capability needed to train staff in situation assessment and command decision-making under changing scenarios (represented by changing situational data).

PHASE I: Perform the initial research necessary to assess potential approaches. Develop a solution approach comprised of the most promising approaches, and assess its feasibility. Develop the initial design for a prototype and demonstrate its application.

PHASE II: Research, develop, and demonstrate the prototype designed in Phase 1 for creating decision support capability using information integrated from structured and unstructured sources. Develop and demonstrate the prototype baseline capability using candidate actual data from operational systems such as integrated data on Eastern Range mission system status provided to the 45 Space Wing WOOC.

DUAL USE COMMERCIALIZATION: Military application: The ability rapidly and accurately integrate operational data from multiple sources, assess readiness, and support command decisions is of high value to all services as well as to C-level staff in the commercial world.

REFERENCES: 1.http://www.globalsecurity.org/space/facility/patrick.htm

2. http://www.metadata-stds.org/OpenForum2003/Presentations/

3. [TANNENBAUM2001] Tannenbaum, Adrienne, Metadata Solutions, Addison-Wesly, 2001

KEYWORDS: data fusion,integrated information,single integrated picture

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AF06-079 TITLE: Data Fusion of Eddy Current, Ultrasonic, and Radiographic Data

TECHNOLOGY AREAS: Air Platform, Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop application-optimized data analysis and fusion/mining algorithms for multifrequency eddy current, ultrasonic and radiographic data.

DESCRIPTION: General corrosion induced material thinning in multilayered aircraft structures is already successfully inspected with conventional depot-based eddy current, ultrasonic, and radiography nondestructive inspection (NDI) platforms. While these NDI techniques are capable of detecting thickness loss at multiple interfaces, they cannot distinguish between these defects if they are located at the same lateral position. Furthermore, corrosion at each interface can occur at both the top and bottom layer; the ratio of this corrosion distribution cannot yet be determined. The complexity of the problem requires the acquisition of multiple NDI data sets which, after adequate data processing and fusion, can provide an overall assessment of the structure.

Multifrequency eddy current, ultrasonic, and radiographic approaches are considered especially suitable for defect detection in multilayered structures. Conventional coil probes and transducers can be employed if optimized for evaluation of thick structures in particular. In addition, the employment of giant magnetoresistive (GMR) probes can be investigated, since GMR probes have outstanding sensitivity in the low analyzing frequency range below 1 kHz, providing large penetration depth for the eddy current signals. Optimized eddy current sensors can measure with four or more different frequencies simultaneously, thus, providing multiple sets of NDI metrics for each scanner position. Research is needed to model these data sets and to use them in application-optimized data analysis and fusion algorithms. The planned output of this approach is two-dimensional mapping of each interface of the multilayered structure, indicating the corrosion related material losses at the respective interface. If necessary, the computation shall distinguish further between the top and bottom surface at each interface. The data analysis can be trained with appropriate specimens simulating aircraft structures and shall be validated by implementing the approach in actual depot or field inspection procedures required eddy current, ultrasonic, and radiographic data shall be obtained using sensors that are optimized for multifrequency data assessment including low frequencies below 1 kHz for deep penetration depth. Conventional eddy current coil, GMR, ultrasonic, and radiographic sensors shall be considered.

PHASE I: Demonstrate the feasibility of a software tool prototype that includes application-optimized data for use in fusion/mining algorithms with multifrequency eddy current, ultrasonic, and radiographic data.

PHASE II: Develop and demonstrate a prototype product based on the results from Phase I to be used in support of an actual aging aircraft application. If necessary, Phase II shall also include sensor development.

DUAL USE COMMERCIALIZATION: Multifrequency eddy current analysis software developed under this effort should have extensive government and commercial applications. The ability to distinguish and quantify multiple defects in an NDI data set is of high importance for improved aging aircraft inspection procedures.

REFERENCES: A. Yashan, R. Becker, G. Dobman, "Use of GMR-Sensors for Eddy Current Testing," Electromagnetic Nondestructive Evaluation (V) (2001), pp. 187-1931. Cole, G. K., G. Clark, and P. K. Sharp, The Implications of Corrosion with Respect to Aircraft Structural Integrity, DSTO Aircraft and Marine Research Library, Melbourne, 1997.

KEYWORDS: data fusion, multifrequency eddy current, ultrasound, radiography, corrosion defects, magnetoresistive probe, nondestructive inspection

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AF06-080 TITLE: Nonfluid Transportable Aircraft Deicing System

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an environmentally-friendly transportable aircraft deicing/anti-icing system based on nonchemical deicing technology. Fluid shall be used only to provide a holdover time to prevent refreeze.

DESCRIPTION: It is envisioned that a contractor will analyze the requirement, evaluate present and maturing technologies and develop an approach to apply one of them (or integrate more than one) into a transportable ground-based aircraft deicing system.

Experience to date in this area suggests that no single methodology may be sufficient to meet requirements. However, a system based on a single method cannot be ruled out. Three possible methods are air, heat, and a very small amount of fluid.

If a heating method is used, the system must provide feedback to the user to prevent overheating of aircraft surfaces.

Regardless of the methodologies used, the design must incorporate the following requirements: (1) reduce overall fluid use by 90 percent; (2) provide a rate of deicing comparable to state-of-the-art fluid-based systems; (3) provide a reasonable anti-icing holdover time; (4) incorporate size and weight limitations for military air transport.

The design shall furthermore consider a cost-benefit business approach with the potential of providing a commercial product. It has been estimated that 75 percent of current aircraft deicing operating costs are associated with containment and disposal of deicing fluid. The design shall consider operating and capital costs of a commercially produced product in order to provide a return on capital equipment cost investment prediction.

The benefits expected to be realized by the Air Force include reduced environmental liability, reduced operating costs, and possibly reduced weather-related limitations on aircraft operational capabilities.

PHASE I: Determine a methodology, or an integrated set of methodologies, that are feasible for an environmentally-friendly groundbased transportable aircraft deicing system based on non-fluid technology. Provide a conceptual design and feasibility report.

PHASE II: Based on an approved Phase I concept, design the system, build a prototype, and provide a technology demonstration. The demonstration shall be conducted under controlled conditions, side-by-side with a state-of-the-art fluid-based system. It is desired that the prototype system shall be provided to the Air Force at the end of the effort for further evaluation and testing.

DUAL USE COMMERCIALIZATION: An alternative deicing system has many applications within both military and commercial aerospace operations.

REFERENCES: 1. Transport Canada, "Deicing with a mobile infrared system (TP 13489E),Dec. 1998, http://www.tc.gc.ca/tdc/summary/13400/13489e.htm

2. Radiant Energy Corporation, "Radiant Energy," http://www.radiantenergycorp.com

3. U.S. Environmental Protection Agency, "Preliminary Data Summary: Airport Deicing Operations (Revised)," EPA-821-R-00-016, August 2000

KEYWORDS: deicing, aircraft, laser, infrared, transportable, environmental

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AF06-081 TITLE: Recycling Composite Material

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and demonstrate cost effective and environmentally-friendly recycling methods for weapons systems that contain organic matrix composite materials.

DESCRIPTION: The Air Force (AF) is increasingly emphasizing environmental responsibility and liabilities relevant to weapon systems that have reached their design life cycle. Many of these systems contain organic matrix composites at the airframe or subsystem level. When a weapon system is retired, the aircraft is either scavenged for parts or eventually sold to salvage dealers who reclaim the high valued components and materials. Some of these systems contain composite parts and coatings - materials not traditionally reclaimed. The responsibility of dealing with the composite components and coatings then becomes the burden of the salvage dealer who may refuse to bid on the scrapped system to avoid the liabilities of disposing of waste that may be considered hazardous. The design and material choices in these weapon systems affect the value of the aircraft to be reclaimed in the long run. Therefore, these materials need to be disposed of in a cost effective and environmentally-friendly manner. Disposal of these materials into landfills or consumed by methods involving incineration or chemical digestion are unacceptable since these processes may result in hazardous byproducts that require special attention. Novel recycling techniques will offer the salvage dealers way of reclaiming these hard to avoid materials.

PHASE I: The contractor shall demonstrate the feasibility of a novel process that is capable of reclaiming the constituent materials of thermoplastic and thermoset organic matrix composites. Cost effective and environmentally-friendly processes are desired.

PHASE II: The contractor shall refine the process defined in Phase I, and demonstrate that the method is safe, cost effective, and able to be commercialized. The AF will define the composite component to be recycled. Phase II will conclude with a demonstration to interested AF organizations. It is desired that the prototype system be delivered to the AF at the end of the effort for additional evaluation.

DUAL USE COMMERCIALIZATION: Successful demonstration and implementation of this technology has direct impact on commercial and military systems that utilize organic matrix composites.

REFERENCES: 1. “Tertiary Recycling Process to Reclaim Composite Aircraft Components,” Contract Number N00421-98-C-1032, Adherent Technologies, Inc., Naval Air Weapons Center, Pax River.

2. DoD Instruction 5000.2, “Operation of the Defense Acquisition System,” May 12, 2003.

3. Jost, K., "Sheet Molding Composite Recycling." Automotive Engineering, Vol 103, Issue 8, Aug 1995.

KEYWORDS: recycling process, pollution prevention, composite materials, carbon fibers, thermoplastic, thermoset

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AF06-082 TITLE: Affordable Manufacturing for Lightweight High Thermal Conductivity Graphite Heat Sinks for Fighter Avionics Modules

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an ultra lightweight thermally high conductive composite thermal plane heat sinks for various fighter avionics applications that are installed in liquid cooled avionics modular racks.

DESCRIPTION: The Air Force is seeking novel manufacturing approaches for lightweight Versa Modular Eurocard (VME) thermal plane heat sinks for various fighter aircraft on avionic modular racks compatibility. The thermal plane highlights are the following: 1) Utilization of high thermal conductivity pitch-based graphite to maximize rail-to-rail thermal conductivity. 2) Coefficient of thermal expansion(CTE) balance system for mechanical integrity. 3) Low cost through use of the following characterization: second generation affordable processed main graphite thermal plane and inexpensive composite in noncritical thermal areas that may emphasize structural requirements. The thermal plane will be designed to deliver as an affordable commercial off the shelf (COTS) approach to manufacturing a 3D composite heat sink. Goals are definite advantages in price, weight, stiffness, performance and manufacturing. Other design requirements are to minimize the thermal resistance between electronic components and the cooling media and minimized thermal resistance between the thermal plane interface, VME or standard electronic module Type-E (SEM-E), type architecture avionic board. Other manufacturing requirements desired are coatings to demonstrate high or low electrical resistance, moisture/salt. The goal is to replace all aluminum and AlBeMet thermal plane heat sinks with high strength carbon fiber organic matrix composite (OMC) or low cost, high production carbon-carbon C-C materials with a 2X conductivity improvement, except for high heat load avionics, which requires a high graphite with a 3X conductivity improvements. Goals of heat power dissipation are 10 degrees F reduction and 20 percent cooling increase and 20 percent reduced weight. Proof-of-concept subcomponent cores processing and manufacturing shall be fabricated and tested, and shall possess properties approaching the above goals for thermal plane heat sink applications. Critical material conductivity, strength/stiffness characterization shall be measured. The concept(s) will be down-selected in Phase II for affordable composite manufacturing, high power, high production class, thermal plane heat sink insertion for a potential standard electronic module format circuit card, which will be developed in detail. Affordable fabrications will be down-selected; thermal and structural material performance analysis shall be conducted for a typical fighter aircraft environment. The modular composite heat sink fabrication, cost and thermal management models and implementation of potential aircraft transition plans will be analyzed.

PHASE I: Demonstrate the feasibility of the proposed economical interface-type architecture avionics high conductivity thermal plane heat sink directed to replacing all metal heat sinks concepts.

PHASE II: The payoff and benefits of the technology will be demonstrated by the fabrication and environmental breadboard test of the selected unit(s). The test data will be compared to the production, aircraft, avionics-type thermal plane heat sinks. Merits and benefits shall be identified.

DUAL USE COMMERCIALIZATION: The use of an efficient thermal management composite material can enhance thermal performance and significantly reduce weight and increase performance of electronic cooled boxes. Thermal management is an issue for commercial as well as DOD platforms. Aerospace and transportation-type electronic boxes have similar requirement to reject heat. Other potential applications include composite thermal management of the vast market of commercial satellite electronic boxes.

REFERENCES: 1. Newland, S "Applications for High Thermal Conductivity Graphite Heat Sinks for Fighter Aircraft," 2004 IECS, Colorado Springs, CO, 2004.

2. Watts, R and Kistner, M "Thermal Conductivity and Structural Properties of Emerging Composites Materials," 2004 Fall SAMPE, San Diego, CA, 2004.

3. Banisaukas, J Rawal, S Silverman, Ed "Carbon Composite for Spacecraft Thermal Management," 2005 STAIF, Albuquerque, NM, 2005.

4. Koch, R Watts, R and Benson-Tolle, T "Challenges and Opportunities for Thermal Management Materials," 2003 Spring SAMPE, Long Beach CA, 2003.

5. Watts, R and Jenkins, L "Aerospace and Spacecraft Applications Opportunities," 2004 Spring SAMPE, Long Beach CA, 2004.

KEYWORDS: organic matrix composites, carbon, thermal, planes, heat, sinks, radar, and transmitter/receivers

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AF06-083 TITLE: Coolanol 25R Replacement for Military Aircraft Radar Cooling Systems

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an environmentally safe coolant for military radar systems without requiring major hardware (H/W) replacement. The advanced coolant needs to be a drainable, purge and replace solution.

DESCRIPTION: Many military radar cooling systems use Coolanol 25R as the coolant. Coolanol 25R is a hydrolytically unstable material that forms a flammable alcohol and silica gel when it decomposes. If leaks occur, this can cause extreme corrosion to coatings and potential fires. Coolanol is approximately $500/ gal compared to $30/gal for MIL-PRF-87252 polyalphaolefin (PAO) which has previously been used for some AF systems without major H/W changes. While PAO coolant meets current requirements, advanced systems require improved performance in heat flux removal rate, heat capacity, thermal and hydrolytic stability, and low wear in pumps while still allowing the systems to operate without major modifications. Eventual commercialization of the coolant is important and offerers should have an effective plan to provide the product to the AF if fully successful.

PHASE I: Demonstrate the feasibility of developing an advanced coolant for use in military radar systems that will meet the requirements described above. Assess material compatibility issues and identify cooling capacitance of the coolant.

PHASE II: Fully develop and demonstrate an optimized coolant formulation. Identify and solve any minor hardware modifications that cannot be totally eliminated and are required for an effective system solution. Deliver a cost impact estimate to convert advanced radar systems to the improved coolant. Include any modifications necessary within the cost estimate. Demonstrate the cooling performance in a laboratory environment simulating a flyable system.

PHASE III/DUAL USE APPLICATIONS: Coolants are widely used for solar heat transfer, automotive cooling, nuclear industry cooling. Any such application is a potential use of this technology.

REFERENCES: 1. PAO Coolant Conversion Workshop Proceedings," DTIC accession number ADB159981, 1991.

KEYWORDS: coolant, environmentally friendly, radar

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AF06-084 TITLE: Friction Stir Welded Aluminum Machining Preforms

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop friction welding techniques for making near-net shape preforms for machining large (10 feet by 3 feet by 6 inch) structures from alloys in the strength range of 7050-T7451.

DESCRIPTION: The replacement of large aluminum structures in legacy aircraft is made difficult when the original assembly jigs are no longer available. While the ability to reverse engineer the existing structure and machine a unitized structure exists, the size of the original structure often precludes being able to get a large block of the desired aluminum alloy in a timely fashion, if at all. Several concepts have been published or conceived to make near-net shapes, referred to as preforms, using friction stir welding and related friction joining technologies 1,2. These would take smaller product forms of an alloy such as 7050-T7451 and friction stir join them together to make a preform from which the structure could be machined out of. Development of detail part geometries, tool geometry and weld parameters is necessary to make these concepts suitable for implementation.

PHASE I: Demonstrate the feasibility of proposed friction welding techniques for making near-net shape preforms.

PHASE II: Further develop the chosen technique demonstrated in Phase I and demonstrate the process on a representative full scale component.

DUAL USE COMMERCIALIZATION: The developed friction stir welding techniques will have applicability in both commercial and military aircraft as well as other industries such as recreational equipment and transportation applications.

REFERENCES: 1. Thomas, W.M. and Sylva, Gil Developments in Friction Stir Welding ASM Materials Solutions 2003, Pittsburgh, PA

KEYWORDS: friction stir welding, preforms, material

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AF06-085 TITLE: Nanocomposites for Lightweight Electronic Enclosures

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a nanocomposite electronic enclosure to demonstrate lower weight with equivalent or better electronic performance.

DESCRIPTION: A new class of nanoconstituents, called vapor grown carbon nanofibers (VGCF) is a relatively mature, low cost material which may enable the use of very light weight electronic enclosures made of polymers rather than metals. When incorporated at only a few percent into a polymer, VGCF can attenuate EM signals significantly over certain frequency ranges. These materials could be produced by low-cost plastics fabrication methods and would weigh approximately half that of aluminum enclosures, possibly at lower cost. The articles will be tested for electrical characteristics, mechanical properties, and thermal conductivity. A proposed full scale design and cost estimate would be required at the end of Phase I. If higher mechanical performance is required, VGCF can be incorporated into organic matrix composite (OMC) systems as well. Previous results on VGCF OMCs have shown that significant attenuation can be achieved in these materials, saving about a third the weight over aluminum. The Phase II demonstration article will be a full-scale electronic enclosure with reduced weight, while maintaining electronic and mechanical performance design properties at minimal cost increase per unit.

PHASE I: Demonstrate the feasibility of building a fullscale electronic enclosure by fabricating subscale coupons and articles.

PHASE II: Develop, design, build, and test one or more fullscale electronic enclosures. It is desired that the enclosure be delivered at the end of Phase II for additional testing and characterization by the government. A cost estimate and draft material and process specifications would be required at the end of Phase II.

DUAL USE COMMERCIALIZATION: Commercial electronics, computers, commercial aviation, automotive body panels, commercial and military satellite structure

REFERENCES: 1. Lafdi, Khalid and Matthew Matzek, "Carbon Nanofibers as a Nano-Reinforcement for Polymeric Nanocomposites," Proceedings of the 35th International SAMPE (Society for the Advancement of Materials and Process Engineering) Technical Conference, Dayton, Ohio, Sept. 28 – 2 Oct 2003 (ISBN 0-938994-95-6).

2. Tibbetts, G.G., C. Kwag, D.G. Glasgow, and M.L. Lake, "Conductivity of Thermoplastic Composites Compounded of Glass Fibers and Carbon Nanofibers," Proceedings of the 35th International SAMPE (Society for the Advancement of Materials and Process Engineering) Technical Conference, Dayton, Ohio, Sept. 28 – 2 Oct 2003 (ISBN 0-938994-95-6).

KEYWORDS: electronic equipment, conductive polymers, nanotechnology, fiber reinforced composites, matrix materials, reinforced plastics

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AF06-086 TITLE: Net Shape Forming of Ceramic Matrix Composites

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and demonstrate low cost net shape forming processes for preceramic polymer derived ceramic matrix composites (CMCs).

DESCRIPTION: Fighter and other military platforms are considering ceramic matrix composites (CMCs) for engine applications due to their potential for weight reduction, reduced cooling, and durability improvements. Cost and fabrication time are key issues that must be addressed, and low cost net shape processing will help address those needs. Polymer derived CMCs, those fabricated by the polymer infiltration and pyrolysis (PIP) method, share much in common with polymer matrix composites, and may benefit from processing methodology common in that industry. Development of processes such as resin transfer molding (RTM) or one of its variants, tailored to CMCs, is required. Teaming which includes a military engine manufacturer and a composite fabricator will be key to ensuring that materials and components of interest are selected and that methods conducive to volume production are developed. A cost analysis to quantify the potential cost reduction and identify issues and needed process improvements should be accomplished in the first phase. One or two components should be identified for demonstration in the second phase.

PHASE I: Address issues such as mold fill uniformity, distortion of the fibers/cloth/perform during infiltration, inclusion of particulate fillers in the preceramic polymer, and the type and composition of the mold. Demonstrate the ability to fabricate composite material with acceptable properties.

PHASE II: Implement process improvements identified at the end of Phase I, and others that identified during subsequent development. Fabricate and evaluate sufficient numbers of components to validate the capability and cost reduction potential of the methodology. Evaluation will require NDE and thermal, physical, and mechanical property testing at a minimum. Develop a detailed process cost model.

DUAL USE COMMERCIALIZATION: The processes developed will be applicable to a variety of ceramic composite materials and have applications in both military and commercial aircraft engines, rocket and satellite propulsion systems, and numerous industrial systems employing corrosion and heat resistant materials.

REFERENCES: 1. M. Erdal, L.A. Ambrosoni, and Z. Guo, "Structural Ceramics Through Particle-Filled Preceramic Polymers: Suspension and Particle Filtration Characterization," Cer. Eng. Sci. Proc., 21[4], pp 61-70, 2000.

2. M. Erdal, S Guceri, M. Allahverdi, W.R. Cannon, and S.C. Danforth, "Compression-Resin Transfer Molding of Particle-Filled Ceramic-Ceramic Composites," Cer. Eng. Sci. Proc., 19[3], pp 231-238, 1998.

KEYWORDS: ceramic matrix composite (CMC), processing, manufacturing, cost reduction

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AF06-087 TITLE: Warpage/Distortion in Machining 7050-T7451 Alloy Components

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop design tools, models and processes for the efficient and distortion-free machining of complex integral aircraft airframe structures.

DESCRIPTION: Current practice for machining aircraft structures is to end mill 90 to 95 percent of aluminum or titanium plate stock leaving precise, complex features typically on thin walled structures. The resulting structures are lightweight and stiff typically consisting of open pockets with thin bottoms, each enclosed by walls of thin ribs perpendicular to the webs. These types of parts typically contain features on only one side. In recent years the technique of high speed milling has become widely predominant in the manufacture of these parts.

However, these types of part geometries can be difficult to machine in a cost effective manner without inducing significant residual stresses and the resultant part distortions. There is a definite need to develop a predictive capability for optimizing the machining practice while minimizing part distortion and residual stresses.

This project will develop an empirical model that provides the machine operator with specific guidelines for efficient machining while minimizing any distortion and warpage. It will be important to consider both the machining induced residual stresses as well as bulk material residual stresses prior to machining. Also consideration will be given to part layout with reference to the rolling direction of the plate stock material. This model will provide best practices type recommendations/predictions for speeds, feeds, depth of cut, tool, fixturing etc for 7050-T7451 and part geometries.

The Air Force (AF)is soliciting proposals to develop a shop floor model for speed machining which provides end mill process parameters specific to alloy and part geometry that increase efficiency, and accuracy while minimizing residual stresses and part distortion. Examples of these types of structures are complete wing skeletons, bulkheads and control surfaces. Select and design a pre-prototype model and carry out all the necessary computations to be ready for a feasibility demonstration and recommendation to build the prototype model for validation testing. Determine the characteristics so as to satisfy the use for several 7050-T7451 parts to be chosen by the AF. Compare the feasibility results with a current art baseline. Develop feasibility study for applying the model to other materials. It is desired that the report and the prototype model be delivered to the AF for further testing and evaluation.

PHASE I: Design the model and validation testing plans, in principle, and carry out basic computations to compare and choose the more promising variant.

PHASE II: Build the prototype model and test its predictive capability of residual stresses and part distortions based on machining parameters during end-milling the required part features in aluminum 7050-T7451. It is desired that the model be delivered to the AF at the end of the effort for further evaluation and testing.

DUAL USE COMMERCIALIZATION: The developed model and approach could be used with modification across all aerospace materials including aluminum, titanium and composites. The technique can be equally applied to the machining of other military (helicopters, unmanned vehicles) and commercial aircraft components.

REFERENCES: 1. F. Huang-Hua, W. Chih-Fu, "A Residual Stress Model for the Milling of Aluminum Alloy", Journal of Materials Processing Technology 51, 1995, Pgs. 87-105

2. M.B. Prime, M.R. Hill, "Residual Stress Relief and Inhomogeniety in Aluminum Plate", Scipta Materiala 46, 2002, Pgs. 77-82

KEYWORDS: aircraft machining, metals, affordability, alloys, machine tools, complex integrated structures, modeling, residual stress, distortion

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AF06-088 TITLE: Protective Coating for Large-Diameter Bearing Races

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and produce surface treatments and technologies to protect large size bearing races against wear and corrosion attack.

DESCRIPTION: Bearing materials of the jet engine thrust vector system experience severe loading conditions and are subject to corrosion attack from both aggressive environments and fluorinated lubricants. Their size is nonconventionally large with an outside diameter of about 4 feet. These bearing races are heavily preloaded to 3-4 GPa contact pressure and need to operate for thousands of hours while exposed to a marine environment and temperatures up to 320 degrees C. They are used to vector jet engine thrust through up to 90 degree angle and can be subjected to severe vibration and dithering motions. High-performance stainless steel alloys (such as Pyrowear 675) are currently used to provide the required load support, corrosion resistance, and fracture toughness. In order to achieve a high surface hardness and compressive residual stress, this alloy is case hardened. However, this process can make the bearing races more susceptible to corrosion attack, reducing the expected service life. These bearings are lubricated with fluorine-based greases with degradation products that can be highly chemically active. Technologies are sought to provide a uniform protective coating on the case hardened surfaces of large size bearing races that will enhance high load wear and corrosion resistance; preserve mechanical properties and fatigue life of the core material; be compatible with fluorinated lubricants in hybrid metal-ceramic bearing systems; and, avoid geometrical distortions of the bearing during fabrication. The program should address both cost and weight considerations of the material system. Project coordination with component manufacturer is recommended.

PHASE I: Demonstrate the feasibility of innovative surface coating technologies for the large hybrid bearings and evaluate service life extension, grease compatibility and corrosion resistance improvement. Demonstrate the improvement in corrosion and wear life through sample testing.

PHASE II: Develop a technological process to coat large sized bearings of the three-bearing swivel duct with advanced coating materials identified in the Phase I effort. Coat and test prototype large size bearing races to demonstrate endurance improvements. Assess the benefits of using these technologies for large sized bearing races based on bearing performance and lifetime cost savings.

DUAL USE COMMERCIALIZATION: The new coating technology could have numerous mechanical applications for both military and commercial systems. These developments could be employed in almost any mechanical system where large sized bearing races can be subjected to wear and corrosion attack.

REFERENCES: 1. M. G. H. Wells, J. C. Beck, R. M. Middleton IV, P. J. Huang, and D. E. Wert, "Rolling contact fatigue behaviour of Pyrowear 675," Surface Engineering 15, pp. 321-323, (1999).

KEYWORDS: protective Coating, bearing, jet engines, corrosion, high friction

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AF06-089 TITLE: Innovative Corrosion Protection via Cold Spray Kinetic Metallization

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a methodology for using a cold spray kinetic metallization process to apply a corrosion-resistant coating to the surface of aluminum alloy aerospace components.

DESCRIPTION: Current high-strength aluminum alloys are not inherently corrosion resistant. Hence, protection schemes are employed to control corrosion. Common protection methods include anodizing, cladding, and priming. However, these methods have significant drawbacks. For instance, cladding can only be applied to sheet materials, while anodizing and priming require special safety precautions to comply with increasingly stringent environmental regulations and also have a limited useful lifetime in harsh environments. Cold spray kinetic metallization offers the potential to revolutionize corrosion protection for aluminum alloys by enabling the application of an environmentally friendly, durable, and corrosion-resistant coating to complex-shaped aerospace aluminum components. During the evaluation, consideration should be given to technical issues (e.g., imparted corrosion protection, coating adherence/strength/durability, impact on fatigue behavior of the substrate, galvanic potential with respect to graphite, titanium, and steel, etc.), process issues (e.g., automatability, ability to apply in areas with tight access, quality/repeatability/inspectability), and affordability/schedule issues (e.g., cost/availability of capital equipment, feedstock, trained personnel). At the end of Phase I, the feasibility of using one or more of the evaluated processes to apply corrosion-resistant coatings to aircraft components without degrading structural performance should be demonstrated.

PHASE I: Demonstrate the feasibility of one or more cold spray kinetic metallization processes in terms of their corrosion protection capability and their applicability to coating complex-shaped aerospace aluminum alloy structures without degrading structural performance.

PHASE II: Phase II will fully develop the process selected during Phase I. It is desired that specific test plans will be developed and possibly coordinated with representatives from one or more aircraft original equipment manufacturers. Target applications would be identified, and commercialization plan identified.

DUAL USE COMMERCIALIZATION: Both military and commercial aircraft employ high-strength aluminum alloys in their construction. Should a successful technique be developed, it is likely to be used in many commercial and military applications.

REFERENCES: 1. T. H. Van Steenkiste. "Aluminum coatings via kinetic spray with relatively large powder particles," Surface and Coatings Technology 154, 237-252 (2002).

2. Chang-Jiu Li. "Deposition characteristics of titanium coating in cold spraying," Surface and Coatings Technology 167, 278-283, (2003).

3. Howard Gabel. "Kinetic Metallization Compared with HVOF," Advance Materials and Processes, 47-48, May 2004.

KEYWORDS: corrosion, aluminum, cold spray, kinetic metallization, cladding, anodizing

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AF06-090 TITLE: Clutch Material for Aircraft Vertical Takeoff Systems

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and produce a reliable clutch material for high-speed and high-torque rotation generated by a jet engine.

DESCRIPTION: Lift systems for vertical take-off and landing is powered by a rotational moment transferred from the main turbine engine through a clutch. The clutch is dry and similar in configuration to an aircraft brake, but operates at a significantly higher speed (up to approximately 8500 rotations per minute). The design constrains the size of the clutch plates to approximately one foot in diameter. The clutch plates are required to withstand a high shear load, resist sliding wear, withstand high peak temperatures, and have high static and dynamic friction coefficients to minimize slippage. The clutch plates need high thermal capacity and thermal conductivity to dissipate large amounts of frictional energy introduced at a very high rate during engagement. It is desirable to have rapid heat dissipation through the clutch material to avoid hot spot formation and achieve reliable, consistent operation. A long service life in a marine environment is required. The current carbon/carbon clutch plate material is challenged to meet the life/wear and friction coefficient requirements.

Innovative clutch materials and their manufacturing technologies are sought to provide reliable, long life, cost effective operation of the clutch. Goals include a 3000 engagement life and a friction coefficient consistently greater than 0.1 and more typically closer to 0.2. Innovative materials such as carbon nanotubes may provide significant improvement in the heat energy dissipation, but need to be incorporated into a composite to satisfy the operational requirements. The program should also address both cost and weight implications of the proposed material system. Project coordination with the component manufacturer is highly recommended.

PHASE I: Demonstrate the feasibility of innovative clutch materials to provide long wear life, stable static and dynamic friction coefficients, heat dissipation, and corrosion resistance. Produce sample materials and demonstrate expected improvements via testing.

PHASE II: Develop the fabrication process and produce a prototype clutch with the advanced material. Test the prototype clutch to demonstrate performance and endurance improvements. Assess the benefits of using the new clutch material, including lifetime cost savings associated with the improvements. Deliver the prototype clutch to the AF at the end of the effort for additional testing and evaluation.

DUAL USE COMMERCIALIZATION: The new clutch material could have numerous mechanical applications for both military and commercial applications. These developments could be employed in almost any mechanical system where high-speed high-torque momentum from turbine engines needs to be directed to other mechanical systems.

REFERENCES: 1. K.C.Ludema, “Sliding and Adhesive Wear”, in Friction Lubrication and Wear Technology, ASM Handbook, vol. 18, p.236, 1992.

2. E.M.Tatarzycki and R.T.Webb, "Friction and Wear of Aircraft Brakes", in Friction Lubrication and Wear Technology, ASM Handbook, vol. 18, p.582, 1992.

KEYWORDS: turbine engine, clutch, vertical takeoff, carbon/carbon, wear, friction coefficient, shear strength, high temperature

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AF06-091 TITLE: <u>Corrosion Modeling and Life Prediction Supporting Structural Prognostic Health Management</u>

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative statistical tools/models/techniques to provide algorithm capabilities to initiate inspections/predict corrosion health status (damage/useful life remaining) of aircraft.

DESCRIPTION: Corrosion and Control Plans seek to minimize life cycle costs due to environmental degradation, including deterioration of nonmetallic materials as well as corrosion of metals in aircraft (A/C) structures. The development and demonstration of the latest techniques for predicting corrosion will support the effective implementation of Structural Prognostics and Health Monitoring (SPHM) and the Autonomic Logistic Information System (ALIS) within the program. The approach selected can focus on the use of corrosion sensors but more importantly on modeling and an understanding of the basic mechanisms of corrosions effect on material and component life. The first objective should be to eliminate the need for periodic corrosion inspections. This may be accomplished through the merging of sensor inputs, an understanding of the particular physics of failure, analytical models, physical models, statistical techniques, and actual failure experience data. It is just not practical to saturate an aircraft with corrosion sensors; thus the heavy need and influence on valid modeling techniques supported by a minimal number of sensors.

PHASE I: Define the architecture including techniques/processes/minimum number of sensors to relate useful life remaining predictions to detectable corrosion in A/C structures. Demonstrate the feasibility of proposed solution. Develop required inputs to models and methods of extracting them from A/C.

PHASE II: Fully develop and demonstrate a prototype of these advanced models, techniques, and programs for the specific fighter aircraft Structural PHM design. Assess the application boundaries, accuracy, and limitations for these modeling techniques. It is desired that the model be delivered to the Air Force at the end of the effort for additional testing and evaluation.

DUAL USE COMMERCIALIZATION: The corrosion models developed will have applications for aging aircraft in both commercial and military settings.

REFERENCES: 1. Wei, R.P. and Harlow, D.G., "Materials Aging, Prognostics, and Life-Cycle Engineering and Management," 2003 TMS Annual Meeting, Materials Prognosis: Integrating Damge-State Awareness and Mechanism-Based Prediction: Role of Probabilistics in Prognostics, March 2-6, San Diego, CA

2. Harlow, D.G. and Wei, R.P. "Life Prediction - The Need for a Mechanistically Based Probability Approach," Key Engineering Material: Probabilistsic Methods in Fatigue and Fracture, Chapter 6, 200, 119-138, 2001.

3. Defense Science Board Report on Corrosion Control, Washington, D.C.: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 2004, DTIC accession number ADA428767.

KEYWORDS: diagnostics, prognostics, corrosion, useful life remaining, prognostic health management

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AF06-092 TITLE: Automated Delamination Onset and Growth Prediction in Composite Structures

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a software package with which to perform automated delamination onset and growth prediction in composite structures containing an initial crack.

DESCRIPTION: A working relationship with a commercial software vendor is recommended. Demonstration of predictive abilities versus data will also be required. Important features of this product shall include (a) use of any common commercial off the shelf (COTS) finite element solver such as ABAQUS, ANSYS, LS-DYNA and/or NASTRAN; (b) use of PATRAN for common pre and postprocessing tasks; (c) ability to efficiently define initial crack geometry, including node duplication, connectivity, and contact algorithm definition; (d) ability to determine 3D strain energy release rates (SERRs) for multiple delamination areas on a single plane (i.e., G versus A) using a virtual crack closure technique; (e) ability to determine SERRs at mesh corners and in growth directions that are not normal to the as-meshed crack front, see [1]; and (f) ability to automatically determine efficient delamination area step sizes based on growth-rate gradients.

PHASE I: Provide theoretical justification and demonstrate the feasibility of the model. Commercialization strategy for a potential Phase II effort will also be identified.

PHASE II: Implement as a user subroutine for potential inclusion in a common COTS finite element package. A graphical user interface suitable to such a production environment is required, so pre-release software testing at government and/or industry sites will be encouraged. It is desired that the software and users manual be delivered at the end of the effort for further evaluation and testing by the AF.

DUAL USE COMMERCIALIZATION: This technology can be applied to all composite structures in DoD or civilian applications.

REFERENCES: Ferrie, C. H. and Rousseau, C. Q. A Method of Applying VCCT to Corner Crack Nodes. 16th American Society for Composites Technical Conference, Blacksburg, VA, Sep 9-12, 2001.

KEYWORDS: automated delamination, software package, composite structure

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AF06-093 TITLE: Techniques for Producing High Strength, Affordable Spinel Windows

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Identify and then validate techniques for producing affordable magnesium aluminate spinel windows with improved strength.

DESCRIPTION: The military demand for affordable yet increasingly accurate infrared imaging and targeting systems has led to challenging requirements for transparent ceramics. For many applications, weapon system designers seek window and dome materials with excellent broadband transmission that are erosion-resistant in variable environments at high speeds and are inexpensive enough for single-use munitions. Single crystal sapphire serves as the baseline material in many of these systems; however, its cost will likely be prohibitively high for large-volume applications.

Recent developmental efforts in aluminum oxynitride (ALON), magnesium aluminate spinel ($MgAl_2O_4$), and other transparent ceramics have led to their consideration as alternatives for sapphire in numerous military systems. They exhibit similar infrared transmission, ballistic performance, and hardness, and they can potentially be manufactured at a cost significantly lower than that for sapphire [1-2]. Magnesium aluminate spinel is generally considered the preferred substitute for infrared (IR) applications because of its superior broadband transmission, but spinel windows may have to be thicker (and therefore heavier) than sapphire windows to provide equivalent mechanical performance.

The goal of this program is to identify and validate techniques for producing spinel windows with improved strength for applications such as IR sensor windows for manned and unmanned aircraft. The strengthening improvements may target any part of the manufacturing process from the raw material through polishing; however, the prime contractor must be able to produce the window blanks. The windows must provide excellent optical properties such as approximately 80 percent transparency from the visible through at least the midwave infrared and index of refraction variation of less than 10 ppm over the full window. The window must also provide sufficient erosion resistance and strength to survive extended exposure at high speeds in varied environments. A goal of the effort is to demonstrate biaxial tensile strengths in excess of 300 MPa, with a weibull modulus of at least 5, for spinel samples.

In addition to identifying techniques for producing spinel windows with improved strength, the contractor should also consider the feasibility of implementing these methods at a scale and cost appropriate to produce 2,000-3,000 windows per year approximately 10 inches by 15 inches in size. The cost impact associated with the various strengthening methods should be identified. The strengthening techniques demonstrated should be practical on a production scale. The steps and costs to implement these techniques should also be identified. This demonstration should show batch-to-batch consistency for both optical and mechanical properties.

PHASE I: Identify and demonstrate techniques that would produce spinel windows with improved strength that meet the optical and mechanical requirements described above. Estimate the cost impact and determine the feasibility of implementing the techniques identified.

PHASE II: Demonstrate and optimize one or more of the most successful strengthening methods identified in Phase I by producing several large spinel windows (at least 10 inches x 15 inches) that meet the optical and mechanical requirements described above. It is desired that one of the windows be delivered to the Air Force at the end of the effort for additional evaluation and testing.

DUAL USE COMMERCIALIZATION: Many of the process improvements that enable spinel window strengthening will likely be transferable to transparent ceramic armor. Transparent ceramic armor provides lightweight protection against small munitions and other threats and is used for armored vehicles, face and body shields for law enforcements officers, and aircraft windows among other applications.

REFERENCES: 1. M.C.L. Patterson, et.al. in R.W. Tustison, ed., Window and Dome Technologies VIII, SPIE, Bellingham, WA, pp. 71-79, 2003.

2. L.M. Goldman, et.al. in R.W. Tustison, ed., Window and Dome Technologies and Materials VII, SPIE, Bellingham, WA, pp. 71-78, 2001.

KEYWORDS: spinel, strengthening, IR windows

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AF06-094 TITLE: High Performance Cage Sensors for Rolling Element Bearing Health Monitoring

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and produce "smart bearing" technology for real time monitoring of the health of rolling element bearings in operation.

DESCRIPTION: Future aircraft will benefit from integrated vehicle health management (IVHM) technologies that will allow aircraft performance to be monitored and assessed real time. This information will be used to determine performance as well as maintenance requirements. A critical concern that would benefit the IVHM concept is health monitoring of rolling element bearings in turbine engine, gear box and other accessories. These bearings, especially at internal locations, are in demanding/hostile environments. Severe temperatures, vibrations and physical location make it difficult to use commercial off the shelf (COTS) sensors with hardwiring for data capture. This program seeks to identify and develop unique technologies that can provide real time input of bearing temperature and vibration. The goal is to develop a robust sensing system that is integrated into the bearing, thus requiring no design changes to the system in which the bearing is installed. The data from the sensor is to be transmitted to an external unit by telemetry. This information should be easily integrated into a total health monitoring system for the aircraft without significant design change. The bearing health monitoring system should be durable and able to withstand high vibrations, and temperatures up to 300 degrees C.

PHASE I: Demonstrate the feasibility of a high performance bearing health monitoring system using prototype bearing assemblies for level testing and validate signal/environmental condition relationships.

PHASE II: Develop prototype bearing assemblies and associated data acquisition systems for flight hardware. Demonstrate performance and reliability in engine/component tests. Assess the cost and performance of smart bearing technologies for fighters.

DUAL USE COMMERCIALIZATION: Smart bearing technology would have pervasive application in commercial and military systems. The intent of this program is aircraft engines and subsystems. However, this bearing health monitoring system may find application in many other subcomponents or in automotive applications where performance enhancement or maintenance reduction warrants the use of a higher cost investment.

REFERENCES: Marble, S., Sadeghi, F., Nickel, D., and Hoeprich, M., "Micro Telemetry for Bearing Component Temperature Measurement," Proceedings of the May 2000 Annual Meeting of the Society of Tribologists and Lubrication Engineers, Nashville, TN, 2000.

KEYWORDS: aircraft engines, bearings, sensors, vehicle health monitoring, high temperature, maintenance reduction

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AF06-095 TITLE: Three-Dimensional Nonlinear Structural Analysis Methods for Gas Turbine Engine Metallic Components and Component Assemblies

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop three-dimensional nonlinear structural analysis methods necessary to enable prognosis systems applicable for aerospace gas turbine engine metallic components and component assemblies.

DESCRIPTION: US Air Force (USAF) engines are required to satisfy both crack initiation (safe-life) and fatigue crack growth (damage tolerant) design criteria under the engine structural integrity program (ENSIP) [1]. Nondestructive inspection techniques such as fluorescent penetrant and eddy current have been implemented by the USAF to detect small cracks at critical locations. This approach, based on systematic inspections of critical life-limiting locations in components, is used to detect cracks that can potentially grow to failure within the next inspection interval. The inspection intervals are determined as 50 percent of the predicted crack growth life from an assumed initial flaw size. These nondestructive inspections require removal of the engine from the wing followed by complete disassembly. Hence, the current life management approach is time consuming and expensive. Advanced and efficient life management practice and increased time-on-wing can be achieved by implementation of diagnostic and prognostic systems being developed under various programs [2,3]. Many of these prognosis systems rely on close coupling between damage-state sensors and component or material failure algorithms [3,4]. The component and material damage evolution and failure prediction tools will be required to utilize signals from limited number of sensors. Hence, analysis methods are required to predict the response of single components and assemblies of components. In addition, these approaches should enable detailed three-dimensional nonlinear structural analysis and damage evolution under complex engine loading conditions. We seek three-dimensional nonlinear structural analysis methods that will enable prognosis systems applicable for aerospace gas turbine metallic engine components and component assemblies. These methods should incorporate newly developed and/or available physically based probabilistic models that either describe damage evolution under service conditions or enable coupling between damage-state sensors and component or material failure algorithms. The proposed models should be based on key damage mechanisms including three dimensional crack growth in components and assemblies of components, non-linear material behavior, surface-treatment induced residual stress effects, and complex mission loading, coupled with detectable sensor parameters. Since the implementation of such advanced prognosis systems requires integration with the operation of the engines, close technical collaboration with original equipment manufacturers (OEMs) is strongly recommended in all phases.

PHASE I: Identify efficient three-dimensional methods that can be utilized for prediction of damage progression and sensor-detectable parameters at the component level. Demonstrate the feasibility of using the computational techniques in a prognosis system. OEM collaboration is encouraged.

PHASE II: Implement, demonstrate and validate computational techniques developed in Phase I that can be used for materials-damage based prognosis of gas turbine engine components and component assemblies. Demonstrate and validate prediction of damage evolution, deformation and life, and coupling with sensor-based technologies under turbine engine operating conditions. OEM collaboration is encouraged.

DUAL USE COMMERCIALIZATION: The technology is directly applicable to military turbine engine components. Commercial benefits include improved life management of components for commercial aircraft engines and land-based turbines.

REFERENCES: 1. Engine Structural Integrity Program (ENSIP), MIL-STD-1783 (USAF), 30 November 1984.

2. Christodoulou, L. and Larsen, J.M., "Using Materials Prognosis to Maximize the Utilization Potential of Complex Mechanical Systems," Journal of Materials, Vol. 56, No. 3, pp. 15-19, March 2004.

3. Russ, S. M., Rosenberger, A. H., Larsen, J. M., Berkley, R. B., Carroll, D., Cowles, B. A., Holmes, R. A., Littles, J. W., Jr., Pettit, R. G., and Schirra, J. J., “Demonstration of Advanced Life-prediction and State-awareness Technologies Necessary for Prognosis of Turbine Engine Disks,” Health Monitoring and Smart Nondestructive Evaluation of Structural and Biological Systems III, Proceedings of SPIE, Vol. 5394, Edited by Tribikram Kundu, SPIE, Bellingham, WA, pp. 23-32, July 2004.

4. Brockman, R.A., Huelsman, M.A., and John, R., “Simulation of Deformation Modes for Damage Detection in Turbine Engine Disks,” in Materials Damage Prognosis, Edited by J. M. Larsen, L. Christodoulou, J. R. Calcaterra, M. L. Dent, M. M. Derriso, W. J. Hardman, P. Hoffman, J. W. Jones, and S. M. Russ, The Minerals, Metals, and Materials Society, (TMS), 2005.

KEYWORDS: 3D, component assembly, crack growth, damage, fatigue, metals, nonlinear, sensor, structural analysis, three-dimensional, gas turbine

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AF06-096 TITLE: Wear Resistant Coatings for Aluminum and Titanium Alloy Housings and Flanges

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop surface modification technology to reduce wear of housings and flanges made of aluminum and titanium alloys.

DESCRIPTION: Aluminum and titanium alloys are widely used for bearing housing and flanges in aerospace propulsion systems due to a low density, good mechanical strength, and high thermal conductivity. However, these alloys can experience an excessive fretting wear, when matched to harder steel surfaces under adverse vibrations, loads, and temperature cycling. LiftFan systems include bearing housings and flanges made of aluminum cast alloys (e.g. A357), aluminum wrought alloys (e.g. 2219), and titanium alloys (e.g. Ti6-4). Fretting wear of their surfaces is traditionally solved using steel inserts or bushings, which are press-fit into aluminum alloy casing, and interface with the bearings. Such approach increases a number of the manufactured parts and weight of the entire mechanism. A replacement of the steel inserts with surface treatment technologies is sought to provide wear resistance to aluminum and titanium alloy housings and flanges. A particular interest is in technologies, which can economically modify surface of aluminum and titanium alloys into a hard alumina and/or titania-based ceramic by a gradual transition from the core metal to the top ceramic layer. A thickness of the ceramic transition layer should be at an order of 100 to 500 micrometers to distribute thermal and mechanical stresses and provide a good load support. Such layer could replace steel inserts, while simplifying design and reducing mechanism weight. For example, a microarc discharge treatment technology can be explored to convert the surface of aluminum and titanium alloys into a complex Al-Si-O and/or Ti-Si-O ceramics and provide relatively thick layers with good wear resistant properties. Developed processes must not affect the bulk mechanical characteristics of the aluminum and titanium housings and flanges and should be resistant to fretting wear at temperatures between –60 to 300 F. A combination of the coating adhesion tests, corrosion tests, fretting wear tests, and fatigue tests of the coated specimens or parts is required for coating qualifications. An attention should be paid to thermal expansions in the bearing – coated housing couple to eliminate loose fittings. Project coordination with lift system manufacturer is recommended.

PHASE I: Demonstrate the feasibility of a surface modification to reduce fretting wear at the surface of aluminum and titanium alloys in contact with steel for application to housings and flanges of the lift system mechanisms. Produce samples and perform testing to demonstrate surface modification benefits.

PHASE II: Develop and validate a manufacturing process for surface modification of housings and flanges made of aluminum and titanium alloys. Produce and test prototypes of new housings and flanges. Assess the benefits of using these surface modification technologies for LiftFan system housings and flanges.

DUAL USE COMMERCIALIZATION: New surface modification technologies for aluminum and titanium alloys could have numerous mechanical applications for both military and commercial applications. These developments could be employed in almost any mechanical system where wear of aluminum and titanium alloys is a limiting factor. The new process may also help to widen the use of aluminum and titanium alloys for mechanism weight minimization. Both aerospace and automotive industry will benefit form the new technology.

REFERENCES: 1. A.L. Yerokhin, X. Nie, A. Leyland, A. Matthews, S.J. Dowey, Plasma electrolysis for surface engineering, Surface and Coatings Technology 122, 73-93, (1999).

2. A.A. Voevodin, A.L. Yerokhin, V.V. Lyubimov, M.S. Donley, J.S. Zabinski, Characterization of wear protective Al-Si-0 coatings formed on
Al-based alloys by micro-arc discharge treatment, Surface and Coatings Technology 86-87, 516-521, (1996).

KEYWORDS: aluminum alloys, titanium alloys, wear, surface treatment

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AF06-097 TITLE: Damage Identification Algorithms for Composite Structures

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an innovative damage identification algorithm for composite structural systems.

DESCRIPTION: The integrity of in-service composite structures needs to be inspected to determine their physical condition throughout their lifetime. Such inspection will be crucial for the future aircrafts due to the increased use of composites which will be expected to perform near their limit conditions. In order to respond to any structural anomaly as a result of impact loads and environmental stresses, associated damages should be detected, identified, quantified, and, if possible, continuously monitored. The damage such as delamination and matrix cracks can be extensive, yet hidden. Consequently, accurate detection, identification, quantification, and monitoring of internal damage are of major concern in the operational environment. Therefore, acquiring knowledge into the nature, extent, and distribution of damage and degradation in a structure while in service using structural health monitoring (SHM) systems is critical to develop subsequent timely strategies to retard deterioration and enhance the air safety.
Innovative and commercially viable concepts are being solicited for the development of structural health monitoring for signal processing and data interpretation to establish quantitative characterization of damages occurred in composite structures. The proposed damage identification algorithms should have capability to identify, quantify, and monitor damage of various forms. The proposed approach should go beyond a simple monitoring system that merely detects the presence of damage without identifying its importance of the safety of the airframe structure.The methodology is expected to recognize the size, forms of the failure modes such as matrix cracks, delamination, etc. The methodology also would have the capability of identifying the multiple damages. The damage modeled must be compatible with sensing schemes that can be practically implemented on Air Force (AF) aircraft.The sensing scheme may include only types that can be practically implemented on AF aircraft. The enhancement of damage image resolution through different excitation signals and filtering techniques should be addressed in the simulation and experimental results. Optimal placement of sensors and actuators by using techniques such as optimization techniques or genetic algorithms should be developed and verified. The product must be implementable on an AF system with a minimum of effort, preferably within 2 years following the completion of the phase II program.

PHASE I: Develop an accurate and efficient damage identification methodology for detecting, locating, and quantifying the damages in the fiber reinforced composite laminates.

PHASE II: Fully develop and validate the methodology by integrated composite structural systems with sensors and actuators through experiments. It is desired that the prototype version of the software be delivered to the AF at the completion of the effort for addtional testing and evaluation.

DUAL USE COMMERCIALIZATION: Use of composite materials in civil and spacecraft will require an accurate and fast assessment of damages under the conditions to be experienced during service. The system developed could be used in any DoD platform, since they all have critical structural components that require health monitoring. Significant cost savings could be achieved by using a wide area inspection system of this nature since real time health monitoring would decrease inspection costs by reducing unnecessary inspections and tear-downs for inspection.

REFERENCES: The First and Second International Workshop on Structural Health Monitoring, Stanford University, 1997 and 1999

KEYWORDS: composite structures, structural health monitoring, matrix cracks and delamination, multiple damages, damage identification algorithms.

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AF06-098 TITLE: Erosion Resistant Coatings for Polymer Matrix Composites

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop erosion resistant coatings on high temperature polymer matrix composites for application to turbine engines.

DESCRIPTION: New aircraft will use polymer matrix composites (PMCs) to replace traditional metallic materials for many components. PMCs offer a tremendous benefit for weight reduction that is critical for enhanced performance. One particular application where PMCs are appealing is the outer fan stator vanes where temperatures up to 600 F will be experienced. A drawback for the use of PMCs is the excessive erosion that occurs when sand is ingested. Erosion resistant coatings offer a solution; however, obstacles would have to be overcome. Thicker coatings, such as plating or thermal spray, rely on mechanical bonds for adhesion. These coatings may be susceptible to bond failure, especially since a large difference in thermal expansion is inherent between the coating and substrate. Thinner coatings, such as physical vapor deposition (PVD), can be applied with chemical bonding for improved adhesion; however, they have not been developed specifically for polymer matrices, and sufficient thickness would be required to deter erosion for the life of the engine component. This program will focus on the optimization of PVD coating processes for application of erosion resistant thin films to polymer surfaces that can withstand high temperature applications.

PHASE I: Develop a PVD process/coating for application to PMCs that provides erosion resistance from ambient up to 600 F. Demonstrate the feasibility using bench level testing that includes erosive wear and thermal cycling.

PHASE II: Fully optimize and develop the selected PVD coating system. Apply PVD coatings to selected aircraft subcomponents for erosion evaluation in engine/component tests to demonstrate durability and performance. Scaleup process for manufacturing. Evaluate the economic feasibility (initial costs and replacement costs) for inclusion of the coating technology on flight hardware.

DUAL USE COMMERCIALIZATION: The use of PMCs is becoming more widespread and therefore the ability to coat for wear, erosion and low friction performance will increase. This technology will greatly promote the use of PMCs for many commercial and military applications including aircraft, automotive and heavy machinery. Basically, anywhere PMCs are being considered for moving mechanical assemblies will benefit from this technology.

REFERENCES: 1. NASA Tech Memorandum, Erosion Resistant Coatings for Polymer Matrix Composites in Propulsion Applications", NASA/TM-2003-212201, March 2003, J.K. Sutter, S.K. Naik, K. Miyoshi, C. Bowman, K. Ma, G. Leissler, R. Sinatra, and R. Cupp.

KEYWORDS: turbine engines, composites, coatings, physical vapor deposition, adhesion, erosion, wear resistance, high temperature.

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AF06-099 TITLE: Methodologies for Integration of Prognostic Health Management Systems with Maintenance Data

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative tools/techniques that would support the integration of prognostic/accurate assessment of actual material condition information within the maintenance/logistics support system.

DESCRIPTION: Prognostics and Health Management (PHM) is a system function that provides comprehensive assessment and reporting of system health, and detection of performance degradation for safety critical and/or maintenance significant functions [1]. Diagnostic and prognostic tools are being developed and implemented for accurate prediction of the remaining life or time span of proper operation of a component [2,3]. This information on the current damage state, predicted damage accumulation and remaining life coupled with the availability of resources and expected mission requirement, will enable the system user to make appropriate decisions about maintenance actions. The PHM approach is significantly different from the conventional mission-cycle-based or time-based life management of aircraft components. Key to accomplishing PHM is being able to integrate prognostic and accurate assessment of actual material condition information from a number of sources to provide a material condition assessment. This assessment should be optimized to work within the maintenance and logistics infrastructure in place on this program.

PHASE I: Define techniques/processes to merge PHM data within military maintenance and logistics infrastructure. Develop initial list of required inputs to models and outline method of extracting them for selected military application. Develop models that are optimized to utilize minimum computing resources.

PHASE II: Develop and demonstrate a prototype of these advanced models, techniques, and programs for a selected military system and applications. Assess the application boundaries, accuracy, and limitations for these modeling techniques.

DUAL USE COMMERCIALIZATION: The models and methodologies developed under this program will have applicability to both commercial and military aircraft as well as potential transition to other transportation systems.

REFERENCES: 1. Hess, A., “The Joint Strike Aircraft Prognostics and Health Management,” 4th Annual Systems Engineering Conference, 22-25 October 2001. Available at http://www.dtic.mil/ndia/2001systems.

2. Journal of Materials, Vol. 56, No. 3, pp. 14-42, March 2004.

3. Christodoulou, L. and Larsen, J.M., “Using Materials Prognosis to Maximize the Utilization Potential of Complex Mechanical Systems,” Journal of Materials, Vol. 56, No. 3, pp. 15-19, March 2004.

KEYWORDS: Diagnostics, Prognostics and Health Management, PHM, data integration, useful remaining life, health management, prognostics, maintenance

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AF06-100 TITLE: Improved Additives for Perfluoropolyalkylether (PFPAE) Lubricants with Silicon Nitride Rolling Elements

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop additives for perfluoropolyalkylether fluids and greases that will reduce their negative interaction with silicon nitride bearing materials

DESCRIPTION: Hybrid bearings utilizing silicon nitride rolling elements in conjunction with steel inner and outer bearing races are being developed for use in gas turbine engines. As the operating temperatures of gas turbine engines continue to increase, the stability of the conventionally used ester and hydrocarbon-based lubricants will no longer be adequate to provide long service life. The primary technology for higher temperature lubricating oils and greases is perfluoropolyalkylether (PFPAE) chemistry. These perfluorinated materials are well known for their superior thermal and oxidative stability over the ester and hydrocarbon-based lubricants. However, this same unique chemistry that provides their higher stabilities also creates some potential problems. One of these is the lack of compatibility with silicon nitride materials. Similar incompatibilities of the PFPAE-based lubricants with conventional bearing metals have been successfully addressed by a combination of PFPAE base oils with maximized stabilities coupled with new, soluble performance-improving additives that significantly improve the compatibility of these lubricants with bearing metals at high temperature. The materials that improve the compatibility of the PFPAE lubricants with metals are not effective at improving their compatibility with silicon nitride. In order to enable the incorporation of the hybrid bearings with the higher temperature PFPAE lubricants, an improved oil that demonstrates excellent compatibility with silicon nitride materials is required. This oil must be based on PFPAE chemistry, as it is obvious that the inherent stability of those fluids will be required in gas turbine engines and accessories. Any additive chemistry developed will have to: be effective over the temperature range of –40 to 650 degrees Fahrenheit, be soluble over that temperature range, and not adversely affect their stability. In addition, it must work in conjunction with and not adversely affect the performance of other additives in the lubricant.

PHASE I: This phase shall demonstrate promising additive chemistry that abates negative interaction between PFPAE fluids and silicon nitride bearing rolling elements. The effectiveness of the PFPAE lubricant developed shall be demonstrated in thermal exposure tests as well as in tribological experiments.

PHASE II: Complete development of a fully formulated PFPAE lubricant demonstrating excellent compatibility with silicon nitride rolling elements. Bench tests and high temperature, highly loaded bearing tests using hybrid bearings composed of silicon nitride rolling elements and steel inner and outer races shall be used.

DUAL USE COMMERCIALIZATION: This technology is directly applicable to a large number of commercial and military applications where the combination of PFPAE lubricants and hybrid bearings are needed for reliable service.

REFERENCES: 1. The Effect of Additives on the Wear Behavior of Bearing Steels with RfO(CF2O)x(CF2CF2O)y(CF2CF2CF2O)zRf Perfluoropolyalkylether Fluids, Tribology Transactions, 41, 78-86 (1998).

2. High Speed Civil Transport (HSCT) Hydraulic Fluid Development, Tribology Transactions, 45, 185-192 (2002).

KEYWORDS: lubricant, grease, perfluoropolyalkylether; perfluorinated, perfluoropolyether, high temperature

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AF06-101 TITLE: Advanced Prognostic Health Management Technologies Using Integrated Detection Techniques with Physics of Failure Mode

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative techniques/algorithms/sensors/capabilities to enable prognostic technologies at the micromaterial level while supporting the overall aircraft system capabilities.

DESCRIPTION: Prognostics and health management is a system function that provides comprehensive assessment and reporting of system health, and detection of performance degradation for safety critical and/or maintenance significant functions. There exists a need to establish an innovative and effective means of performing micromaterial level prognostics, within the current fighter aircraft capabilities set and architecture. These methods of detection should be performed in realtime and incorporate the development and use of physics of failure models for the particular component/material at the micro level.

PHASE I: Determine feasibility of providing techniques for micromaterial level prognostic technologies using integrated detection/physics of failure models. Provide approach for recommended combination of techniques/algorithms/sensors/models to accomplish objective. Show capability on a JSF design material.

PHASE II: Develop and demonstrate a final application for the combination of techniques, algorithms, sensors, and models produced in Phase I. Provide the architecture required to implement the above combination of capabilities. Demonstrate the recommended combination of these capabilities on specific JSF component designs.

DUAL USE COMMERCIALIZATION: Military application: The advanced technologies and capabilities are applicable to advanced military aircraft as well as commercial aircraft.

REFERENCES: 1. Challenges for SHM transition to future aerospace systems, Goggin, P, Proceedings of the 4th International Workshop on Structural Health Monitoring, Stanford University,Stanford, CA, September 15-17, 2003, pp. 30-41. 2003

2. Enhancement of physics-of-failure prognostic models with system level features, Kacprzynski, G L; Roemer, M J; Modgil, G; Palladino, A; Maynard, K, 2002 IEEE Aerospace Conference Proceedings. Vol. 6, Big Sky, MT; UNITED STATES; 9-16 Mar. 2002. pp. 6-2919 to 6-2925. 2002

KEYWORDS: diagnostics, prognostics, physics of failure, micromaterial, JSF, PHM

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AF06-102 TITLE: Aircraft Damage Locator

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a system that can quickly and accurately interpret visual damage location on an aircraft structure in three-dimensional space and transfer the information to a computer model of the aircraft.

DESCRIPTION: Military aircraft often receive damage to their structure and special features due to a variety of causes. The damage is typically detected visually or through the aid of handheld nondestructive inspection devices. Determining the exact location and spatial orientation of the damage is critical for a number of reasons including: determination of effect of damage to system capability, transfer of information for offsite consultation, and accurate documentation of damage for future reference. Typically, measurements are made from structural features such as fasteners, doors, or panels and then transferred manually to paper, which is an inaccurate, insufficient, and time-consuming process. The purpose of this program is to develop an inexpensive, portable data collection system that can be quickly setup in a remote location, map the damage on military aircraft in a three-dimensional coordinate system, and translate that information to a digital model of the aircraft. The goal is to provide the warfighter with a tool that can be used to digitize fixed points on the aircraft for mapping the aircraft to a digital model. Then, the warfighter can outline the damage using the tool to accurately identify the damage location relative to the digital model. This three-dimensional representation of the damage can then be used to feed other models for onsite engineering analysis or can be sent offsite electronically for rapid evaluation and documentation.Identify key requirements from users including input data, system setup, hardware, system speed and accuracy, output data. Demonstrate capability to quickly and accurately capture damage location on a system and map it to a digital model.

PHASE I: Demonstrate the feasibility of the proposed system including the identification of input parameters and output tolerances/requirements for accurate damage assessment. It is desired that "breadboard" prototype system be demonstrated to show how the system would perform. This may not include full integration as in the Phase II prototype.

PHASE II: Fully develop, integrate, and demonstrate a prototype aircraft damage locator system utilizing a selected AF aircraft model. The prototype system will include a users manual and necessary hardware/software. Innovative commercialization strategies are encouraged such a teaming with an aircraft prime contractor, software vendor, etc.. It is desired that the prototype system be delivered to the AF at the end of the effort for further evalaution and testing.

DUAL USE COMMERCIALIZATION: With minor modification, the aircraft damage locator can be adapted to work on vehicles of any type as well as buildings and static structures such as bridges. This might become a cost effective means for automobile insurance agencies to speed the time and improve the accuracy of performing automobile repair estimates. Insurance estimators might also be able to use a tool like this to evaluate computer designed tract homes experiencing damage due to hurricanes, earthquakes or fire.

REFERENCES: 1. Aircraft Survivability?, JTCG/AS Newsletter, Spring 2002. Available at www.bahdayton.com/surviac/PDF/JTCGAS_spr02.pdf

KEYWORDS: aircraft battle damage repair, aircraft battle damage, damage location, defect modeling

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AF06-103 TITLE: Advanced Manufacturing Processes for Reduced Cost of Ceramic Matrix Composite Engine Components

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Reduce the cost and cycle time to manufacture ceramic matrix composite components for gas turbine engine applications.

DESCRIPTION: Requirements for advanced propulsion systems call for significant increases in performance. Advanced materials enable longer life, reduced weight, and increased performance. Ceramic Matrix Composites(CMC) offer a huge potential to increase the performance of gas turbine engines, however the cost of CMC make wide implementation impractical. Advanced manufacturing techniques can reduce the cost and cycle time to implement advanced CMC in gas turbine engines. Particular areas of interest include: simulation of CMC manufacturing processes to enable the application of lean manufacturing, weaving, coating, machining, quality control, nondestructive inspection, and effects of defects. Proposals shall demonstrate a reasonable expectation that new manufacturing approaches will lead to lower cost and/or cycle time for producing CMC. The ability to achieve mechanical properties suitable for the particular gas turbine engine application shall also be demonstrated. The potential cost savings and cycle time reductions of the demonstrated processes shall be validated. Commercialization plans and qualification requirements shall be established to offer these new techniques to the aerospace industry for production, transition, and qualification in Phase III.

PHASE I: Demonstrate the feasibility of innovative manufacturing methods that will result in substantial cost and cycle time reductions to produce ceramic matrix composites for turbine engine applications.

PHASE II: Fully develop the manufacturing techniques developed in Phase I and demonstrate that these techniques can be easily implemented to achieve the cost and/or cycle time reductions claimed. The manufacturing techniques shall be demonstrated in a pilot-scale manufacturing environment for the chosen component applied to a current Air Force CMC component.

DUAL USE COMMERCIALIZATION: The manufacturing process improvements for the ceramic matrix composite engine components will have applications to turbine engines in both military and commercial aircraft.

REFERENCES: 1. Walter Krenkel, Roger Naslain, and Hartmut Schneider (Editors), High Temperature Ceramic Matrix Composites, January 2002.

KEYWORDS: ceramics, fiber weaving, composites, lean manufacturing, machining

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AF06-104 TITLE: Three-Dimensional Deformation and Life Prediction Methods for Ceramic Matrix Composite Components

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and validate three-dimensional mechanism-based long-term deformation and life prediction methods for advanced ceramic matrix composites under aerospace gas turbine engine loading conditions.

DESCRIPTION: Ceramic matrix composites (CMC) are targeted for use in advanced aerospace turbine engine components which are exposed to temperatures greater than 1000C [1-3]. The current understanding of CMC behavior is based on extensive work on materials employing two-dimensional fiber architectures. However, in many cases, the complexity of the thermal and mechanical loading conditions in a gas turbine engine may require the use of a CMC fabricated using a three-dimensional (3D) fiber architecture. In addition, the CMC components also contain stress concentration sites such as corners, holes, fasteners and joints. Limited investigations have been conducted to understand the durability of CMC containing three-dimensional fiber architectures [4,5]. Hence, we seek fully validated three-dimensional mechanism-based models that are capable of predicting the long-term deformation and life under aerospace gas turbine engine loading conditions. The proposed work should develop or adapt full-field test techniques required to assess and predict long-term durability under multiaxial stress states and steep stress gradients. The models should be validated using subelement characterization based on targeted applications under complex environmental and thermal-mechanical loading conditions similar to that expected in engines. The ability of the models to predict the local and global deformation during these experiments should be verified using appropriate measurements. Multiaxial stress states due to rapid transient through-thickness thermal gradients should also be considered. The test techniques and models should be applicable to 3D architectures and component features or shapes that are expected in CMC components. Active participation by propulsion contractors in all phases of this program is encouraged to ensure transition of these modeling and subelement validation technologies.

PHASE I: Identify three-dimensional loading configurations, fiber architectures and environments simulating life-limiting locations in CMC components. Demonstrate feasibility of manufacturing corresponding subelements. Demonstrate feasibility of 3D mechanics-based deformation and life prediction models.

PHASE II: Implement, demonstrate and validate modeling techniques developed in Phase I that can be used for durability assessment, and deformation and life prediction of three-dimensional CMC components targeted for use in gas turbine engines. Demonstrate and validate applicability of models to accurately predict the full-field three-dimensional behavior at life limiting locations in the CMC components.

DUAL USE COMMERCIALIZATION: Commercial benefits include incorporation of advanced CMC materials in commercial aircraft engines and land-based turbines.

REFERENCES: 1. Integrated High Performance Turbine Technology (IHPTET) Brochure, Edited by C. Lykins and K. Watson, Wright Laboratory (WL/POT), Materials Directorate, Wright-Patterson Air Force Base, OH, 1995. Information also available at http://www.pr.afrl.af.mil.

2. Hill, R.J., "The Challenge of Integrated High Performance Turbine Engine Technology (IHPTET)," in Eleventh International Symposium on Air Breathing Engines, Edited by F.S. Billig, American Institute of Aeronautics and Astronautics, 19 September 1993.

3. Fohey, W.R., Battison, J.M., Nielsen, T.A., and Hastings, S., "Ceramic Composite Turbine Engine Component Evaluation," in Ceramic Engineering and Science Proceedings, Edited by G.N. Pfendt, American Ceramic Society, Westerville, OH, July-August 1995.

4. Morscher, G.N., Yun, H.M., and DiCarlo, J.A., "Matrix Cracking in 3D Orthogonal Melt-Infiltrated SiC/SiC Composites with Various Z-Fiber Types," Journal of American Ceramic Society, Vol. 88, No. 1, pp. 146-153, 2005.

5. Ogasawara, T., Ishikawa, T., Ohsawa, Y., Ochi, Y., and Zhu, S., "Tensile Creep Behavior and Thermal Stability of Orthogonal Three-Dimensional Woven Tyranno ZMI Fiber/Silicon-Titanium-Carbon-Oxygen Matrix Composites," Journal American Ceramic Society, Vol. 85, No. 2, pp. 393-400, 2002.

KEYWORDS: 3D, architecture, ceramic matrix composite, CMC, damage, durability, gas turbine, holes, joints, life prediction, mechanisms, three-dimensional

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AF06-105 TITLE: Solid Rocket Motor Nozzles Made From Tantalum Carbide Continuous Fiber Composites for Boost Applications

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Produce and characterize tantalum carbide (TaC) tow-based fibers and TaC/TaC composites for aggressive environments such as nozzle throats of solid rockets using highly aluminumized propellant.

DESCRIPTION: The missile and rocket community requires higher performance solid rocket motors for boost applications. New boosters require increased thrust so that they can travel at higher speeds and/or carry bigger payloads than current systems. To meet these requirements, high aluminum propellants that operate at temperatures in excess of 6000°F and at pressures greater than 2000 psi are being formulated. Current metallic nozzles, made from tungsten and rhenium, are not able to contain these high temperature blasts without melting or ejecting due to creep.

A possible solution is to exploit the many attractive properties of tantalum carbide (TaC) for this application. TaC has the second highest melting point of any known material and it does not undergo a destructive phase change upon heating or cooling. Additionally, it has high erosion resistance in an aluminumized propellant. It resists grain boundary attack from both molten and vapor phase aluminum and alumina. Furthermore, it has high hardness which makes it resistant to ablation from high velocity impact of alumina particles produced in the blast. Therefore, TaC is expected to be an excellent candidate for next generation rocket nozzle throats for boost applications such as the Evolved Expendable Launch Vehicle (EELV).

Unfortunately, monolithic structures made from TaC lack the strength or strain capability to accommodate the thermal stresses generated in a nozzle during the first few seconds of blast. There are only a few ways to accommodate this stress, i.e. elastic/plastic deformation or cracking. In a monolithic ceramic, a single crack forms and grows until catastrophic failure occurs. However, in a ceramic matrix composite (CMC), many matrix microcracks form and deflect along fiber/matrix interfaces without fracturing the fibers. Fibers bridge the cracks and hold the composite together. Microcrack damage is spread over a large area without catastrophically failing the component.

In the past, carbon fiber reinforced ceramic matrix composites have been fabricated by both chemical vapor infiltration (CVI) and polymer infiltration pyrolysis (PIP). Both of these processes have problems associated with insufficient matrix yield, extreme matrix cracking, spalling, and fiber debonding during processing. The matrix degradation problem is caused by the generation of large tensile stresses due to the coefficient of thermal expansion (CTE) mismatch between the carbon fiber and the ceramic matrix. The development of TaC continuous tow-based fibers that can be incorporated into TaC matrices should eliminate the CTE mismatch problem and prevent matrix cracking and spalling during the processing phase. A pyrolytic carbon or boron nitride (fiber/matrix) interface coating may provide the toughness mechanism needed to hold the system together during operation.

Offerors must present a rational argument as to why their process will result in a high volume yield, tow-based fiber with the desired properties and performance. The process must have potential for economical production of a large quantity of tow-based fibers and/or woven-tow preforms. The process should produce fine diameter fibers of less than 10 microns that are amenable to tow forming. Contamination control and volatile species in the processing phase are major concerns for these materials. Low melting point impurities tend to segregate to the grain boundaries resulting in poor strength and creep resistance. Impurities vaporize inside the material during calcinations causing pores that limit strength. Extreme care must be taken to minimize these effects.

PHASE I: The offeror will develop high volume yield processes to synthesize high tensile strength, continuous tow-based TaC fibers. Phase I deliverables will be a small quantity of the raw or precursor materials, 10 high-strength (1 GPa) fibers that are 10 inches in length and 10 microns in diameter.

PHASE II: The offeror will scaleup the fiber manufacturing process and produce TaC/TaC composites in both plate and subscale nozzle forms. Tow-based fibers will be produced for property evaluation, weaving studies, and compositing studies. Deliverables will be 200 feet of high strength (1 GPa) tow-based fiber for tensile and creep tests. A plate and two small nozzles should be manufactured and delivered.

DUAL USE COMMERCIALIZATION: The technology developed by this effort will have use for miitary rockets and missiles, while commercial applications of ceramic rocket nozzles include boost capabilities for space-based systems such as the space shuttle solid rocket motors and telecommunication satellites.

REFERENCES: 1. E. L. Courtright et al., "Ultrahigh Temperature Assessment Study: Ceramic Matrix Composites," WL-TR-91-4061 (ADA262740), Air Force Wright Laboratory, Wright-Patterson AFB, OH, September 1992.

2. A.J. Perry, "The Refractories HfC and HfN - A Survey I and II," Powder Metall. Int., 19, No. 1, 29 (1987).

3. Aviation Week & Space Technology, "New Nozzle Shows Potential for Increased Efficiency", p. 15, March 24, 2003.

KEYWORDS: solid rocket nozzle throats, ceramic, zero erosion, tantalum carbide.

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AF06-106 TITLE: Lightweight Conformal Electromagnetic Interference (EMI) Shielding

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 a lightweight polymer system capable of providing broadband EMI suppression.

DESCRIPTION: EMI is defined as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in some forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses, intermodulation products, and the like (1). Current state-of-the-art EMI shielding materials that are polymer based typically contain up to 87 percent silver or similar metals in order to meet generic shielding requirements on the order of 2dB/mil. These materials suffer substantially from loss of mechanical integrity due to their highly loaded nature, resulting in easy tearing and breakdown under friction. In an attempt to overcome this challenge, some manufactures of polymer-based EMI materials have typically based materials on thermosetting systems that have a high hardness (i.e., > 100 A). This, however, limits the scope of use of these systems and can lead to embrittlement. These systems also tend to have a very high specific gravity or density due to the large amount of metal found in the system.

We seek new and novel methods to produce low density, highly versatile polymer-based EMI shielding materials. These materials should have the ability to be easily processed and maintain mechanical and electrical integrity under harsh environmental conditions. Materials developed should be able to be fabricated into forms such as spray-on shielding, conformal dip-coated shielding, extrudable case components, caulking-gun-delivered flexible materials for joining panels, and be used as adhesives.

PHASE I: Develop and demonstrate a shielding effectiveness greater than 5 dB/mil, in a polymer matrix over broad frequency range (min 200 kHz to 20 GHz). The system should demonstrate a density of less than 2.0 g/cc, an ability to be coated conformably onto complex surfaces, and harness of 40 to 70 Shore A.

PHASE II: Further develop and demonstrate scalability of the process to make materials from Phase I efforts. Refine shielding effectiveness to 8 dB/mil (minimum 200 kHz to greater than 20GHz). Demonstrate performance in a platform-specific configuration by implementing technologies into and constructing prototypes for test and evaluation.

DUAL USE COMMERCIALIZATION: Transition technologies to provide lightweight conformally coatable EMI materials. Commercial benefits include improved coaxial cable shielding, static-dissipating carpet adhesives, and reduced piece parts in electronics enclosure manufacture.

REFERENCES: 1. United States, Joint Chiefs of Staff. DOD Dictionary of Military Terms and Associated Terms. Joint Publication 1-02. Washington, DC: JCS, 1997.

2. Baker-Jarvis J., Janezic M., Riddle B., Holloway C., Paulter N., and Blendell J., "Dielectric and Conductor-Loss Characterization and Measurements on Electronic Packaging Materials," NIST Technical Note 1520, 2001. Available at http://www.boulder.nist.gov/div813/rfelec/properties/Publications/Baker-Jarvis%20TN%2001.pdf

3. Joint Spectrum Center Website, MIL-STD-462(x) MEASUREMENT OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS, http://www.jsc.mil/jsce3/emcslsa/stdlib/docs/MilStd/History/MIL-STD-462.pdf

4. Joint Spectrum Center Website, MIL-STD-461(x) ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT, http://www.jsc.mil/jsce3/emcslsa/stdlib/docs/MilStd/history/MIL-STD-461.pdf

KEYWORDS: electromagnetic interference shielding, electromagnetic pulse shielding, polymer, spray coating, roller brush painting

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AF06-107 TITLE: Air Sensor for Hydraulic Fluid

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a sensor to measure the amounts of free and dissolved air in the hydraulic fluid

DESCRIPTION: Excessive air in hydraulic fluid can cause severe problems in aircraft hydraulic systems. Not only does excess air cause poor response from the system to inputs from the pilot, but it also reduces the stiffness of the control surfaces. An additional problem caused by excess air is cavitation that occurs when the air comes out of the fluid resulting in severe damage to the components as well as localized degradation of the hydraulic fluid. These problems are manifested when there is free air in the hydraulic fluid. At normal temperature and pressure, approximately 18 percent of air by volume is soluble in the military hydraulic fluids, (MIL-PRF-83282, MIL-PRF-87257 and MIL-PRF-5606). In order to prevent free air from forming in the fluid, the sensor must be capable of measuring both the free air and the dissolved air in the hydraulic fluid. The sensor must be compatible with the hydraulic fluids and functional over the anticipated temperature range of the hydraulic fluid of -40 to 275 degrees F. The sensor is not to be mounted on aircraft but on ground support equipment, e.g., hydraulic fluid purifier or hydraulic test stand.

PHASE I: Demonstrate the feasibility of the technical approach proposed to measure the dissolved and free air content of military aerospace hydraulic fluids over the temperature range of -40 to 275 degrees F.

PHASE II: The Phase II effort will build on the technology demonstrated during the Phase I contract and will develop it into a working prototype. The long term compatibility of the sensor with MIL-PRF-87257, MIL-PRF-83282 and MIL-PRF-5606 will be demonstrated. Calibration procedures will be developed that will be simple enough to use in the field.

DUAL USE COMMERCIALIZATION: If necessary, modification may be needed to make it compatible with commercial aerospace hydraulic fluids, such as Skydrol and Hy-Jet hydraulic fluids, which are phosphate ester based rather than hydrocarbon based like the military aerospace hydraulic fluids. Additionally, the sensor could also be modified for use in other fluids where the air content requires to be measured.

REFERENCES: 1. Military Aerospace Fluids and Lubricant Workshop Proceedings, November 2004.

KEYWORDS: hydraulic fluid, sensors, air sensors, hydraulic fluid purification

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AF06-108 TITLE: Integrated Materials for Efficient Airframe 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.

OBJECTIVE: Develop integrated material solutions that combine thermal protection concepts with warm airframe structures for next generation reusable hypersonic and reentry vehicles.

DESCRIPTION: Current state-of-the-art reentry and hypersonic vehicles consist of low temperature structural materials, such as aluminum alloys, with insulating ceramic tiles bonded to the surface. This approach has worked relatively well for the Space Shuttle, but there are several disadvantages to this approach including the following:

1. The current approach is maintenance intensive, requiring thousands of man-hours after every flight for inspection, repair and waterproofing of the fragile ceramic tiles. This is not acceptable for future USAF applications in which the vehicle must be operationally responsive.
2. The tiles provide insulation, but they are parasitic in that they do not carry any structural loads. The result is a heavy structure, not optimized for weight, and expensive to operate.
3. The system can result in catastrophic failure if an insulating tile is lost and the underlying cold structure is exposed to extreme temperature.

An alternative approach for future hypersonic vehicles involves utilizing novel materials and innovative design and manufacturing techniques to integrate the thermal protection system with the airframe to create efficient load-carrying structures. In addition, it is estimated that by using a 600 degrees F airframe material, a 15 percent weight savings over traditional lower temperature airframe materials can be realized. An integrated approach will encounter challenges of how to combine and join different materials together optimally to form an efficient structure. This topic will focus on the modeling, selecting, joining, processing, and testing of materials for integrated structures.

PHASE I: Design integrated structures based on mechanical/thermal models, and address the joining, processing and fabrication of the warm airframe and thermal protection. The contractor shall demonstrate the feasibility of the most promising concept experimentally or analytically.

PHASE II: The most promising integrated concept defined in Phase I will be refined using analytical and empirical methods. Coupon and subcomponent specimens will be fabricated and tested in representative environments to assess performance objectives. The contractor shall deliver an optimized structural component and a manufacturing maturation plan to the Air Force for further assessment.

DUAL USE COMMERCIALIZATION: This effort will produce integrated structures for miltary hypersonic vehicles. Commercial applications of the technology include commercial launch and space vehicles. Integrated structures consisting of different types of materials will have broad applicability to commercial rocket engines, aircraft engines and other extreme environment applications.

REFERENCES: 1. Airframe Technology Development for Next Generation Launch Vehicles, David E. Glass, IAC-04-V.5.09

2. D. J. Rasky, H. K. Tran, and D. B. Leiser, “Thermal Protection Systems,” Launchspace, pp.49, June 1998.

3. Polyimide Composites in Launch Vehicle Propulsion,” High Temple Workshop XXIV, Sacramento, CA, February 2004

KEYWORDS: thermal protection systems, hypersonic vehicles, high temperature materials

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AF06-109 TITLE: Photo-Electrochemical Generation of Hydrogen for Fuel Cell Operation

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Explore and develop high-efficiency, low cost, safe, light-weight photo-electrochemical systems for the solar production of hydrogen for micro fuel cell operation.

DESCRIPTION: The development of low cost, renewable energy capabilities is critical to the Air Force for air, terrestrial, and space applications. The current dependency on fossil fuels and traditional batteries has resulted in a variety of problems including: dependence on foreign countries for fuel, pollution of our environment, and the need to transport bulky, heavy generators and batteries with deployed troops.

A variety of alternative energy sources are currently being investigated by the Materials and Manufacturing Directorate including: low cost photovoltaics for solar power, improved fuel cells for low cost, cleaner and quieter power production, light-weight thin-film batteries, and the generation of hydrogen via photoelectrochemical (solar) process to fuel emerging fuel cell systems. The focus of this program is the development of a high efficiency photoelectrochemical system for the production of hydrogen using solar energy.

Providing fuel and batteries to power small unmanned aircraft in remote locations presents a logistical challenge. The purpose of this program is to explore and develop the harvesting of energy from the environment to power small unmanned air vehicles. Studies using hydrogen fuel cells to power large aircraft are currently underway at Boeing, NASA, and other aircraft companies(1). Prototype aircraft have been flown to demonstrate the technology. In these systems, the hydrogen is stored onboard to provide the fuel needed for flight. In this study we propose the development of the technologies needed for onboard, real-time hydrogen production from water using solar energy. Through the integration of in situ hydrogen production with fuel cell systems the fuel cell becomes regenerative. The goal of this program is to explore and develop high efficiency, low cost, safe, lightweight photoelectrochemical systems for the production of hydrogen for energy harvesting micro fuel cell operation in small unmanned aircraft.

PHASE I: Provide a feasibility demonstration of an improved approach to hydrogen generation using solar energy.

PHASE II: Develop a prototype solar powered hydrogen generation unit. The contractor will work with Air Force personnel to design and fabricate a working hydrogen generation unit which integrates into operational fuel cells. The system will be evaluated relative to current technologies. It is desired that prototype hydrogen generation system be demonstrated at the end of the Phase II effort.

DUAL USE COMMERCIALIZATION: Military applications include the production of power via fuel cells in remote applications. Useful for airbase, special operations, aircraft, UAV and satellite applications. Commercial applications involve a variety of consumer uses including automobiles and power supply in remote locations.

REFERENCES: 1. Michael Gratzel, "Photoelectrochemical Cells," Nature 414, 338 - 344 (15 November 2001).

2. Michael Gratzel, "Mesoscopic Solar Cells for Electricity and Hydrogen Production from Sunlight," Chemistry Letters Vol.34, No.1 (2005).

3. Licht S., Halperin L., Kalina M., Zidman M., Halperin N., "Electrochemical Potential Tuned Solar Water Splitting," Chem Commun (Camb),(24):3006-7, 2003 Dec 21.

4. Zou Z., Ye J., Sayama K., Arakawa H., "Direct Splitting of Water Under Visible Light Irradiation with and Oxide Semiconductor Photocatalyst," Nature,
414(6864):625-7, 2001 Dec 6.

KEYWORDS: hydrogen generation, photoelectrochemical, solar, water splitting, fuel cell, photocatalysis

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AF06-110 TITLE: Materials for Terahertz Frequencies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop materials that enable systems utilizing electromagnetic radiation at terahertz (THz) frequencies.

DESCRIPTION: The Terahertz portion of the frequency spectrum (0.3-30 THz) has attracted interest for various potential 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 sources and detectors that are in turn limited by materials. We seek novel materials development that enables significant improvement in the operation of these systems in terms of all or some of the following measures: component size and weight, wall-plug efficiency for generating THz radiation, average power generation, instantaneous power generation, detectivity, room temperature operation, and coherent generation/detection for low noise and background subtraction. Our interest is in both laser-based and electronic-based approaches for generating and detecting THz radiation, primarily in the 0.5-3 THz regime. The materials to be developed may be either bulk or engineered.

PHASE I: 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 improvement in system performance.

PHASE II: Develop the proposed material and/or the relevant material processes and demonstrate the materials properties and their usefulness for commercial and military applications. As part of the development activity, the material(s) may be integrated into a component or device. Manufacturing processes for commercialization of the material and/or product shall be developed.

DUAL USE COMMERCIALIZATION: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities for integrating the novel material into THz system hardware. Commercial benefits would be for airport security and wideband data transmission if the right materials are developed.

REFERENCES: 1. J. Federici et al, "Terahertz Imaging Using an Interferometric Array," Appl. Phys. Lett., vol. 83, p. 2477 (2003).

2. F.C. DeLucia, "Science and Technology in the Submillimeter Region," Optics and Photonics News, August 2003.

3. W. Shi, Y.J. Ding, N. Fernelius, & K. Vodopyanov, "Efficient, Tunable, and Coherent 0.18-5.27 THz Source Based on GaSe Crystal," Optics Letters 27(16), 1454 (2002)

KEYWORDS: terahertz, materials, novel, power, efficiency, detectivity, transmission

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AF06-111 TITLE: Materials for Midinfrared (mid-IR) Laser Sources

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 materials and material structures that enable improved midinfrared (mid-IR) laser sources.

DESCRIPTION: The mid-IR spectral band (2 to 5 microns) has long been important for numerous military and commercial applications, primarily because the spectral band is an atmospheric window or region with low optical attenuation in the earth's atmosphere. For many applications, there is a need for generating laser light in the sub-bands of this range, and such laser sources have significantly improved during the past two decades. However, important limitations to laser performance still exist, especially for wavelengths closer to 5 microns, and many of these limitations are fundamentally due to inadequate materials. We seek novel materials development that enables significant improvement in the operation of mid-IR solid-state laser sources in terms of average power, energy per pulse, and wall-plug efficiency. Our interest is in nonlinear optical crystals (bulk and engineered structures), laser-host crystals (bulk and diffusion bonded constructs), and the associated coatings and/or surface structures for antireflection or partial reflection. The potential contractor is encouraged to consider material solutions that surpass the commercially available materials. Suitable approaches could involve major improvements to the properties of existing materials or new materials with significantly improved properties. In either case, the potential for this improvement must be demonstrated in the proposal to be based upon solid scientific evidence.

PHASE I: Materials and/or material processing techniques shall be developed that enable significant improvement in the operation of mid-IR laser sources as described above. The materials shall also be characterized, and demonstrations performed that clearly show the potential for this improvement.

PHASE II: The contractor shall further develop the proposed material and/or the relevant material processes as well as to fully demonstrate the materials properties and their usefulness for commercial and military applications. All necessary manufacturing processes for commercialization of the material and/or product shall be developed as well.

DUAL USE COMMERCIALIZATION: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities for integrating the improved material into laser-based systems. Commercial benefits would be for remote chemical detection, medical laser procedures, and scientific instruments.

REFERENCES: 1. Reference 1 P. Schunemann, "Non linear crystals provide high power for the mid-IR," Laser Focus World 35, 85 (Apr 1999).

2. Reference 2 C. Aydin, A. Zaslavsky, G. J. Sonek, & J. Goldstein, "Reduction of reflection losses in ZnGeP2 using motheye antireflection surface relief structures," Applied Physics Letters 80 2242 (2002)

3. Reference 3 F.K. Hopkins, "What Drives Nonlinear Optics R&D? Military Laser Applications," Optics & Photonics News 9, 32 (Feb 1998).

KEYWORDS: midinfrared, mid-IR, laser-host, nonlinear-optical, antireflection, laser

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AF06-112 TITLE: <u>Continuous Runway Load-Deflection Evaluation Methodology</u>

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: To develop rapid nondestructive evaluation (NDE) technologies to determine the load carrying capacity of runways for various aircraft operations.

DESCRIPTION: The deployment of US military forces often requires aircraft operations on runways of unknown construction, roughness, and load carrying capacities. Air Combat Control Teams are deployed to the airfields of interest to rapidly determine the condition and operational capability of the airfields. Part of this process requires determining the strength of the concrete and subgrades, and is commonly determined by coring the runways, and /or the use of falling weight deflectometers (FWD) and dynamic cone penetrometers (DCP). These techniques are slow, laborious, and only check discrete points on the runway. Recent developments in ground penetrating radar technologies provide data on layer thicknesses, voids, and other geometric properties of pavement systems, but provide little if any strength data. Some research has been completed on rolling weight deflectometers, but to date the devices built are of questionable accuracy, cumbersome, heavy, and not very mobile. It is desirable to produce air droppable lighter weight devices that will rapidly collect continuous data using sensor technologies that are capable of accurately measuring deflection profiles around a loaded wheel as a function of time and space. It is envisioned development will be completed of software and data reduction algorithms to reduce deflections to a pavement classification number used to qualify a given aircraft on a given pavement.

PHASE I: Sensor technologies for measuring small deflections over an area as a function of space and time (optical, electro/mechanical, etc) will be considered. Select a technology that is most effective. Design, built, and test a bench scale rolling weight system to demonstrate the technical feasibility.

PHASE II: Design, build, and test a lightweight prototype rolling weight deflectometer that can evaluate the load carrying capacity of any runway. It should be air droppable and capable of reducing deflection data into load carrying capacity of the runway. It is desired that the prototype unit will be a deliverable of the Phase II program for additional government evaluation.

DUAL USE COMMERCIALIZATION: A successful development of a compact and efficient unit will have a multitude of commercial applications in addition to Air Force operations. They can be used to evaluate operations and maintenance on airport runways, roads and bridge systems.

REFERENCES: 1. Bay, J.A. Stokoe, K.H., and Hudson II, W.R., Continuous Highway Pavements Deflection Measurements Using a Rolling Dynamic Deflectometer (RDD), DTIC accession number ADD341143, January 01, 1996.

2. Bush, A. J. and Cox III, B., Evaluation of Laser Profile and Deflection Measuring System, DTIC accession number ADA147630, September 01, 1984.

3. Weil, Gary J., Non-Destructive Testing of Bridge, Highway and Airport Pavements, DTIC accession number ADD335322, June 01, 1993.

4. Johnson, R.F. Bondurant, P.D. Marvin, M.H., Rolling Weight Deflectometer for Quantitative Pavement Measurements, DTIC accession number ADD340177, January 01, 1996

5. Rish, Jeff W., Adcock III, Avery, Tuan, D., Baker, Christopher Y., Welker, Samuel L., and Hugh II, W., Electro-Optical Approach to Pavement Deflection Management, DTIC accession number ADD338748, January 01, 1995.

KEYWORDS: rolling weight deflectometer, NDE of pavements, deflection profiles of pavements, runway

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AF06-113 TITLE: Advanced Detection of Improvised Explosive Devices (IEDs)

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: Develop advanced materials or nondestructive evaluation/inspection technologies that enable the capability to detect improvised explosive devices (IEDs) carried or hidden within motor vehicles.

DESCRIPTION: Recent global events confirm IEDs are being used repeatedly against U.S. military and coalition forces for military and political gain. Explosive materials are frequently carried within vehicles as “car bombs” or “truck bombs”, also known as vehicle-borne IEDs (VBIEDs), that are typically abandoned along roadsides and are detonated by remote control as U.S. or coalition motor vehicle convoys pass it. VBIEDs are also driven by suicide drivers and are detonated as the vehicle approach a stationary checkpoint or other intended target. A VBIED commonly consists of explosive materials placed within the passenger compartment, carried in the trunk, engine or other compartments, or otherwise hidden within or under any part of the vehicle or its components.

In order to maximize the protection of U.S. and coalition forces, it is desirable to provide early detection, identification and advanced warning of an approaching or proximal VBIED with sufficient warning time that permits the ability to take appropriate action at a sufficient distance to protect personnel and other assets. As a “car bomb” or “truck bomb” may be used in a stationary or mobile mode of attack, the proposed technology should be able to address at least one and preferably both of these modes of VBIED attack.

Innovation and creative concepts based on advanced materials and/or traditional or non-traditional non-destructive evaluation/inspection (NDE/NDI) approaches and methods are being sought for the development of VBIED detection capabilities to address the aforementioned need. It is expected that multiple approaches may be submitted in response to this SBIR Program that provide equally viable solutions for the detection of VBIEDs. Novel detection approaches incorporating innovative use of advanced materials and advanced sensing and detection technologies are expected to play a key role in creating this new capability. It is important for potential Offerors to submit proposals that are within the mission structure and core technology areas of the Materials & Manufacturing Directorate (AFRL/ML). A description of ML core technology areas is available at http://www.afrlhorizons.com/. This topic is not intended to be duplicative of related Department of Defense efforts; rather, it is focused on exploiting advanced materials and/or NDE/NDI materials interrogation and characterization technologies that will provide increased performance and capability over various VBIED detection approaches currently available.

The Offeror's proposed capability to address detection of VBIEDs should enable detection, identification, and provide warning of the approaching VBIED at sufficient distances when the detection capability is deployed at a fixed location. Alternatively, the proposed capability could be mounted to a vehicular platform that will accompany a convoy, and would be used to detect and warn against a stationary VBIED as the moving convoy approaches it.

The proposed detection capability should: (1) be safe for use in populated areas and occupied vehicles; (2) enable accurate and rapid detection, identification, and warning of a variety of commonly used explosive materials configured as a VBIED; (3) accomplish vehicle interrogation and detection in real-time or near-real-time such that a timely warning of the approaching VBIED can be provided to the operator; (4) reliably operate under a variety of local environmental conditions (e.g., wind, dust, temperature, humidity, precipitation, etc.); (5) indicate the relative position (or at a minimum, the relative direction) of the VBIED; (6) be reliable such that "false positives" and “false negatives” are minimized; (7) enable detection of the VBIED in a manner that maximizes the separation distance between the VBIED and personnel operating the detection system; (8) minimize the deployment/logistical footprints; (9) minimize adverse impacts to the user’s current operational practices; and (10) be fully operable, usable, and maintainable by a soldier-operator having a basic level of computer or similar skills.

The proposed detection capability would ideally enable: (1) interrogation of the vehicle such that occupants could remain in the suspected vehicle, and with the doors, trunk lid, and hood remaining closed; (2) detection to be accomplished discretely, without the vehicle occupants’ knowledge that the vehicle had been interrogated for the presence of explosive materials; (3) detection that would not utilize an expensive, infrastructure-intensive design that, if in close proximity to the suspected VBIED, could become a high-value target itself; and (4) autonomous operation that provides a clear warning of a VBIED without dependence on operator interpretation or interaction.

It is intended for all advanced technologies developed as part of this SBIR program to be demonstrated in a laboratory environment. No sensitive or classified information will be needed or developed as part of this technology development program. As the program proceeds towards a Phase II Enhancement or Phase III Program and prior to development of an actual fieldable system, security and classification issues will be addressed and a determination will be made at that time relative to program classification, handling procedures, and DD Form 254 applicability in accordance with existing AF security Policies. The Phase I and Phase II Programs WILL NOT involve classified information.

PHASE I: Demonstrate the feasibility of utilizing advanced materials and/or NDE/NDI technologies to detect, identify and locate moving and/or stationary “car bomb” and “truck bomb” VBIEDs. The conceptual system should be identified as well as how advanced, high performance materials and/or advanced NDE/NDI technologies will enable and/or enhance detection capability.

PHASE II: Develop and integrate the advanced materials and/or NDE/NDI technologies into a prototype VBIED detection capability. Demonstrate VBIED detection performance and limitations in a laboratory environment. Detection performance shall be accomplished as a “best effort” without regard to predetermined objectives.

PHASE III DUAL USE APPLICATIONS: The Department of Homeland Security has identified as a priority the need to detect VBIEDs hidden in the vicinity of transportation hubs and other domestic infrastructure, creating the opportunity to transfer the developed technology to the civil sector. The actual technology developed may also have applications to advanced NDE/NDI of complex structural systems.

REFERENCES: 1. S. Doctor, Y. Bar-Cohen, and A. E. Aktan, editors, "Nondestructive Detection and Measurement for Homeland Security," San Diego, CA, Proceedings of SPIE, Vol. 5048, 4-5 March 2003.

KEYWORDS: bomb detection, explosives detection, car bomb, improvised explosive device (IED), IED detection

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AF06-114 TITLE: Improved Manufacturing Technology for Investment Casting Cores

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: Explore and demonstrate innovative manufacturing technologies that reduce the cost of core manufacturing in investment casting processes for complex turbine blades.

DESCRIPTION: The offeror is encouraged to examine processes associated with the manufacture of cores used in investment casting of advanced turbine blades. Advanced engines are making use of complex cavity designs to provide unique cooling schemes in turbine blades. The cooling schemes include complex cavity shapes with tight tolerances, thin walls, and multiple walls. Core materials, design, coatings, fabrication, placement in tooling, survival of metal pouring, removal and process yield are all key aspects affecting cost, cycle time and performance of advanced turbine blades. The offeror shall develop innovations that will reduce core manufacturing cost and cycle time. These innovations should be generic enough to be applicable to the greatest possible number of Air Force engines. The offeror shall demonstrate the engineering, manufacturing and economic feasibility of the innovation to produce the targeted engine component(s) by specifically addressing the high cost and long cycle time elements of the current manufacturing method. Additionally, a detailed process assessment shall be made to document the potential of the innovation to reduce cost, cycle time, and process yield. An initial commercialization plan shall be developed and a business case established to quantify future investments, including equipment changeover and/or qualification expenses. Commercialization plans and qualification requirements shall be established to offer these new techniques to the aerospace industry for production, transition, and qualification in Phase III.

PHASE I: Demonstrate the feasibility to produce economically and superior quality cores for advanced turbine blade castings. Prototype cores and/or core structures shall be produced and characterized to demonstrate the feasibility of the innovation.

PHASE II: Demonstrate that the innovation selected will reduce cost and cycle time while improving quality. Tooling and processes to produce full-scale prototypes will be described and demonstrated to establish process reproducibility under relevant production conditions. The potential cost savings and cycle time reductions of the demonstrated processes shall be validated.

DUAL USE COMMERCIALIZATION: The developed technologies will have applications for both military and commercial engines.

REFERENCES: 1. Investment Casting, Perer R. Beely and Robert F. Smart (Eds.), London, Institute of Materials, 1995.

2. M. Donachie Jr. and S. Donachie, Superalloys: A Technical Guide, Materials Park, OH, ASM International 2002.

3. Investment Casting Institute, Standard Test Procedures for Pattern Materials, 1999.

KEYWORDS: Casting, manufacturing, titanium, superalloys

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AF06-115 TITLE: Improved Manufacturing Technologies for Polymer Matrix Composite Engine Components

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: Investigate and demonstrate innovative manufacturing technologies that reduce the cost of polymer matrix composites as they relate to military engine components.

DESCRIPTION: The offeror is encouraged to examine processes associated with the manufacture of polymer matrix composites as they relate to military engine components. Advanced engines are planning the increased use of polymer matrix composites to reduce the weight and increase the engine thrust to weight ratio. However, the cost of polymer composites can be prohibitive especially when considering hand layup in some of these engine applications. The innovative manufacturing approaches must significantly reduce the acquisition cost of polymer composite engine components so they are cost comparable to alternate metal designs. The offeror shall consider innovations that will reduce both manufacturing cost and cycle time. These innovations should be generic enough to be applicable to the greatest possible number of Air Force engines. The offeror shall demonstrate the engineering, manufacturing and economic feasibility of the innovation to produce the targeted engine component(s) by specifically addressing the high cost and long cycle time elements of the current manufacturing method. Additionally, a detailed process assesment shall be made to document the potential of the innovation to reduce cost, cycle time, and process yield. An initial commercialization plan shall be developed and a business case established to quantify future investments, including equipment changeover and/or qualification expenses. Commercialization plans and qualification requirements shall be established to offer these new techniques to the aerospace industry for production, transition, and qualification in Phase III.

PHASE I: Demonstrate the feasibility of their innovation to produce economically and superior quality polymer matrix composites as they relate to military engine components. Prototype structures shall be produced and characterized to demonstrate the feasibility of the innovation.

PHASE II: Demonstrate that the innovation selected will reduce cost and cycle time while improving quality. Tooling and processes to produce full-scale prototypes will be described and demonstrated to establish process reproducibility under relevant production conditions. The potential cost savings and cycle time reductions of the demonstrated processes shall be validated.

DUAL USE COMMERCIALIZATION: The developed technologies will have applications for both military and commercial engines.

REFERENCES: 1. Sanjay K. Mazumdar, Composites Manufacturing: Materials, Product and Process Engineering, Boca Raton, FL: CRC Press 2002.

2. A.G. Bratukhin and V.S. Bogolyubov (Eds.), Composite Manufacturing Technology, London: Chapman and Hall, 1995.

3. P.K. Mallick (Ed.), Composites Engineering Handbook, New York: M. Dekker, 1997.

KEYWORDS: polymer, composites, manufacturing

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AF06-116 TITLE: Corrosion Prediction for Nonchrome Based Coatings Systems

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a degradation model for nonchromate containing aircraft coating systems, which can be used to predict the service life of the coatings and the onset of substrate corrosion.

DESCRIPTION: Military aircraft coatings systems are multifunctional, providing appearance, signature and barrier properties to the aircraft. The aircraft coatings experience combined stress from ultraviolet (UV) light, moisture and temperature and pollutants in the air such as chlorides and nitrates. Exposure of coating systems to environmental and operational stresses leads to chemical and physical changes, which alter the mechanical properties, and eventually result in coating degradation followed by corrosion of the substrate. Typical US Air Force aircraft have a multilayer coating system comprised of a chromate conversion coating, an epoxy primer (containing chromates such as strontium chromate) and a polyurethane topcoat. Chromates present in the pretreatment and primer provide excellent corrosion protection to the substrate.

As long as the chromates are present in the pretreatment and primer, the topcoat barrier properties are not critical for corrosion prevention. The hexavalent chrome present in the coating system, however, is carcinogenic and requires substantial maintenance costs for hazardous waste disposal. DoD wide, nonchrome paint systems are being used or considered more widely. Both nonchrome pretreatments and primers have been developed to replace hexavalent chrome containing materials. In the absence of chromates, the barrier properties of the topcoat may play a more significant role in protecting the aircraft structure from corrosion. Research is sought to model the performance of non-chrome containing aircraft coating systems. The model should incorporate the effects of environmental stresses on coating degradation, estimate service life as a function of service environment, and estimate the onset of substrate corrosion. The model should be validated with appropriate field experiments.

PHASE I: A commercially available nonchromium based coating system shall be identified for analysis. Critical corrosion and combined stress factors shall be identified and analytical models developed to predict their performance. Laboratory testing on the identified system will verify model predictions.

PHASE II: A nonchrome coating system service life/corrosion prediction model will be developed based on the laboratory testing of multiple nonchrome systems, and field validation. The product from Phase I would be further developed to include the effects of all primary environmental stresses. Service data should be used where applicable to verify model results.

DUAL USE COMMERCIALIZATION: Models developed under this effort should have extensive government and commercial applications. Protection of structural and nonstructural elements exposed to corrosive environments is of key concern in transportation, construction, and electronics industries.

REFERENCES: 1. Gordon P. Bierwagen, “Reflections on corrosion control by organic coatings," Progress in Organic Coatings, 28, 1996, p. 43-48.

2. L.B. Reynold, R. Twite, M. Khobaib, M.S. Donley and G.P. Bierwagen, Progress in Organic Coatings, 32, 1997, p. 31-34.

3. J. W. Martin, S. C. Saunders, F. L. Floyd, and J. P. Wineburg, “Methodologies for Preicting the Service Lives of Coating Systems,” NIST Building Science Series 172, 1994.

KEYWORDS: corrosion, prediction, nonchrome, coating

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AF06-118 TITLE: Resistant Coatings for Metal Turbine Blades

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop advanced erosion resistant coatings for turbine blades.

DESCRIPTION: Operation in arid environments presents a challenge to modern aircraft engines. Sand ingestion causes severe erosion resulting in high engine maintenance costs and reduced efficiency. One method to mitigate the problem is the use of resistant coatings on fan and compressor blades. Erosion is of great concern for fighters as current designs use blisk technology where the blade and disk are one structural unit. Therefore, severe wear on the blades will cause significantly greater maintenance issues than legacy aircraft. Current thin film resistant coatings are based on physical vapor deposition techniques using multilayer structures. These films are thin, 5 to 10 micron, because of residual stress buildup which can make the coating spall. Tremendous strides in physical vapor deposition (PVD) techniques and coatings have been made over the past 10 years. This program seeks to identify new PVD coatings for erosion resistance. Of primary importance is adhesion to the surface, coating toughness, and stress control (to allow thicker coatings). Also, the coatings cannot cause increased fatigue in the blisk.

PHASE I: Demonstrate the feasibility of a PVD coating for steel and titanium alloys. Focus on coating toughness, adhesion and thickness. Verify coating performance with level erosion tests and thermal cycling. Validate coating mechanical properties/performance at temperatures up to 600 degrees C.

PHASE II: Fully develop and optimize the PVD coating system. Apply a PVD coating to selected aircraft subcomponents for erosion evaluation in an engine test. Scaleup the process for manufacturing. Evaluate the economic feasibility (initial costs and replacement costs) for inclusion of the coating technology on flight hardware.

DUAL USE COMMERCIALIZATION: Erosion resistant coatings have application to other Air Force systems including legacy aircraft. This technology is also useful for aircraft and helicopters of other DoD agencies.

REFERENCES: ASM Handbook Vol.18, "Friction, Lubrication and Wear Technology," 1992, pg. 199, 1992.

KEYWORDS: jet engines, compressors, fans, coatings, physical vapor deposition, adhesion, erosion, wear resistance, high temperature.

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AF06-119 TITLE: High Temperature Sensors for In Situ Interrogation of Damage States in Structural Materials Components

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop durable sensing technologies that enable interrogation of either material damage state or parameters (temperature, speed, etc.) essential for life management of turbine engine components.

DESCRIPTION: Current life management of aerospace gas turbine engine components is typically based on expensive and time consuming nondestructive inspections (NDI) at fixed cycle and/or time intervals. Since the actual operation is expected to be different for each aircraft even within the same unit and the material behavior is inherently probabilistic in nature, NDI based on current state of damage as opposed to fixed cycle or time intervals will be more efficient. The estimation or prognosis of the current damage state requires reliable sensors that can provide damage (e.g. cracks, damage precursors, etc.) or loading (e.g. temperature, vibration, speed etc.) signatures at various locations in the engine [1-3]. The implementation of these in situ sensors coupled with prognostic systems will enable advanced and efficient life management practice and increased time-on-wing [1-3]. Recent investigations [4] have shown the applicability and advantages of continuous monitoring of structural response and thermal loading conditions using various types of sensors. Ideally, a network of sensors could be located such that damage at various locations is monitored during system operation. These local and global sensing technologies could be based on active and/or passive interrogation. Sensors are sought for components and locations with different temperature capability requirements: 500 degrees to 1500 degrees F for rotating disks and 1300 degrees to 1500 degrees F for near-blade locations. The deliverables of this program include reliable and durable sensors for in situ monitoring of damage states and validated signature analysis and prognosis methods to predict the remaining life of structural components in near- or actual-vehicle operating environments. Since the implementation of such advanced prognosis systems requires integration with the operation of the engines, close technical collaboration with original equipment manufacturers (OEMs) is strongly recommended in all phases.

PHASE I: Identify and/or develop low-power sensor technologies that will enable quantification of degradation states, failure modes, and usage conditions of structural components. Demonstrate the feasibility of using these sensors for materials damage prognosis in a simulated operating environment.

PHASE II: Develop and demonstrate sensor technologies to quantify damage in components under simulated gas turbine engine operational conditions. Demonstrate sensor durability, low false-alarm rate, ability to track material and/or structural damage states, and ability to predict remaining life capability through prognostic methods. Delivery of a prototype system for further evaluation is encouraged.

DUAL USE COMMERCIALIZATION: Commercial benefits include improved life management of turbine engine and/or airframe components for commercial aircraft.

REFERENCES: 1. Christodoulou, L. and Larsen, J.M., "Using Materials Prognosis to Maximize the Utilization Potential of Complex Mechanical Systems," Journal of Materials, Vol. 56, No. 3, pp. 15-19, March 2004.

2. Cullinane, W.F. and Strange, R.R., "Gas Turbine Engine Validation Instrumentation: Measurements, Sensors, and Needs," Proceedings of SPIE, Vol. 3852, Harsh Environment Sensors II, Editor: Anbo Wang, SPIE, Bellingham, WA, pp. 2-13, December 1999.

3. Hess, A., "The Joint Strike Aircraft Prognostics and Health Management," 4th Annual Systems Engineering Conference, 22-25 October 2001. Available at http://www.dtic.mil/ndia/2001systems.

4. Russ, S. M., Rosenberger, A. H., Larsen, J. M., Berkley, R. B., Carroll, D., Cowles, B. A., Holmes, R. A., Littles, J. W., Jr., Pettit, R. G., and Schirra, J. J., "Demonstration of Advanced Life-prediction and State-awareness Technologies Necessary for Prognosis of Turbine Engine Disks," Health Monitoring and Smart Nondestructive Evaluation of Structural and Biological Systems III, Proceedings of SPIE, Vol. 5394, Editor: Tribikram Kundu, SPIE, Bellingham, WA, pp. 23-32, July 2004.

KEYWORDS: damage, durability, engine, high temperature, in situ, life management, prognosis, sensor

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AF06-120 TITLE: Manufacturing Structures in a Limited Production Environment

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop tools and techniques to enable fast, affordable manufacture of aircraft structures for small production runs.

DESCRIPTION: With the advent of spiral development for military weapon systems, the trend for military production runs appears to favor small lot sizes. Spiral development offers the chance to field a limited initial capability. Subsequent lots can spiral in advances in technology to improve warfighting capability. Today, structures are not seen as a technology that can be spiraled in as technology improves. The structure is seen as the basic building block of the weapon system that will not change throughout its life. This is due to many factors such as high up front costs for tooling and prohibitive costs to recertify a structure for flight if significant changes are made.

Innovative approaches are needed to put the structure in play for spiral development as technological improvements for structures offer reduced weights, lower costs, or shorter manufacturing cycle times for subsequent cycles. These approaches can look across many areas. Areas of interest include but are not limited to: 1.) rapid design and manufacturing approaches to building and assembling airframe structures to military specifications; 2.) low cost, flexible tooling. This tooling needs to be as durable as invar tooling. It should also offer precision control for aerospace manufacturing tolerances and military aircraft performance requirements that invar tooling offers; and 3.) rapid, efficient demonstration of flight safety of the airframe.

PHASE I: The contractor shall identify candidate tools and techniques for enabling spiral development of aircraft structures and demonstrate their feasibility.

PHASE II: It is expected that the small business will team with an airframe parts manufacturer for Phase II, although Phase I interaction with a manufacturer is highly encouraged. The contractor shall demonstrate the applicability of their tools and techniques to the aircraft structures manufacturing environment.

DUAL USE COMMERCIALIZATION: The Navy and Army have similar applications in shipbuilding, rotorcraft, and ground vehicles. Commercial applications include heavy earthmoving equipment, exotic automobiles, recreational sporting industry, commercial aircraft and ship building.

REFERENCES: 1. Wanthal, S. and Butler, B. “The Composites Affordability Initiative-Phase 3 Update.” Society for the Advancement of Material and Process Engineering, 35th International Technical Conference, Dayton OH, September 2003.

KEYWORDS: spiral development, manufacturing, structures, assembly, tooling, design, certification

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AF06-121 TITLE: Graphical User Interface for Fire Modeling Codes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a graphical user interface (GUI) for scenario development, processing and post processing major existing fire modeling codes for improved usability by fire research and engineering personnel.

DESCRIPTION: Fire modeling has been used to evaluate fire spread and damage for a wide variety of applications of Air Force interest. These models have been used to design and evaluate key aircraft structures and air base facilities, they have also been used to determine sources of accidental fire damage and evaluate fire extinguishing agents and techniques. At present these codes are difficult to use and require an extended training period before they can be successfully applied. The GUI should provide a method of importing 2D and 3D CAD models of structures and other key fire environments including pool and spray fires and converting these models for actual model computation. The GUI should also allow the user to operate the modeling software in interactive or batch modes in desktop and parallel processing environments. The following government developed codes should be supported at a minimum: CFAST , FDS , both from NIST. Support for additional software codes including VULCAN and FUEGO from Sandia National Laboratory would be preferred. It is also desired to provide desktop and high performance computing interfaces to permit for FDS permitting installation in a multiprocessor environment under an MPI scheme.

PHASE I: Evaluate fire modeling codes and interface requirements for developing modeling scenarios and for connecting the fire scenarios with the models. Demonstrate an interface that can be used on an Intel PC platform under both Windows 2000 or later and X-Windows in UNIX related operating systems.

PHASE II: Fully develop the GUI and implement scenario generation, model execution and post processing routines. Provide interactive and batch mode control/execution interfaces for the minimum case models. Provide an Application Programming Interface to permit ready implementation of other codes. It is desired that initial software be delivered at the end of the effort for further government evaluation.

DUAL USE COMMERCIALIZATION: Easily used fire modeling software would enhance both commercial and defense fire protection engineering permitting effective application of modern “performance based” fire protection codes and standards.

REFERENCES: 1. Jones, W. W., et al, Technical Note 1431, A Technical Reference for CFAST: An Engineering Tool for Estimating Fire and Smoke Transport, National Institute of Standards and Technology Building and Fire Research Laboratory Gaithersburg, MD 20899, April 2003

2. Smokeview/FDS Version 4.0, http://fire.nist.gov/fds/svtest. NISTIR 6784, 2003 Ed.

3. Fire Dynamics Simulator (Version 4) – User’s Guide, Fire Research Division Building and Fire Research Laboratory, National Institute of Standards and Technology Building and Fire Research Laboratory Gaithersburg, MD 20899, November 2003.

KEYWORDS: fire modeling, software

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AF06-123 TITLE: Analytical Techniques for Complex Logic Devices in Safety-Critical Applications

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop robust techniques to verify and validate the functionality and reliability of complex logic devices for safety-critical applications.

DESCRIPTION: Due to the strong potential for rapid fielding of weapon systems, hardware miniaturization, increased computational capacity and a significant decrease in parts obsolescence a significant increase in the use of high density (10 million plus gates) reprogrammable logic devices for Safety-critical and safety-related weapon system applications (i.e., cockpit reprogrammability, suspension and release equipment (S&RE), electronic safe and arm devices [ESADs] etc.). Implementing systems for air-delivered conventional weapons and platforms into these high density complex logic devices posed challenges to safety analysis and approval process. Industry has been adopting the Radio Technical Commission for Aeronautics (RTCA) DO-254 standard, entitled “Design Assurance Guidance for Airborne Electronic Hardware" as the required analysis and documentation for safety critical hardware devices in conjunction with RTCA DO-178B standard for software. DO-254 was developed by the avionics industry to establish hardware deployment guidelines for developers, installers, and users, when microcomputer hardware, including Field Programmable Gate Array (FPGAs), Programmable Logic Devices (PLDs) and Application Specific Integrated Circuits (ASICs) are deployed in weapon and aircraft equipment designs. Simulation based techniques (using test vectors) as well as formal methods are mature for hardware verification and validation; however significant research is still needed for dense complex reconfigurable hardware. Formal methods of verifying and validating models in C-language and Very High-Speed Integrated Circuit Hardware Description

Language (VHDL) are readily available, however, formal methods/techniques are not available to verify and validate similar designs created by higher level tools once they are implemented in reconfigurable hardware. Formal methods used for software verification and validation may be applicable to reconfigurable hardware. Innovative techniques and approaches for verifying and validating the functionality and reliability of reconfigurable hardware are needed. New design tools (Viva, Celoxica, Clearspeed etc…) have significantly enhanced capability to design and implement complex high density reconfigurable circuits and computationally intense algorithms into programmable logic devices. Techniques to verify and validate such complex designs and insure that they meet safety-critical requirements have not kept pace with the design tools. The recently released, Society of Automotive Engineers (SAE) Architecture Analysis & Design Language (AADL) Standard # AS5506, for modeling and analyzing embedded systems may be useful for this research effort. This standard defines a language for describing both the software architecture and the execution platform architectures of performance-critical, embedded, real-time systems. An XML based resource (processors, memory, interface, intellectual property core, algorithms etc…) description language may also be useful. Phase I, investigate alternative techniques and approaches to verify and validate intellectual property (IP) cores both hard and soft (processors, memory, interface, algorithms etc…) implemented in reconfigurable hardware perform as specified. Techniques and approaches should be compatible with commonly available design tools from vendors such as Xilinx, Mentor Graphics and Synplicity to name a few. In Phase II develop and demonstrate a prototype tool environment based on the most promising alternatives investigated and defined in Phase I.

PHASE I: Investigate alternative techniques and define approaches to verify and validate reconfigurable hardware based systems reliably perform as specified.

PHASE II: Develop and demonstrate a framework environment based on the most promising alternative investigated and defined in Phase I.

PHASE III DUAL USE APPLICATIONS: Commercial applications include commercial airliners, trains and mining equipment. Military applications include air-delivered conventional weapon, jets and bombers.

REFERENCES:

1. Munitions Directorate, Http://www.mn.afrl.af.mil

2. Radio Technical Commission for Aeronautics (RTCA) DO-254 Standard, Http://www.DO254.com

3. Society of Automotive Engineers, Standard AS5506, http://www.sae.org

4. SAE AADL Information Site, http://www.aadl.info/

5. Specication-driven Validation of Programmable Embedded Systems, http://www.cise.ufl.edu/~prabhat/Publications/mishraThesis.pdf

KEYWORDS: reconfigurable systems verification, safety-critical, fuzes, ASIC, FPGA, RTCA DO-254, RTCA DO-178B, AADL

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AF06-124 TITLE: Air Target Sensor Techniques for Automatic Target Recognition (ATR)

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Investigate the use of RF waveforms as well as signal processing and Doppler exploitation techniques for air targets. The techniques developed should address issues like clutter cancellation, innovative phenomenology of waveform and/or signal processing for exploring Automatic Target Recognition techniques for application to future air-to-air missiles.

DESCRIPTION: Major strides have been accomplished in lowering the cost and manufacturing of RF components and materials in the development of transmit/receive (TR) modules, direct digital synthesis, and signal processing techniques. The cost of energy efficient electronically steered antenna (ESA) apertures and output power of TR modules have made it possible for development of low cost effective ESA seekers for air-to-air applications to be investigated. Most of the ESA TR module-based sensors lend themselves to natural applications of multi-channel radar seeker systems. The use of waveform diversity, multi-channel sensor and Space Time Adaptive Processing (STAP) techniques provide a great capability for exploring the benefits for use in ATR, and clutter canceling techniques for applications for countering small air targets flying low to the ground. This topic encompasses exploring the utilization of new digital waveforms, munition based multi-channel AESA, and adaptive digital signal processing for clutter canceling, generating target signature phenomenology and for use in Automatic Target Recognition of air targets. Techniques must be feasible in the presence of electronic countermeasures. Research efforts should include novel methods of applying the new techniques and for generating research into possible munition applications. Derivation of techniques as well as modeling and simulation will be conducted to include expected performance of techniques developed. Analysis will focus around the requirements of waveform and signal processing techniques that lend themselves to attaining possible target signatures and phenomena that could be characterized and used for ATR applications. An analysis will be conducted for determining possible surrogate system and/or development of hardware and signal processing techniques for a demonstration that will assess the performance gained with the ATR techniques on air targets. A possible demonstration could be conducted for assessing performance. A final report detailing possible benefits and candidate techniques developed for applications will be delivered. The report will also include a plan for implementation and/or demonstration, and.will include the expected development and applicability of implementation for a demonstration.

PHASE I: Study the various waveform and adaptive signal processing techniques for air target sensors and possible exploitation of signature for mitigating clutter, and applications for ATR approach for air targets.

PHASE II: Demonstration of derived techniques from Phase I using computer modeling and simulations. A level of effort should also be conducted on demonstrating clutter mitigation and ATR signature benefits. Address implementation and or incorporation into existing surrogate system for demonstration.

PHASE III DUAL USE APPLICATIONS: These waveform and adaptive processing digital processing techniques have direct application to homeland defense, and air borne UAV collision avoidance. This technology is critical to the development of advanced military munitions, asymmetric warfare, and aircraft radar systems.

REFERENCES:

1. Nilubol, Chanin, Pham, Quoc H., Mersereau, Russell M., Smith, Mark J.T., Clements, Mark A, "Translational and Rotational Invariant Hidden Markov Model for Automatic Target Recognition," SPIE vol. 3374 (Apr. 1998).

2. Antonik et al., "Intelligent Use of CFAR Algorithms", AD-A267 755/7/XAB, Kaman Sciences Corp., Utica, N.Y. May 1993.

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Keywords: HRR, ATR, automatic target recognition, range Doppler processing, automatic target algorithms

KEYWORDS: HRR waveform, ATR, automatic target recognition, range Doppler processing,clutter canceling STAP algorithm, multi channel ESA radar, automatic target detection

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AF06-125 TITLE: Miniature Wide Band Power Amplifiers for Miniature Munitions

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop low cost and reduced sized power amplifiers to be integrated into a miniature weapon.

DESCRIPTION: There is a continuing trend in today's electronics market for compact packaging. Conventional weapons are becoming smarter and smaller in an effort to increase accuracy and minimize collateral damage. Future systems will employ a data link that can provide such information as targeting updates, bomb damage information, location, and health status. The weapon will have improved standoff ranges leading the weapon data link to require greater power output in a reduced package to fit in the smaller munition. This leads to the need for a low cost and easily manufactured miniature power amplifier. The power amplifier needs to be robust to withstand high thermal operating environments. General requirements for a new reduced-size power amplifier: a) less than 25 cubic inches; b) operating frequency range from at least 225 MHz to 2 GHz; c) threshold power output of 25 to 50 Watts; d) method of dispersing excess heat. The ability to trade power output, size, and still be able to disperse heat for the weapon’s flight time needs to be investigated. Project effort can be enhanced by working with a weapon prime manufacturer to introduce weapon realistic environmental conditions to be added to a modeling effort and looking towards Phase III.

PHASE I: Investigate state of the art or potential candidate wide band gap materials for coverage of the frequency range. Develop path to show approach to meeting 25 cubic inch form factor and have output power at the antenna between 25 and 50W.

PHASE II: Demonstrate with breadboard electronics or better the approach developed in Phase I to meet the general goals stated above. Testing in a laboratory environment to show operation over the desired frequency range and power level out. Modeling of the potential hardware design to show size and thermal heat dispersal.

DUAL USE COMMERCIALIZATION: Small, wide frequency range power amplifiers are needed for commercial communication radios for law enforcement. Besides weapons, the AF, Navy, and Army have requirements for radios for numerous platforms - handhelds, UAVs, and aircraft, all of which could be potential users for a small, low cost power amplifier with an output of 25-50 Watts.

REFERENCES: 1. ADA321667 “On the Possibility of Harmonic Operation of Cyclotron Wave Parametric Amplifiers”, 28 FEB 1997, Wallace M. Manheimer

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3. ADB011607 “FET Power Amplifier”, APR 76, Wisseman, W. R.; Adams, R. L.; Macksey, H. M.; Sokolov, V.; Tserng, H. Q.

4. ADP006987 “The Future Role of Semiconductor Optical Amplifiers”, 22 MAY 92, Marshall, I. W.

KEYWORDS: Power Amplifier, Wide Band gap materials, Munition, wide frequency band, broad band

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AF06-126 TITLE: Airframe Materials for Hypersonic Tactical Missiles

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop low cost materials and fabrication technologies for hypersonic (Mach 5 to 8) tactical missiles.

DESCRIPTION: A need exists to significantly increase our capability in tactical, air-to-ground missile systems. There is a desire to vastly increase the range capability of future missiles while keeping the time to target low. Meeting all these requirements will place a large burden on the airframe design. Long-range requirements drive the external vehicle shape to high lift-to-drag airframe configurations. The low time-to-target requirement means the missile will need to accelerate quickly and then maintain high-speed flight. These requirements will drive the airframe configuration to be lightweight yet capable of retaining very high strength while at high temperature. Standard high temperature metal alloys such as nickel-steel or columbium-based alloys have too high a weight penalty to be used. Existing coated carbon matrix composite, ceramic, or graphite-polyamide materials have the potential to meet the needs of advanced missiles; however, innovative advances must be made to make these materials affordable for tactical missile use. Whatever material is pursued, it must be suitable to low-cost processing and part manufacturing.

PHASE I: Identify and define candidate materials and/or material processing techniques for high strength applications at temperatures experienced during hypersonic flight (Mach 5 to 8) for minimum 15-minute flight duration. Materials shall be evaluated through analysis and/or test of small specimens.

PHASE II: Demonstrate the benefit of the material concept generated in Phase I by fabricating, processing, and characterizing an airframe structural component or subcomponent such as a fuselage section, wing, or control fin.

PHASE III DUAL USE APPLICATIONS: Demonstration of a lightweight, high strength, high temperature material suitable for structural applications will have a large variety of uses in the aerospace industry. Such materials can be used for aircraft and missile fuselage, wing, and tail surfaces. Potential applications would also be in high temperature regions of commercial aircraft engines and commercial space launch vehicles.

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1. Fleeman, E.L., Licata W. H., Berglund, E., "Technologies for future precision strike missile systems,", NATO Research and Technology Organization Lecture Series, RTO-EN-018, June 18-29, 2001. (ADA394520)

2. Douglas, Mitchell; Lindgren, John, “Hypersonic weapons technology for the time critical mobile ground threat”, DMSTTIAC-SOAR-99-01, January 1999. (ADA361137)

KEYWORDS: high temperature materials, carbon-carbon composites, polymer-matrix composites, hypersonic, missile airframe

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AF06-127 TITLE: Techniques for Remotely/Autonomously Detecting and Destroying Chem/Bio Agents

TECHNOLOGY AREAS: Chemical/Bio Defense, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology, enhanced with nano-technology, to remotely and autonomously, detect and neutralize chemical and biological agents.

DESCRIPTION: Recent advances in chemical and biological (chem/bio) sensors devices, especially those that can detect more commonly used threat agents on the nano-scale level, are making possible a new generation of chem/bio sensors. This technology has been demonstrated in commercial chemical sensor devices that recognize agents by their molecular make-up, commercial biological sensor devices that recognize the DNA sequence of agents, and such sensors that have been enhanced with the use of nanotechnology to significantly improve their sensitivity, selectivity, response time, and affordability. The current effort would use existing technology to develop a device, enhanced with nano-technology that has revolutionary chem/bio detection performance, and has the additional capability of neutralizing both chem/bio agents. A detection system, designed on the nano-scale, will significantly increase the accuracy in the selecting correct agents (>95% probability), while reducing the frequency of false alarms (<5% probability). Ideal techniques for neutralization in the device, like the use of catalytic materials against chemical agents, should be relatively benign to humans and the environment. The use of new mechanisms to neutralize both chem/bio agents is highly encouraged. These devices need to be able to collect the detected agent, possibly with high surface area templated absorbents, and present it, maybe by suctioning it, to the neutralizing system in the device. The device should also be autonomous, inexpensive, be miniaturized, be able to monitor surroundings, operate in real time (milliseconds), have low power consumption, be redundant, and be deployable for use in highly threat environments. The device should be intelligent with information processing electronics and have a communication capability easily accessible to operators. With an Air Force goal to deploy autonomous devices that significantly reduce collateral effects, the development of this technology will offer an “all-in-one” ideal solution for detection and neutralization in chem/bio targets.

PHASE I: Further identify the key requirements for a device that will detect, monitor, collect, and deactivate agents. Evaluate the neutralization of simulant agents, develop techniques that fulfill requirements, and develop the hardware.

PHASE II: Develop a production–scalable process to implement the device identified in Phase I. Evaluate this device for its ease of manufacture. Conduct long term reliability testing to measure effectiveness.

PHASE III DUAL USE APPLICATIONS: The sensor/neutralizing device developed for the Department of Defense is equally applicable for use as a commercial air purification system.

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2. https://intranet.munitions.eglin.af.mil/index.html

KEYWORDS: Agent detection, entrapment, deactivation, neutralization, chemical/biological agent

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AF06-128 TITLE: Modeling and Simulation of Biological Agent Response to Combustion Effects

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Investigate combustion neutralization technologies for biological agents; develop a model compatible with existing lethality assessment codes.

DESCRIPTION: Weapons directed at enemy stores of chemical and biological agents can cause extreme collateral damage by venting live chemical and biological (chem/bio) agents from broken containers in to the surrounding area. This is severely hazardous for friendly forces, noncombatants, and the surrounding environment. An Agent Defeat weapon is specifically designed to cause substantial damage to the target, while minimizing collateral damage. Recent advances in the development of agent defeat weapons have shown that High Temperature Incendiary (HTI) devices are an ideal solution. While causing minimal damage to the exterior of target, HTI weapons depend on their extremely high temperatures to inactivate vented threat agents within the target. Currently, the defeat of biological agents is considered the most serious challenge. Most of the published research on thermal inactivation of agents has been connected with food preservation, biological agent inactivation in liquid media at temperatures less than 120 Celsius for heat exposure times of minutes to hours, and heat inactivation of biological agents in gas-flows at only ten milliseconds or greater. The current effort would be to investigate, validate, and develop a lethality model that correctly estimates the neutralization of biological agents due to combustion, and not just thermal diffusion. Develop a research plan that investigates the combustion of biological agents and includes a series of testing.

Since the effect of heat on spores ranges from recoverable injury, to thermal kill, up to incineration at very high temperatures in the presence of oxygen, it would be very useful to collect test data that show the required the temperatures and time boundaries between each of these processes. To replicate characteristics of a bomb explosive environment, document the effects of the composition of the gas environment surrounding the agent during each of these processes. It would be useful to gather test data that shows the required high temperatures needed to neutralize biological agents in from hours, to minutes, to less than ten milliseconds. In parallel, based on allthe test data gathered, create new or modify existing computer codes to model biological agent combustion, with respect to agent neutralization.

PHASE I: Evaluate all identified research for phenomenology and efficacy of biological agent neutralization. Evaluate all identified models for their ability to accurately assess biological agent combustion, with respect to neutralization. Perform combustion tests on biological agents for the purpose of collecting data for use in modeling all aspects of the combustion of biological agents and deliver test data.

PHASE II: Use test data from Phase 1 to develop a biological agent combustion model suitable for use with or in existing lethality assessment codes. Coordinate with responsible assessment code agency to ensure suitability and compatibility of combustion model with these codes. Conduct reliability testing to measure effectiveness.

PHASE III DUAL USE APPLICATIONS: Biological combustion models of this type would be of use not only to the Department of Defense, but also to organizations such as the Department of Homeland Security or commercial decontamination Companies.

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3. Chemical Weapons: Better Management Tools needed to Guide DOD’s Stockpile Destruction Program, GAO-04-221T, October 30, 2003

4. Chemical Weapons: Lessons Learned Program Generally Effective but Could Be Improved and Expanded, GAO-02-890, September 10, 2002

KEYWORDS: Biological and Chemical Agents, Combustion, Burning, Decontamination, Neutralization, Computer Modeling

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AF06-130 TITLE: Improved Omnidirectional Multiband Antenna for Miniature Munitions

TECHNOLOGY AREAS: Electronics, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an antenna capable of use over multiple frequencies.

DESCRIPTION: The antenna system will be affordable and suitable for high data rate applications with weapon data links. The antenna should be capable of providing simultaneous communication of various frequency ranges within the UHF band, be structurally integrated on the airframe, and be compatible with the weapon data link. Current smart weapon concepts incorporate weapon data links to provide health status and bomb damage information (video or data) back to the aircraft. There is a trend towards making smaller smart weapons to increase attack accuracies, resulting in limiting collateral damage. General requirements for a multi-band antenna for munition applications covering both missile and bomb type airframes should be: a) its size will need to be minimized and conformal to both missile and bomb body; b) the antenna should be omni directional; c) heat dissipation must be adequate; d) novel antenna should operate at improved levels of efficiency; e) it should operate within 200 to 1206 MHz. Analysis will cover dome material and expected electromagnetic properties and ground plane effects. Validated simulations should be used to predict efficiency, effective gain, voltage standing wave ratio (VSWR), bandwidth coverage, and insertion loss. Analysis or simulation on the predicted performance of the antenna design will be conducted. Several antennas will be fabricated and tested in RF chamber to measure the performance and compare to prediction. Analysis or simulation will be conducted to predict estimated range capability given a certain signal to noise and transmitter power. A final report will be written to include test results and an update to the antenna design.

PHASE I: Analysis will be conducted in determining the type of antenna needed for conformal adaptation to the munition aeroshell with minimum interference and degradation of omni coverage.

PHASE II: 1) Define the objective antenna material specification and conduct limited testing on the materials and subsystems for fabricating several antennas. 2) Establish expected performance of antenna through experiments and fabrication and testing of prototype antenna.

PHASE III DUAL USE APPLICATIONS: Military application: Military applications include munition data links, unmanned air vehicle data links, and wireless communications. This technology has an industrial use in wireless information communications. Applications could include hand held computer devices, automobile communications, and mobile computer networking.

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3. Gong et al., "Characterization of Cavity-Backed Conformal Antennas and Arrays Using a Hybrid Finite Element Method with Tetrahedral Elements", The University of Michigan, Ann Arbor, Michigan, 1992, pp. 1629-1632.

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KEYWORDS: Antenna, Multi-band, UHF, Conformal, Munition, Missile

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AF06-131 TITLE: Measuring Particulate Entrained Mass-Flow from Internal Detonations

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop cost-effective, robust, and accurate techniques to capture the dynamic pressure/time history during a detonation event.

DESCRIPTION: Many structures are specifically designed to protect against damage from conventional air-launched munitions. Underground hardened bunkers and tunnels are prime examples and contain heavily reinforced walls, doors, etc. If a weapon does successfully penetrate into the airspace and detonate, the effects are usually confined because of the heavy protection incorporated into the walls, floors, etc. However, the gases produced will flow from this confined high pressure region to areas of lower pressure. Historically, we have referred to this air-flow phenomenon as “dynamic-pressure”. If the flow was simply gases the dynamic pressure could be measured by current various techniques, such as hot-wire anemometer, pitot-tube, stagnation gauges, etc. Accurate measurement of the dynamic pressure is necessary to calculate the total pressure. However, testing has demonstrated that the dynamic pressure from an internal detonation is far from “clean”, but instead contains massive amounts of particulate and debris. This hostile environment precludes use of the measurement techniques employed in a “clean” air-flow situation yet the need to measure and quantify this flow is critical because this mass-flow is responsible for understanding the damage mechanisms observed in the structures of interest. Thus, a new technique is needed that will survive the hostile environment and provide an accurate time history of the mass flow of interest. Adequately show how this approach will survive the event, capture the mass-flow properties throughout the time event, the physics utilized in the technique, and a plausible packaging and employment method that would be used. Demonstrate the capability of this technique in a relevant environment. Demonstrate that this technique is cost effective and will survive the event, will capture the mass-flow properties throughout the time event. Provide fabrication-level engineering drawings of the recommended packaging of the device and recommendations for manufacturing.

PHASE I: Develop a feasible cost-effective approach to capturing the dynamic pressure/time history during a detonation event containing extremely hostile mass-flow composed of high temperatures, high velocity gases and particulate flow.

PHASE II: Develop the brass-board hardware capable of capturing the dynamic pressure/time history during a detonation event containing extremely hostile mass-flow composed of high temperatures, high velocity gases and particulate flow.

PHASE III DUAL USE APPLICATIONS: flame Spray, Plasma Coating, Etc.—provides a wide selection of coatings without compromising any characteristics of the substrate on which they are applied. Coating material groups include Ceramics, Carbides, Pure Metals, Metal Alloys, Abradables, Stainless and more. Coating methods include Wire Arc Spray, Combustion Wire Spray, Combustion Powder Spray, Plasma Spray, High Velocity Plasma Spray etc. During these processes the flow of gas contains entrained particles in a very hostile environment. Techniques to measure the dynamic pressure in this flow could be used to characterize the flow to improve the process and/or develop new materials, applications, etc or to provide flow information in a control circuit. Flame Spray techniques are used to provide resistance to abrasion, cavitation, fretting, and oxidation. It can be used for dimensional buildup, EMI/RFI shielding, dielectric and thermal barrier, etc. Flame spray is currently used in the following industries: Aerospace, turbine engines, oil, marine, textile, electronics, etc.

- Process Industry – Measuring the mass flow in applications where hot, corrosive, or abrasive materials are being pumped could improve process control.
- Mining Safety – Characterizing the dynamic pressure (which causes the most damage to personnel and equipment from an accidental mine explosion) will allow development of safety barriers and techniques to mitigate the hazard.
- Turbines – the intake and exhaust of turbine engines are exposed to particulate environments that can cause high wear to pressure sensors. This is especially true for operations in environments where dust, sand, and other particulate matter are abundant.
- Boilers – pulverized coal-fired burners require process control for efficiency. A dynamic pressure measurement that operates within the flow of particulate coal and that does not clog will provide improved process control
- Environmental –

1. Flue gases often contain particulate matter that can clog pitot-type pressure sensor or restrict long-term measurement devices. Since the static pressures in typical flue pipes is minimal the most accurate measure of flow is via dynamic pressure measurement thus a technique is needed that will provide this measurement in the hot gas environment.
2. Techniques to eliminate chemical or biological hazards by combustion are commonly used. In some cases the material is in particulate form. Process control requires accurate measurement of the feed rate, thus a measurement of the mass flow is necessary.

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2. ADM001466 “Twenty-Ninth DOD Explosives Safety Seminar Proceedings (CD-ROM)", Dec 2000

KEYWORDS: Mass-flow measurement, dynamic pressure measurement, multi-phase flow, Internal Detonation, particulate flow, entrained flow measurement

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AF06-132 TITLE: Fatigue Resistant Wire for Airborne Applications

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop fatigue resistant electrical wire technology for application in high vibration airborne environments.

DESCRIPTION: Because of the extreme environment that it operates in, an aircraft imposes severe environmental condition on its components. The entire system, subsystems, and every component must be designed with great caution. To a large extent, the design of the subsystems and components will determine how well the aircraft perform and how long it can perform (due to maintenance). An observed failure mode in aircraft, airborne weapons systems, pods, instrumentation systems, etc. is the simple open circuit created by wire breakage in electrical circuits. This breakage is caused by the harsh environment that aircraft imposes on the electrical wire--causing abrasions, defective insulation, loose terminations, and potential corrosion. These severe conditions cause problems with grounding connections for power, distribution equipment, and electromagnetic shielding, which in turn causes electrical bonding resistance to significantly increase due to corrosion or loosening of connections. Variables that may affect wire degradation are creep (time), thermal variations, electrical loads, mechanical loads (bending, static, dynamic/flexure, abrasion, vibration, thermal expansion), chemicals (cleaners, hydraulic fluid, lubricants, deicing fluids, etc. from aircraft), humidity, oxidizers (Ozone, NOx, SOx, etc.), radiation (heat, ultraviolet), and biological organisms. It is desirable that the wire has a high tolerance for these environmental conditions. These wires must have sufficient mechanical strength to allow for these conditions, but wire properties must not cause excessive voltage drop levels and must meet circuit current carrying requirements. The occurrence wire breakage/degradation is often noted at termination/connection points or other stress points subject to the effects of high vibration flight environments. These occurrences result in aircraft downtime and higher maintenance costs. Innovative technologies in mechanical design and/or fatigue resistant wire technology are required to resist these affects experienced by current technology.

PHASE I: Develop fatigue resistant alloys for electrical wire used in airborne environments. Alternately, develop affordable, space efficient, innovative mechanical designs to resist the effects of the high vibration flight environment. Evaluate component designs under simulated loads to evaluate utility.

PHASE II: Develop a production-scalable process to implement the technology identified in Phase 1. Evaluate the fatigue resistant wire design and new mechanical wire design through load and vibration testing. Conduct long term reliability testing of preferred wire design.

DUAL USE COMMERCIALIZATION: The fatigue resistant wire teachings can be applied to any weapon system, aircraft or munition. Of particular utility will be the ability to reliably perform after years of storage. Commercially, the automobile and civilian aircraft industry will greatly benefit from the application of the technology.

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KEYWORDS: fatigue, fatigue resistant, wire, high vibration, flight environment, instrumentation, alloy

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AF06-133 TITLE: Multi-mode Weapon Algorithms for Future Miniature Munitions

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and simulate innovative trajectory shaping and fuzing algorithms to optimize the performance of miniature munitions against a widely varied target set.

DESCRIPTION: Modern electronics design and packaging has allowed very sophisticated weapon system concepts to be realized in an expendable package. This environment allows us to re-examine integrated weapon concepts which had high payoff in performance yet were not pursued because of high development cost, high manufacturing costs, and high risk. Modern software-driven munitions in development offer an opportunity to optimize weapon performance by sharing information between subsystems that traditionally operated stand-alone. The goal of this SBIR topic is to assume full interoperability between the electronic subsystems of a miniature air-to-surface munition and asks for development of a synergistic endgame trajectory and warhead burst point control algorithms based on all the available information. Available information will be as follows: 1) GPS corrected INS munition position, munition orientation, and munition velocity; 2) Guidance system estimate of target location (centroid of target) with respect to the munition, target orientation, target direction of travel (if moving), target classification (tracked, wheeled, boat), and target sub-classification (armored personnel carrier, missile launcher, transport). Based on the target type and encounter geometry, a robust optimal endgame trajectory and fuzing algorithm would be developed to maximize performance. This may include flying into the target at a specific vulnerable location or flying by the target to achieve the desired warhead fragment pattern on a more vulnerable location. Phase I should assume a unitary blast/fragmenting warhead and should limit analysis to a few select encounters for demonstration of the proposed concept. Phase II would demonstrate the concept's operation against a robust set of targets and across the various classes and sub-classes of targets. The munition should have the ability to process the optimal endgame trajectory and fuzing solution for all targets of interest in case of in-flight re-targeting.

PHASE I: Based on the target type and encounter geometry, design an optimal endgame trajectory and fuze burst point control algorithm for the munition.

PHASE II: Develop a complete launch-to-lethality simulation of a notional weapon concept that uses the proposed real-time algorithms to optimally engage the target.

PHASE III DUAL USE APPLICATIONS: In addition to military use on all classes of air delivered munitions, these high speed target engagement algorithms could be directly translated to active vehicle collision avoidance systems under development. These systems will use a combination of onboard and networked sensors to track the location, orientation, and velocity of all vehicles within a field of interest. Based on these algorithms, an impending collision could either be actively avoided (braking, maneuvering) or the vulnerability reduced by controlling the geometry of the impact.

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KEYWORDS: Fuzing, Adaptive Algorithms, Guidance Systems, Lethality, Warheads

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AF06-135 TITLE: Novel Power Supply for Miniature Munition

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop compact power supply technology suitable for next generation miniature munitions.

DESCRIPTION: Miniaturized smart munitions provide opportunities for precision target engagement with less collateral damage. Yet the smaller size of these munitions imposes more rigorous constraints on electrical power sources and systems. These compact weapons still have power hungry electronic and electromagnetic systems that are used for many purposes, including communications, radar and fin control, and thus require more compact power sources with less stringent thermal isolation constraints. In essence, the decreasing volume available for batteries, and the increasing demands for electronic-based autonomy have exceeded the capability of suitable power sources such as thermal or liquid reserve batteries. The requirements on these batteries are generally: a) one hour operating time after “activation,” if applicable, b) 20 year shelf life, c) functional from -60 degrees F to +150 degrees F, d) capability to withstand shock environment commensurate with munitions launch and target impact e) environmentally benign in disposal, f) internal diagnostics, g) case temperature rise to less than 150 degrees F when thermally isolated. New power source (battery) technology must obviously exceed the nameplate capacity of existing thermal or liquid reserve military batteries by a significant margin.

PHASE I: Identify and develop technology (materials, electrochemistry, etc.) for a novel power source that meets technical specifications. Describe operational benefit of technology, and theoretically compare to off-the-shelf alternatives.

PHASE II: Construct a miniaturized power source and verify performance in a relevant operational environment.

DUAL USE COMMERCIALIZATION: The power source developed for the DOD could be used for many different micro air vehicle platforms as well miniature munitions. It will be equally applicable for use as a commercial power source in any electronic device currently requiring a power source.

REFERENCES: 1. Linden, “Handbook of Batteries,” McGraw Hill, 2002, ISBN: 0071359788

2. “Journal of Power Sources,” Elsevier.

3. “Journal of Fuel Cell Science and Technology,” ASME.

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KEYWORDS: electrochemical cell, fuel cell, power supply, smart munitions, thermal reserve battery, liquid reserve battery

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AF06-136 TITLE: Desensitizing Weapons Via Multi-part Explosives

TECHNOLOGY AREAS: Electronics, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Identify and validate multi-part explosives to desensitize munitions.

DESCRIPTION: Develop a low-cost, multi-part chemical component fill that once mixed would work as an explosive fill used in conventional warheads and commercial applications. This new technique would be used in place of the more traditional melt-cast and plastic-bonded explosive mixtures and fill methods. New explosive formulations or techniques for sensitizing the explosive fill need to be developed which are designed to enhance insensitive munitions characteristics and yet maintain the current explosive performance of the material to be replaced. Traditional weapons are metal cases (warhead) filled with a liquefied explosive material that either solidify during the process time though a cooling process (melt-cast) or through a curing process (plastic-bonded) once it is cast into the bomb body. Once produced, the bomb bodies are then placed in storage, transported and used operationally. Chemical and physical stability of the explosive is essential prior to its use; it would be required to meet both performance and sensitivity standards. The sensitivity of the item is determined from the results of IM tests as identified in Mil-Std 2105C and the performance standard is defined by lethality levels against specific target sets. These two attributes, sensitivity and performance are often used as “trade space” yet are always limited to the chemical, mechanical properties of the explosive fill. An alternate fill composition may involve the use of two (or more) different materials mated within the weapon or commercial application prior to employment. Each material by itself would meet IM standards and be significantly less sensitive when combined prior to use. Initiation of the main fill must be possible with existing fusing an initiation train methodologies. For military applications, during deployment of the weapon the materials would be mixed and then detonated as intended. The mixing process could potentially be conducted during a specific operational step or steps occurring through routine deployment of a weapon. The explosive fill could be “readied” at (1) the bomb build-up area (2) after load-out on the aircraft, during transit to the target site (3) after it has been released from the aircraft. Some of the advantages and disadvantages which need to be examined in detail prior to selection of a new formulation or loading technique include but is not limited to; (1) if the weapon is readied at the build-up area and the mission scrubbed, safety of the technicians and reconstitution of the weapon (2) hazards associated with the mixing process in relation to personnel, equipment, infrastructure and aircraft in the localized area (3) if “readied” during the sortie (in flight) can it be reconstituted once returned to the base or must it be reclassified as non IM (4) any hazards associated with the mixing process “on station” including time limitations. And finally, if the system is “readied, sensitized” following weapon release, activation and mixing times must be accounted for and understood to ensure proper release conditions affecting explosive performance, employment restrictions, and safe standoff distances.

PHASE I: Identify a cost effective, multi-chemical component explosive fill meeting IM requirements.

PHASE II: Conduct sub-scale testing to demonstrate the feasibility of incorporating the technology into full scale weapons. Demonstrate the capability to use the technology in operational environments, safety requirements, performance and time-scales.

PHASE III DUAL USE APPLICATIONS: A successful demonstration of this technology has broad applicability to munitions and explosives safety for military and commercial applications, specifically for dual-use in mining, construction, and demolition applications and other IM and safety requirements.

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4. ADA206512 “Munitions Advanced Development FY 89 Program Plan”, NAVAL SEA SYSTEMS COMMAND WASHINGTON DC, 1989.

KEYWORDS: explosive fill, energetics materials, explosive manufacturing, chemical explosive, detonation physics

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AF06-137 TITLE: Novel Multi-mode Seeker Dome for Miniature Munitions

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop low-cost multi spectral durable seeker domes for use in Small Diameter Bomb miniature munitions.

DESCRIPTION: Miniaturization of electronics allows packaging of today’s munition sensors into smaller areas. Conventional weapons are becoming smarter to increase accuracy, and smaller to minimize collateral damage. Future systems will employ a seeker with multiple sensors that utilize a common aperture. Multiple sensors will provide the flexibility to operate in different operational environments, increase the ability to determine the desired target, and improve weapon accuracy. This leads to the need for a seeker dome that is transparent in all of the spectral bands of the seeker, that demonstrates improved durability and robustness, improved resistance to large temperature ranges, and is all weather capable. General requirements for low cost and durable seeker domes are a) transmissivity at the appropriate frequencies of operation; b) minimal effects such as insertion loss, boresight error, and diffusion; c) low cost manufacturing of the dome; d) survivability of dome through harsh environment and adverse weather; e) wide dynamic temperature and shock resistance; f) capability to withstand supersonic/high-speed environments; g) reduced size and weight of dome for use on miniature munitions; h) and the capability to operate in the near infrared (IR) , mid-to-long wave IR and millimeter wave (MMW) spectral bands. The effort will address the modeling and simulation that would determine the dome requirements (such as thickness, permeability, dielectric constant, transmissivity, and malleability of the material.) Tradeoffs will address the pros and cons of the characteristics of possible candidate materials. The simulations and modeling should also address the predicted performance of the dome at the respective frequencies. Analysis will be conducted on frequencies selected within the spectral bands that would produce the best performance, the frequencies and spectral bands will be furnished by the topic sponsor. A design for building the dome will be delivered with final report. Limited environmental testing will be conducted, to determine the capability of the dome to survive the harsh environment of miniature munitions. A final report will be written incorporating the test results, suggested manufacturing technique, and estimated cost of the dome.

PHASE I: Perform an analysis on current and new materials that are in the forefront of having the appropriate characteristics for implementation as domes for miniature munitions.

PHASE II: Sample materials will be fabricated to test characteristic properties. Once the right properties have been established, several prototype domes will be fabricated for characterization within the desired spectral bands.

PHASE III DUAL USE APPLICATIONS: Military application: Dome materials that allow the transmission of multiple spectral bands give munitions, aircraft, and surveillance devices the ability to share apertures, promoting better data integration of the multiple sensors and enabling more aerodynamically efficient vehicle designs. Commercial communications systems and aircraft sensors would benefit from this shared aperture.

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KEYWORDS: IR, Infra Red, Windows and Domes, Seeker, Munitions and Missiles, MMW, Millimeter Wave Radar

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AF06-138 TITLE: Self Healing Materials for Airframe Structures

TECHNOLOGY AREAS: Materials/Processes, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop self-healing composites suitable for munitions and airframe structures.

DESCRIPTION: In recent years, munitions designers have been increasing the use of composite materials to meet demanding weight and strength requirements. While composite materials have excellent strength to weight characteristics, the ability to detect failures and degradations within the composite remain a challenge. Undetected material flaws can reduce the lifetime of components and lead to catastrophic system failures. The development of novel, self-healing materials would eliminate the need to detect flaws. In particular, the Air Force is looking for self-healing composites that would recover their original strength to the greatest extent possible. While totally passive self-healing techniques are most desired, limited in-situ active techniques may be considered. For example, one-time-only application of heat or vibration to initiate the self-healing may be possible if such techniques could be shown feasible on full up munition systems in-situ. Demonstrate that the process or procedures used restores the specimen to its pre-cracked state with regard to stiffness, strength and fatigue life. Materials shall be evaluated through analysis and/or test of small specimens.

PHASE I: Identify and define candidate materials and/or material processing techniques for self-healing composites suitable for munitions and airframe structures with a goal of recovering greater than 70 percent of the virgin load capacity.

PHASE II: Demonstrate the benefit of the material concept generated in Phase I by fabricating, processing, and characterizing an airframe structural component or subcomponent such as a fuselage section, wing, or control fin.

PHASE III DUAL USE APPLICATIONS: Demonstration of a lightweight, high strength, self-healing composite material suitable for structural applications will have a large variety of uses in the aerospace industry. Such materials can be used for aircraft and missile fuselage, wing, and tail surfaces.

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KEYWORDS: polymer-matrix composites, fracture toughness, delamination, composite repair, self-healing

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AF06-139 TITLE: Airborne Radar Ground Clutter Mitigation

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Improve detection capability in radio frequency high clutter environment engagements, look down, shoot down orientations.

DESCRIPTION: Explore the utilization of digital terrain elevation data (DTED) and other data sets in the prediction and mitigation of clutter in airborne fire control and active missile radars. Particular emphasis is to be placed on low altitude radars in highly heterogeneous terrains. It is desired that innovative algorithms developed herein be applicable to I/J band surveillance, fire control and weapon systems such as Joint Stars/E-10, AN/APG-63(V)1 and 2, and AMRAAM. These systems are capable of High, Medium, and Low Pulse Repetition Frequencies (PRF) pulsed- Doppler type waveforms. The algorithms must be broad in scope such that they accommodate the breadth of waveforms emitted by these types of radars, e.g., pulsewidths ranging from 0.1 to 10 us, PRFs from 1 to 500 KHz, through antennas ranging from sub degree to 20 degree beamwidths with first sidelobe levels of -17dB. Research efforts include mainlobe and sidelobe clutter prediction, multipath mitigation, and effectivity of deterministic spatial filtering. Novel methods of data compression, e.g., wavelets, for storage and processing are encouraged to minimize real time processing loads and memory.

PHASE I: Determine the most promising technology(s) to improve target detection in high clutter, low altitude engagements. Evaluate these technologies in a laboratory environment using selected spatial filtering and data compression techniques, and determine their utility in clutter mitigation.

PHASE II: Using results from Phase I, develop, test and evaluate the most promising technologies in mitigating clutter. Prototype and demonstrate filtering and compression techniques using realistic scenarios.

PHASE III DUAL USE APPLICATIONS: Clutter mitigation is useful for detecting and tracking airborne objects. The prediction and mitigation of clutter methods will assist the military in searching for targets and will potentially assist the commercial industry in developing collision avoidance systems.

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2. ADA130537 “Airborne Systems Course Textbook. Radar System Test and Evaluation”, NAVAL TEST PILOT SCHOOL PATUXENT RIVER MD, FEB 1981, Masters, George W.

3. ADA244893 “Target and Clutter Scattering and their Effects on Military Radar Performance”, ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT NEUILLY-SUR-SEINE (FRAN CE), Ottawa, Canada, May 1991.

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KEYWORDS: Radio frequency target detection, high clutter, high resolution imaging, target imaging, camouflage

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AF06-140 TITLE: <u>NOVEL INFRARED (IR) EMISSIVE DEVICES</u>

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop novel infrared emissive devices capable of high frequency modulation and temperature change.

DESCRIPTION: Current gas sensing systems and Hardware in the Loop Infrared (IR) projection arrays rely on the use of Silicon Infrared Resistive Emitter Arrays to realistically simulate dynamic infrared objects and backgrounds at temperatures up to 700 Kelvin. Technology based on resistive arrays has many benefits including flicker-less emission, broadband output, greater than 512 by 512 pixel spatial resolution, and high frame rates. However, the dynamic range of this technology does not provide for radiometric duplication of the full range of scenarios likely to be encountered by future weapons systems. Current arrays have limitation in output, limiting the apparent temperature, and suffer from droop across the array due to resistive losses at high current operating conditions. Alternative methods are needed to represent images or objects such as targets with hot engine exhausts or rocket plumes, and infrared countermeasures as examples of the target set that will stress the ability for radiometric duplication. Innovative approaches are required for simulation of point and spatially extended objects whose apparent temperature may exceed 3000K. For the purpose of defining approaches, the emitter approach should be realizable within at least a two-micron bandpass anywhere within the 2-14 micron band. Ideally, the source array concept should be able to achieve at least a 512 squared spatial resolution, and, if pixelated, achieve pixel response times of less than 1.25 millisecond. One approach may be using an array of IR light emitting diodes as a infrared scene projector for testing IR detection systems, particularly thermal imaging systems or seeker systems. IR-LEDs are heterostructure devices capable of negative luminescence. Cold scene temperatures below ambient may be able to be simulated by the use of negative luminescence. Preferably the diodes emit and absorb radiation in the 3-5 µm and 8-14 µm wavelength regions. In practice, the fundamental switching speed of IR light emitting diodes is in excess of 1 MHz. The frame rates that may be achieved are therefore determined not by the thermal time constant of each pixel but by the frequency of the multiplexer drive circuit.

PHASE I: Develop concepts and demonstrate viability of point source multi-wavelength quantum emitters and arrays of IR quantum emitters.

PHASE II: Develop and fully characterize pixelated single and multispectral quantum IR emitters that emit over the 2-14 micrometer spectrum.

DUAL USE COMMERCIALIZATION: Further develop and integrate devices for commercial and military applications in process control, gas sensing, biomedical devices, IR line of sight communications, signal simulation, sensor stimulation and testing of IR sensors. High performance IR emitter arrays and devices would enhance instrument performance in such applications as IR spectrometers, night vision, and IR sources which could promote significant applications outside military scope in communication, night vision, weather science, material science, metrology, industrial process monitoring, and surveillance. Realtime embedded spectroscopy for auto and aircraft emission control would be greatly enhanced by this new technology.

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KEYWORDS: Infrared Light Emitting Diode, mid-wave IR, Long-wave IR, negative luminescence, antinomide LED, quantum well infrared emitter

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AF06-141 TITLE: Micro Munition Technologies

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop micro munition technologies for future micro platforms with air and/or ground mobility modes for employment in complex urban environments.

DESCRIPTION: New munition research is required to address targets that are dispersing in urban canyons, forest edges, caves, and mountains. These targets generate technology challenges which include collateral damage, bomb damage information (BDI), confined airspace, datalink dropout, data latency, and target uncertainty/mobility. The technology solutions will focus on the development of munitions that can adapt by becoming smarter (robust datalink, situational awareness, supervised autonomy) and smaller (precise lethality, platform agility, multi-functional subsystems).

Technologies under consideration for future micro platforms include innovative and integrated aero/propulsive flight controls, aerodynamic shaping and morphing control surfaces for low speed aerodynamics, and bio-inspired air and terrain mobility modes. Goals are to insert these technologies into platforms with the following characteristics or capabilities to improve platform agility and mission flexibility: (1) projected area of less than 8 inches, (2) fly a minimum of 1 mile to a designated location and return, (3) have a flight ceiling of at least 100 ft, (4) have required sensors and flight control to fly or crawl through an open 2 ft by 3 ft window on the side of a building, and (5) have an operation time of approximately 1 hr.

PHASE I: Define the concept, identify key technologies, and predict the performance of the proposed technology for BDI and urban operations using modeling and simulation or concept demonstration. Identification of critical parameters and application to identified concept of employment of the platform in a relevant operational environment.

PHASE II: Finalize the design concept of the proposed technology for BDI and urban operations. Develop a prototype that demonstrates the concept in the identified operational environment. Final report should highlight prototype concept design, how operational environment requirements are supported, and how the prototype concept addresses system integration of additional technologies that are required to successfully fulfill operational environment objectives

PHASE III DUAL USE APPLICATIONS: Innovative micro munition technologies could be used in many DoD and commercial areas. Loitering micro air platforms could be used for law enforcement, such as tracking individuals or vehicles involved in criminal activities. Micro robotic ground platforms could be used to ingress difficult to access buildings for surveillance related to search and rescue operations. Multi-mode mobility platforms could be used to assist in remote reconnaissance, or for very large scale farming operations.

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KEYWORDS: Munition airframe, platform flight control, laminar flow control, low speed aerodynamics, micro air vehicle maneuverability, micro propulsion, robotic sensing, robotic swarming, micro power supply

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AF06-142 TITLE: Advanced LADAR Research for Munition Seekers

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop novel systems, components and techniques for high resolution 3D imaging laser radar including optical multidiscriminant techniques for precision guidance of advanced weapons.

DESCRIPTION: Imaging laser radar (ladar) systems must be compact, inexpensive and reliable for use in seekers for autonomously guided munitions. Current ladar systems rely on photon time-of-flight or coherent mixing to determine range to target. Novel ladar systems, ladar system components, or ranging techniques which offer range precision of better than 3 inches, range resolution of at least 1 foot, and an amplitude dynamic range of at least 10 bits are a priority. Technologies offering optical multidiscriminant seekers are also of interest. For optical multidiscriminant seekers, a co-registration of 1/20 of a pixel across channels is required. All systems should address nth pulse detection (up to 4 hits) for imaging occluded or obscured targets. Innovative ideas must lead to a low-cost, medium-range (2-5 km) imaging ladar seeker constrained to a volume of less than 250 cubic inches. Current ladar components include lasers, optical detectors, optical scanners, transmit and receive optics, and ranging electronics. High energy eye-safe (>1.5 micron wavelength) laser and focal plane arrays (>256x256) for optical detection that offer or support single-shot imaging of a scene are of particular interest. Novel techniques to electronically scan the single-shot transmitter and receiver are of particular value in eliminating current gimbal requirements. This will drastically reduce weight and cost. Also of interest are techniques for improved signal-to-noise for laser ranging, techniques that lend themselves to implementation in small packages, and techniques that allow imaging with eye-safe wavelengths in the near to mid-IR range. Exploration into the use of multiple laser wavelengths, phase information, and polarization information to increase ladar system performance is highly encouraged. Proposed components and techniques should be capable of implementation in small packages at low cost appropriate for use on autonomously guided airdropped munitions. Proposals to improve ladar components should include an envisioned ladar system architecture that utilizes the component. Proposed schemes should be appropriate for implementation in a laboratory breadboard setup.

PHASE I: Phase I of this project should investigate the performance of the proposed component or technique through modeling & simulation or fabrication of critical elements of the design. The results will be used to establish a prototype component or system design and outlined in a detailed report.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype component or ladar system based upon the design developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in ladar systems and components can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses of ladar systems include remote sensing applications for environmental monitoring, security systems, geographic surveying (e.g. tree height, mine surveying, tunnel profiling), industrial monitoring applications (e.g. saw positioning, quality control in steel manufacturing, conveyor belt load volumes), and collision avoidance sensors for transportation systems. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems. Advances in individual ladar components may result in a wide variety of commercial and military applications, depending upon the particular component and the nature of the advance. Lasers, optical detectors, and optical scanners have many uses in a wide range of commercial and military systems.

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KEYWORDS: laser radar, LADAR, laser ranging, direct detection, coherent laser radar, laser applications, optical scanners, optical detectors, focal plane array

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AF06-143 TITLE: Home on Structured Interference/Multipath

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Electronics

OBJECTIVE: Research and development of a passive sensor capable of detecting and locating intentional or unintentional low power GPS multipath or structured interference source.

DESCRIPTION: The Global Positioning System (GPS) has become the standard source for accurate position, navigation and time (PNT) information. Current delivery platforms and munitions employ integrated GPS/INS guidance systems to provide accurate navigation performance. Likewise in the civilian sector, “First Responders” rely heavily GPS for accurate PNT with an emphasis on timing which is used in modern communications systems. The effect of invalid GPS signals, caused by either intentional or unintentional sources, is erroneous PNT information which has a direct impact on the performance of the platform or weapon system. Modern communication systems, DoD and civilian, that rely on accurate timing for synchronization, will become non-operational or intermittent at best. Because of the need for accurate delivery of weapon systems and reliable communications, interference with the GPS signal is unacceptable.

Multipath/structured interference may be caused by natural or man-made obstructions, or can be electronically generated. This creates multiple signals which can stress or confuse GPS receivers. It is anticipated that this problem can be addressed using digital signal processing techniques, multi-element antenna arrays and antenna signal processing to discern, identify and track the true signal through the noise of the erroneous signals. It is envisioned that this technology will be deployed on a stand alone system, using small platforms such as UAVs, HMMWVs or small water craft. Innovative technologies that can address the technical challenges must operate within the physical constraints including limited payload and power capacity. Additionally this technology may be employed on non-recoverable platforms and therefore cost becomes a key factor.

The purpose of this SBIR effort is to investigate and develop novel technologies with the capability to identify, track, locate, and possibly home to intentional or unintentional structured interference/multipath sources with signal strength on the order of -166 dBw to -146 dBw. The intent is to develop technology that is suitable for integration into Precision Guided Munitions (PGMs), small Unmanned Air Vehicle(UAV) and ground based platforms. It is anticipated that this technology will find a home in land, sea or air platforms. This technology design should consider size, weight, power consumption, and operational complexity.

PHASE I: Investigate the feasibility of developing a passive sensor capable of detecting and locating intentional or unintentional low power GPS multipath or structured interference sources. A detailed concept of operations and system design of this technology is anticipated.

PHASE II: Development and demonstration of a Phase I prototype system. This prototype must demonstrate the capability to detect, identify, locate, and home to a GPS structured interference/multipath source. This demonstration shall incorporate data collection and analysis tools (visual mapping tools i.e., Falcon View etc...) to present data for real time and post mission evaluation.

PHASE III DUAL USE APPLICATIONS: Potential military applications include PGMs, UAVs and ground based platforms. Potential commercial uses include the adaptation of this technology for use in Homeland Security and First Responder operations. This technology holds the potential to help identify, locate, and eliminate sources of interference that disrupt DoD and commercial GPS reliant systems. This technology will be useful in air and ground based applications. Miniaturization of this technology will support the development of smaller systems capable of being man-portable applications.

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3. Grewal, Mohinder S., Weill, Lawrence R., and Andrews, Angus P., "The Multipath Problem" in Global Positioning Systems, Inertial Navigation, and Integration, John Wiley & Sons, Inc., 2001, pp.115-116.

KEYWORDS: Sensor, Guidance, GPS, Seeker, Munition, Structured Interference, Multipath, Geo Location

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AF06-144 TITLE: Micro Fuel Cell (MFC) for Micro Air Vehicle (MAV) Power

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop & advance enabling technologies for a micro fuel cell that will out perform current re-chargeable and non re-chargeable battery technology used to power MAVs and other small robotic platforms.

DESCRIPTION: The Air Force is currently conducting research to develop micro platforms for covert operation to detect, identify, track, and ultimately defeat limited access and underground targets. This platform research is currently limited by the restricted time of operation due to power constraints; therefore different power-supply technologies are being investigated. In addition, the use of micro platforms to conduct special operations is increasing across all services. Current battery technology is unable to provide necessary time of operation for some MAVs and ground mobile robotic platforms resulting in a strong desire for longer lasting power sources. The focus of this SBIR is to develop a micro fuel cell (MFC) that will outperform and outlast current batteries used to power micro air vehicles and other small robotic platforms. General requirements for the fuel cell include: A.) High current draw capability with a target of around 5-6 amps max, and 2 amps steady state; B.) Voltage capability of around 12 volts; C.) Quickly and easily recharged; D.) Outlast battery of comparable size; E.) No larger than 2.5" x 1.25" x 5/8". This technology has great potential to be utilized in the commercial world as well. If successful this technology could replace many batteries in many applications which they are used today.

PHASE I: Define proposed concept, identify key technologies, & predict performance of proposed design of a MFC through model and simulation techniques. Identification of the following parameters are critical: 1 Determine fuel cell type (methanol, hydrogen, etc). 2 Determine theoretical power generation.

PHASE II: Finalize MFC design and conduct following: 1 Develop and demonstrate prototype based on PHASE I model and sim. 2 Integrate prototype into conventional package. 3 Investigate MFC / battery or capacitor hybrid possibilities. The final report should include documentation of performance, tech shortfalls, required additional research, and projected performance based on sizing and power draw variables.

DUAL USE COMMERCIALIZATION: The micro fuel cell developed for the DOD could be used for many different micro air vehicle platforms as well as other micro robots. It will be equally applicable for use as a commercial power source in any electronic device currently requiring a power source.

REFERENCES: 1. AFRL/MN Home Page: http://www.mn.afrl.af.mil

2. Micro Air Vehicles – Towards a New Dimension in Flight:
http://www.darpa.mil/tto/mav/man_auvsi.html

KEYWORDS: Fuel Cells, Micro Fuel Cell, Micro Air Vehicle, Micro Power Supply

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AF06-145 TITLE: Innovative Fuze Technology Research

TECHNOLOGY AREAS: 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: Research and develop innovative technology for application in air-delivered munition or submunition fuzes.

DESCRIPTION: The Fuzes Branch of the Air Force Research Laboratory Munitions Directorate (AFRL/MNMF) develops and integrates technologies that have application to fuzes for air-delivered weapons, including (but not limited to) guided and unguided bombs, missiles, and submunitions. Fuzes must reliably remain in a safe mode until the appropriate post-deployment environments (such as freefall) are sensed; the fuze must then arm the weapon and, upon receiving a signal from a terminal detection device (TDD), initiate the explosive fill (or other damage mechanism).

AFRL/MNMF thus seeks proposals for innovative technologies that can be integrated into the design or testing of air-delivered weapon fuzes. Areas of broad technical relevance include environmental and TDD sensors (e.g., optical, acoustic, etc.), radar systems, communication systems, and explosive initiation/micro-detonics. Some specific research areas of interest include, but are not limited to (1) innovative, self-adjusting, shock-survivable, multi-axial accelerometers with sensitivity in a wide dynamic range from 0.001 to 100,000 times the acceleration of gravity while maintaining 60 dB resolution; (2) miniaturized (<5 mm^3), low power (<5 mW) sensors for monitoring real-time structural health of a warhead case or for measuring small-scale (< 0.01 mm) plastic deformation and accompanying algorithms for a self-destruct feature; (3) non-inertial void sensors with a maximum range > 1 m and <1 cm resolution; (4) miniaturized (volume < 5 mm^3) methods for efficiently harvesting environmental energy for miniature weapons, such as wind turbine generators for submunitions, capable of providing a specific power of >500 W/kg; (5) Coherent RF simulation software or hardware for target scene generation that models fuze hardware with 1 transmit and N # of coherent receivers operating at frequencies from 1 to 800 GHz; (6) miniaturized (system volume < 100 cm^3), shock-hardened (to 30,000 times the acceleration of gravity), low frequency (< 300 MHz) RF electronics and hardware, including antennas; (7) novel explosive initiation mechanisms for insensitive explosives; and (8) exploding foil initiators (EFI's) with very low energy (<300 V) firing thresholds.

A successful program will demonstrate the concept through design or testing in Phase I. Subsequent Phase II efforts will involve developing and testing prototype (brassboard) versions of the technology.

PHASE I: Provide a design and/or proof-of-concept demonstration of the fuze-related technology.

PHASE II: Design, fabricate and test a prototype system.

PHASE III DUAL USE APPLICATIONS: A successful demonstration of this technology will lead to applications in air-delivered as well as gun-launched munitions (such as land- and sea-based artillery shells). The dual-use potential will vary depending on the particular technology.

REFERENCES:

1. Munitions Directorate Homepage <http://www.mn.afrl.af.mil/>

2. Military Handbook of Fuzes, MIL-HDBK-757(AR), 15 April 1994. (Public Releasable via USA Information Systems, Inc; www.usainfo.com, 757-491-7525)

KEYWORDS: Fuzes, munitions, environments, safe, arm, fire, targets, explosive initiation, radar, sensors.

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AF06-146 TITLE: Electro-Explosive Effects (E-Cubed, E3)

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop technologies for insensitive munitions or selectable effects munitions using externally-applied transient electromagnetic (EM) fields to: alter the sensitivity of energetic materials; or alter, enhance and/or control detonation physics or chemistry.

DESCRIPTION: The effects of electromagnetic fields upon energetic materials are real, but are not well understood. Most work has focused on the safety aspects of low-level stimuli (i.e., electromagnetic susceptibility, electrostatic discharge). There is no reason to expect that the properties of energetic materials that govern the ability to detonate are immune to strong electromagnetic fields. The fact that most un-reacted, bulk explosives have low conductivity and permeability suggests that transient fields may be applied to the interior of the explosive. Even modest amounts of electrical energy applied over very short times results in a very high power application. The guiding premise of this work is that the sensitivity or other key parameters of explosive materials can be influenced with externally-applied transient electromagnetic fields.

These phenomena may have applications for conventional munitions. [Note: This topic addresses ways to improve blast and/or fragmentation munitions via electromagnetic effects on chemical reactions; it excludes any directed energy kill mechanisms or nuclear concepts.] If the sensitivity of an explosive material can, in fact, be altered by a strong transient electromagnetic field, then a number of potential paradigm shifts could be realized. Sensitive primary explosives used in boosters could be replaced with more insensitive “secondary” explosives, which would be sensitized by applied EM fields during the fuzing event. Or, complex wave-shaping might be done by applying a transient field in the earliest portions of the detonation event. Several researchers have established that detonation fronts are more electrically conductive than the bulk explosive or cooler reaction products and these properties might be exploited using externally applied fields. This could lead to very different methods of designing multimode warheads. Yet another shift could occur in the size of explosives if applied fields could reduce critical diameters for micro-munitions. And, finally, this technology might be used to tune the blast output in a dial-a-yield warhead.

In this effort we anticipate the study of the detonation of very small quantities of conventional (commonly available) energetic materials when various electromagnetic fields are applied just prior to and during the initiation event. These fields can be tailored to produce stress, cause ohmic heating, orient polar molecules, and alter various other conditions that normally do not occur in the detonation process. Since the focus of the Phase I effort is electro-explosive phenomena rather than weaponization, laboratory power supplies can be used to mimic a weaponized power supply in Phase I experiments.

The proposer has significant flexibility in formulating its approach to meeting the technical goals, including: (1) the type of electromagnetic stimuli (electrical fields, magnetic fields, or some other part of the electromagnetic spectrum); (2) the method of applying the EM stimuli (e.g., direct currents, voltage potential between electrode plates); (3) the choice of energetic material (e.g., aluminized explosives, intermetallics); and (4) the property that is altered (e.g., sensitivity, reaction rate). The proposer should identify how the particular effect would be exploited for military and commercial applications.

PHASE I: Investigate the effects of electromagnetic fields upon explosive detonation. Identify and develop methods to exploit these effects. Perform basic modeling and simulation and/or proof-of-concept experiments to show viability of concept(s).

PHASE II: Simulate (with high-fidelity models) and/or measure the effects of EM fields upon detonation. Develop and test concepts to exploit this phenomenon.

PHASE III DUAL USE APPLICATIONS: Electromagnetic enhancement or control of chemical reactions has high commercial potential. Electric fields have already been used to enhance combustion in commercial processes. For example, electric fields increase the heat transfer and flame speed in propane burners. And, electric field activation in combustion synthesis (also known as Self-propagating High-temperature Synthesis, or SHS) of advanced ceramic materials allows thermal energy to be concentrated in hot spots, eliminating undesirable pre-combustion reactions induced by bulk heating. This ability to preferentially select desired reactions, or to eliminate undesired reactions, has widespread appeal to the chemical and manufacturing industries. This technology has evident mining, and demolition applications. Applications that are pertinent to both the military and commercial explosives community are: insensitive boosters (via real-time enhancement of the sensitivity of energetic materials for fuzes), novel wave-shaper techniques, and micro-explosives. Military applications include insensitive munitions, selectable yield warheads, and enhanced blast ordnance.

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1. F.K. Lu, C.H. Kim, D.R. Wilson, H.-C. Liu, W.S. Stuessy and G.A. Simmons, “Exploratory Study of Conductivity in Detonation Waves,” 37th AIAA Aerospace Sciences Meeting and Exhibit (11-14 January 99).

2. G.O. Thomas, D.H. Edwards, M.J. Edwards, and A. Milne, “Electrical Enhancement of Detonation,” Department of Physics, University of Wales (30 December 91)

3. R.J. Lee and P.K. Gustavson, “Electrical Conductivity Profiles Directly Behind the Detonation Front for Various Cast-Cured Explosives,” 34th International Annual Conference of ICT (Institut für Chemische Technologie) (24-27 June 03).

4. M.A. Cook and T.Z. Gwyther, "Influence of Electrical Fields on Shock of Detonation Transition," University of Utah Department of Metallurgy, AF-AFOSR-56-65, September 28, 1965

5. U. Anselmi-Tamburini, F. Maglia, G. Spinola, and Z.A. Munir, “Combustion Synthesis: an Effective Tool for the Synthesis of Advanced Materials,” Chimica & Industria (December 2000).

KEYWORDS: insensitive munition, insensitive explosive, electromagnetic fields, detonation, explosives, wave shaping, miniaturization, conductivity

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AF06-147 TITLE: Micro Damage Mechanisms

TECHNOLOGY AREAS: Electronics, Weapons

OBJECTIVE: Identify, develop, and demonstrate components/technologies having application to warheads for micro-munitions.

DESCRIPTION: In the future, micro-sized (cm3) warheads will be needed as payloads on air, space, surface, and subterranean micro-vehicle delivery systems. In particular, the Munitions Directorate is interested in payloads compatible with small aerial vehicles where small is defined as having no dimension larger than 12 inches. The goal of these micro damage mechanisms is functional defeat of high value targets which include but are not limited to; urban targets, mobile and moving targets as well as hard and deeply buried targets. The targets of most interest include moving and stationary vehicles, communications equipment and improvised explosive devices. The desired micro damage mechanism should be difficult to detect (stealth and or covert), provide long denial-of-service periods, and result in low collateral damage. Lethal and non-lethal mechanisms can be considered. Damage mechanisms are not limited to energetic materials or conventional explosives. Damage mechanisms could be but are not limited to; electrical, optical, chemical, incendiary, kinetic, mechanical or some combination of damage mechanisms. Damage mechanisms need not be limited to single vehicle delivery; swarms of micro vehicles might be used to deliver identical payloads for an additive effect or different payloads for on-site fabrication of a larger payload or synergistic effects. For the purpose of this effort, micro-sized warheads will be defined as having the volume of one cubic centimeter or smaller. Proposals with damage mechanisms that are larger than the desired cubic centimeter size will be considered only if they include a discussion on the level of effort it would take to shrink the volume size. Proposed damage mechanisms that can respond to and neutralize and/or render inoperable a wider variety of targets will be more highly favored than damage mechanisms that are only useful against a small set or single target. Key performance parameters are generally the ratio of lethality (or the duration of the denial of service) to a particular quantity such as cost, size, weight, shelf life, etc. The other aspects of RAM (reliability, availability and maintainability) also manifest as key performance parameters. The proposer should identify and detail all auxiliary equipment needed to implement these non-conventional damage mechanisms. This discussion should include such things as what type of vehicle or transportation is needed, what sensor or homing mechanism are required, whether damage mechanism operates autonomously or requires in-the-loop control, and whether fuzing capabilities would be needed to implement the damage mechanism.

PHASE I: Determine and clearly demonstrate the scientific or technological merit and feasibility of the innovative damage mechanism. Clearly define the target set for which the concept is applicable. A technical evaluation of the end-state concept compared to alternative approaches may be appropriate.

PHASE II: Produce well-defined, deliverable, technology demonstration hardware with a road map for incorporating the damage mechanism as a warhead in a delivery vehicle.

PHASE III DUAL USE APPLICATIONS: Military application: Micro-explosive systems hold the promise of being a basic enabling technology with widespread applications to the military. To a lesser extent they may have applications in mining and demolition industries or be useful in very small scale materials processing (e.g., surface treatment and hardening of materials)

REFERENCES:

1. D. Scott Stewart, “Miniaturization of Explosive Technology and Microdetonics,” XXI ICTAM, 15-21 August 2004, Warsaw, Poland, http://fluid.ippt.gov.pl/ictam04/text/sessions/docs/MS4/12976/MS4_12976.pdf

2. “Miniaturization of Explosive Systems Technology,” AFRL Technology Horizons Magazine, August 2004, http://www.afrlhorizons.com/Briefs/Aug04/MN0313.html

3. D. Scott Stewart, “Towards the Miniaturization of Explosive Technology,” Proceedings of the 23rd International Conference on Shock Waves, October 2001, http://www.tam.uiuc.edu/publications/tam_reports/2001/984.pdf

KEYWORDS: Micro Air Vehicle (MAV), micro-explosive system, micro-detonics, collateral damage, military operations in urban terrain (MOUT), hard and deeply buried targets (HDBTs)

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AF06-148 TITLE: Biologically Inspired Adhesive Microstructure

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop innovative technologies to enable micro platforms the ability to traverse horizontal and vertical surfaces.

DESCRIPTION: The use of MAVs and micro robots for intelligence, surveillance, and reconnaissance (ISR) is of growing interest to the Air Force. If multi-mode mobility MAVs or micro robots had the ability to climb walls or walk/crawl on a ceiling, it would have the ability to perform multiple missions with an unprecedented amount of flexibility. For example, if a micro robots mission was to enter into a suspected chemical/biological warehouse to gather intelligence (i.e. video imagery), it could perform this mission very efficiently by climbing the wall and staking out in the corner of the ceiling undetected. This ability to be mobile on virtually any solid surface will require innovative adhesion materials/technologies. An essentially new research thrust on studying the climbing capability of the gecko has been of major interest. The ability to not only climb walls but also hang upside down from the ceiling has postulated many research questions. In addition to this, the gecko has the added advantage of having dry, self-cleaning, dynamically modulated adhesive feet. These advantages give unlimited life in sticking ability, unlike modern adhesive materials (i.e. tapes, glues, etc.). Recent studies indicate that this is actually achieved by small intermolecular forces known as van der Waals forces. This force, which occurs when unbalanced electrical charges around molecules attract each other, is individually miniscule, but the effect of several million collectively produces a powerful adhesion. An effective adhesive material would probably have to utilize a multi-level micro structure design that would engage the surface so the naturally occurring van der Waals forces could be maximized. The development of this new material would incorporate understanding at the nanoscopic scale of the fibers and/or microstructure of both the gecko feet and the proposed adhesion material. The major technical risks will be in the development, fabrication, and adhesive efficiency of this type of material.

PHASE I: Define the proposed concept, identify key materials/technologies, and predict the performance of the proposed design of an adhesive microstructure concept that will allow micro platforms to climb walls and walk across ceilings.

PHASE II: Finalize the design of the adhesive microstructure. Develop an operable prototype or suitable device that demonstrates the intended technological concept in a relevant operational environment.

PHASE III DUAL USE APPLICATIONS: Technology developed on this program will have a wide range of military application. The material technology to be demonstrated under this topic will provide the enabling technology for MAVs, micro robots, soldiers, and other platforms to climb, walk, crawl, or stick to almost any solid surface. This technology can be applied to several commercial markets (robotics for search and rescue, interior design (picture mounting), construction, etc.).

REFERENCES:

1. AFRL/MN Home Page: http://www.mn.afrl.af.mil

2. Micro Air Vehicles – Towards a New Dimension in Flight: http://www.darpa.mil/tto/mav/man_auvsi.html

3. http://www.newscientist.com/news/news.jsp?id=ns99993785

4. http://usatoday.com/tech/news/techinnovations/2002-08-27-gecko-feet_x.htm

KEYWORDS: Adhesive microstructure, micro air vehicle, micro robot, gecko, adhesion material

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AF06-149 TITLE: Collision Avoidance

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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 low-latency collision avoidance algorithms for flight in urban terrain suitable for hosting on micro-air vehicles with limited optical sensor resolution, frame rate, and computational power.

DESCRIPTION: AFRL/MN has an ongoing interest in micro-air vehicles (MAVs) suitable for various stressing missions, an example of which is bomb damage indication (BDI) missions in urban terrain. Such MAVs must be able to operate autonomously with limited a priori knowledge about their environment. This requires an on-board capability to detect and avoid obstacles in real-time. Due to their small size (< 12" wingspan) and limited payload (<8 ounces), the collision-avoidance function must be complementary / coincident with other mission functions such as guidance, navigation, control, and sensing; and share computational resources with other processes.

Various collision-avoidance paradigms exist for autonomous vehicles in cluttered environments. Many draw inspiration from biological systems – both vertebrate and invertebrate. Unfortunately, the realization of such paradigms in engineered airborne systems is extremely difficult. Currently, the most mature collision avoidance systems are used for ground vehicles where the problem complexity is somewhat reduced due to fewer degrees of freedom, simpler dynamics, and less restrictions on payload.
Respondents may propose biological and/or "analytical" inspired solutions. Solutions may include novel hardware development in imaging sensors and embedded processors with the caveat that such hardware would likely replace payload rather than augment payload on a MAV. As such, imaging hardware should be suitable to conduct close-range BDI in the visible or IR spectrum and processing hardware should have some reserve for navigation, guidance, and control functions.

Respondents may assume that nominal vehicle stabilization and control is provided by a MEMs-grade inertial system with GPS position aiding when available. Basic air data such as a static and dynamic pressure are often available also. These may be considered for external inputs to the collision-avoidance function. Update rates vary, but are commonly in the 10-60Hz range for inertial attitude and acceleration and 1-2Hz for GPS positioning. Proposed solutions should not be dependent on GPS for robust performance.

Sensor hardware should provide sufficient resolution to conduct BDI on vehicle sized regions from 300m or further. Optics may be non-linear, but should be sufficiently calibrated to provide linear images in post-process for human interpretation of regions of interest. For reference, typical sensors on current MAVs are visible spectrum, grayscale and color, VGA resolution, 30-60Hz frame rate, with linear optics. Small, uncooled IR sensors are of interest for enhanced night capability.

Respondents should have an ability to collect/generate appropriate data to support their algorithm development and performance analysis. The government sponsor will provide developmental data to the extent possible, but should not be considered the primary data source in early phases.

Key performance parameters include –
- Detection distances for man-made (buildings, walls, wires) and natural (trees, terrain, bushes) obstacles.
- System response times characterizing latency between image acquisition and obstacle determinations
- Computational requirements in terms of image resolution, frame-rate, and detection probability for various obstacles

PHASE I: Develop candidate algorithms for real-time collision avoidance on MAVs and test in simulation or on collected imagery. Generate a system architecture for real-time performance on MAV appropriate hardware. Investigate trade-space between sensor payloads, vehicle dynamics, and computing resources.

PHASE II: Integrate phase I algorithms with flight-ready hardware for real-time test and demonstration in controlled environments. Extend performance studies to real-time tests and validate phase I performance predictions. Conduct extensive algorithm refinement through a spiral development approach. Identify phase III transition partners.

PHASE III DUAL USE APPLICATIONS: Onboard collision-avoidance algorithms are critical to successful use of MAVs in urban environments. With this capability, MAVs could conduct a wide array of militarily significant missions such as BDI, reconnaissance, surveillance, and situational awareness in complex environments inappropriate to current UAVs. Commercial interest includes homeland defense, industrial robotics, and automated assistants.

REFERENCES:

1. R.C. Nelson et al., Obstacle Avoidance using flow field divergence, IEEE trans. On Pattern Analysis and Machine Intelligence, 11(10):1102-1106,1989

2. T. Gandhi et al., "Detection of Obstacles in flight path of an aircraft", Proceedings IEEE Computer Vision and Pattern Recognition, v2, p 304-311, 2000.

3. J. McCandless et al., "A predictive optical flow algorithm for aircraft detection", Proc of SPIE, v3522, p193-203, 1998.

KEYWORDS: collision avoidance, obstacle detection, micro-air vehicle, flight in urban terrain

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AF06-150 TITLE: 1.6 Hazard Class Detonator

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Significantly reduce the firing energy required to reliably initiate a 1.6 Hazard Class Extremely Insensitive Detonating Substance (EIDS) with an Exploding Foil Initiator (EFI).

DESCRIPTION: Investigate the feasibility of significantly reducing the firing energy required to reliably initiate a 1.6 Hazard Classification Extremely Insensitive Detonating Substance (EIDS) directly with an Exploding Foil Initiator (EFI). This technology would allow for a Logistics Reduction by incorporating the fuze into a 1.6 hazard class weapon during storage and transportation, which requires every article of explosive contained in the munition to meet the 1.6 Hazard Classification Criteria. Technology would allow for an Increase in Explosive Storage Capacity of full-up “wood round” munitions, and significantly lower Transportation Hazards that may be associated with full-up in-line explosive munitions in highly urbanized areas and sensitive aero space applications. Successful implementation of Technology will likely require, but is not limited to, thorough research and evaluation of the following areas: 1.) Explosive confinement methods and innovative activating processes to increase sensitivity to Exploding Foil Initiators; 2.) Evaluation and testing of ultra-fine triamino-trinitrobenzene (TATB), submicron Nitro-1,2,4-triazole-3-one (NTO) as well as other suitable Advanced Energetics Nano particle explosive materials; 3.) Use of Highly Efficient EFI Firesets that are optimized for accelerating large fliers. Fireset optimization will require research in EFI bridge materials, flier materials, as well as optimal inductance levels and capacitive discharge units (CDU's) for accelerating large fliers. Overall optimization will focus on reducing the electrical energy required to initiate an EIDS with an EFI down to a weaponizable level. Additionally, since the overall size of the CDU will be a major constraint for implementing technology within a reasonable design space, effort will also require packaging of all components within a volume comparable to that of a typical bomb fuze. Although effort will focus primarily on initiating EIDS materials, research will likely yield significant insight into the design of more robust and reliable, non-1.6 hazard classification detonators that are fully (Insensitive Munition) compliant and do not require placarding of Net Explosive Weight quantities of less than 1000 lbs.

PHASE I: Evaluate and test explosive confinement methods and innovative activating processes to increase the sensitivity of an EIDS such as triamino-trinitrobenzene (TATB)to Exploding Foil Initiators.

PHASE II: Phase II program will involve further research in significantly reducing the firing energy and a prototype demonstration of a fuze detonator.

DUAL USE COMMERCIALIZATION: Technology would likely be inserted into Insensitive Munition General Purpose Bomb Fuzes, and may have application in High Speed Penetrator (HSP)Weapons that require extremely insensitive in-line detonators.

Technology may also have applications in Harsh Thermal and Shock environments of Mining, Oil Drilling, and aerospace industries.

REFERENCES: 1. http://www.dscc.dla.mil/downloads/packaging/AFMAN24_204_I.pdf

2. http://www.findarticles.com/p/articles/mi_m0KAA/is_6_29/ai_78360369

KEYWORDS: 1.6 Hazard Classification Detonator, Insensitive Munition detonator, TATB (triamino-trinitrobenzene), Exploding Foil initiator (EFI), Improved Hazard Classification Detonator, Extremely Insensitive Detonating Subastance (EIDS) detonator

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AF06-151 TITLE: Synthetic alternative binder systems for melt castable explosive fills.

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a low-cost, domestic alternative for the Carnauba wax that is currently used as an ingredient in melt-castable binder systems.

DESCRIPTION: Carnauba wax is a naturally occurring, high ester content wax melting between 78 and 82 °C. The wax, along with a synthetic wax and a di-ester, plasticizing oil, is used as a melt-castable binder system for TNT, tritonal and Composition B explosives. A detailed description of usage, relative ratios of ingredients, and explosive compositions can be obtained from U.S. Patent No. 6,641,683. It is desired to have a low-cost, a good alternative for the Carnauba wax component. The wax may either be naturally occurring or synthetic, but must mimic the properties of Carnauba wax as closely as possible. The solid product must be tack free at 25 °C, show no signs of softening or melting below 60 °C, have a melting point between 78 and 90°C, and a weight loss upon drying of less than 0.25%. The product should be capable of retaining high concentrations (~50 weight percent) of ester-based oils such as dioctyl adipate, dioctyl sebecate, di-(isodecyl) pelargenate, and dioctyl azulate when subjected to thermal cycling between -40 and 65 °C. Product may be a mixture of components, surfactants, and/or oils, but must not phase separate or decompose when held in the molten state for periods of time in excess of two hours. Ideally, the viscosity of the molten wax should be as low as possible.These new explosive formulations have been designed to enhance insensitive munitions characteristics and weapons performance.Describe the synthetic production process and evaluate other commercial uses of both the synthetic and the natural alternative that would indicate its feasibility for use in explosives. Develop approaches to verify that material properties are sufficient and meet the specifications provided.

PHASE I: Identify both a natural alternative and a synthetic and compare the properties of each.

PHASE II: Process explosive compounds with the alternative and demonstrate its use through a limited set of explosive qualification testing to include rapid aging.

DUAL USE COMMERCIALIZATION: A successful demonstration of this technology has broad applicability to munitions and explosives safety. These new explosive compounds could improve manufacturing process control which has great potential for dual-use in mining, construction, and demolition applications.

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Cliff, Matthew D.

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4. ADD013168 "Melt-Castable Explosive Composition", DEPARTMENT OF THE AIR FORCE WASHINGTON DC, 22 MAY 1987, Spencer,Arthur F.

KEYWORDS: explosive binder, combustion compounds, melt-castable binders, explosive safety, energetic chemicals

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AF06-152 TITLE: <u>Telemetry and Flight Termination System Technologies</u>

TECHNOLOGY AREAS: Electronics, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Feasibility of a Low Cost Miniature Common Telemetry Unit and Flight Termination System to reduce specially instrumented stores, testing costs, and flight-testing missions.

DESCRIPTION: In order to flight test a munition or new weapon concept on DOD land ranges, the munition must be able to terminate flight at any point during a mission when safety becomes a concern. The objective of flight termination is to prevent the munition from transgressing the boundaries of a pre-determined permitted flight sector of the kinematic footprint, by "imposing conditions of zero lift, yaw and thrust. A Flight Termination System (FTS) limits the risk of the munition flying outside the pre-determined sector, due to its own possibility of failure. The Range Commanders Council has developed a common design and testing requirements standard, RCC 319-99 that details Flight Termination Systems for virtually all government test ranges. In addition the flight termination requirement, telemetry data must be collected in order to monitor and analyze the performance of the weapon. Munition flight safety officers depend on this information to tell them how the flight vehicle (missile) is performing according to predetermined parameters (including trajectory) and determine if the test should be terminated. Such constraints require that the telemetry system perform its duties flawlessly. Otherwise, a loss of property or life could occur. Currently open-air flight-testing, is heavily relied on for evaluating aircraft-stores certification. Presently, telemetry units and flight termination system used for testing are considerably large, costly and have to be specially instrumented for the different aircrafts and stores. Due to the rapid change in technology of aircrafts and store electronics the need for innovative instrumentation improvements are needed. Recent advances in miniaturizing electronics, i.e. field programmable gate arrays and micro-electromechanical systems, offer opportunities to reduce cost and risk of testing while providing accurate and reliable flight test data for validation of modeling and simulation tools. An additional benefit may also be gained in the area of parts obsolescence by obtaining the ability to use inventory stores for testing. The feasibility of developing a low cost miniature common telemetry unit and flight termination system, to get significant increase in testing and evaluation accuracy, is currently being investigated. The areas of particular interest are subminiaturizing individual components of the system (especially Inertial Navigation System, Joint Tactical Radio System-compatible radios, and Safe and Arm devices – work is currently being done on GPS, Telemetry and Flight Termination Receiver/Decoder), which can be integrated into a complete telemetry and flight termination solution. The entire system will need to be around 10-15 cubic inches, so each component will have to be a fraction of that in order to be truly subminiature and must be able to be integrated into the telemetry and flight termination system.

PHASE I: Perform innovative analysis to determine effectiveness and technical feasibility of a low cost miniature component of a common telemetry unit and flight termination system.

PHASE II: Develop and demonstrate an innovative prototype of the most promising concept in Phase I.

PHASE III DUAL USE APPLICATIONS: Miniature Common Telemetry Unit and Flight Termination System has several commercial and military applications – for example telemetry units may be used in the medical field to monitor cardiac conditions of patients. Miniature Common Telemetry Units may also assist in new space missions with NASA.

REFERENCES:

1. Explosive Safety Procedure for Static Ejection System(EOP 7303-22), July 1999

2. Technical Order 11A18-7-7. Aircraft External Stores Jettison Impulse Cartridges

3. IRIG Standard 106-96

KEYWORDS: Telemetry, Flight Termination System, FPGA, Flight Testing, common data link

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AF06-153 TITLE: Novel Thermal Management Solutions for Confined Electronics

TECHNOLOGY AREAS: Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Design, build, and demonstrate a thermal management solution for electronics in confined spaces.

DESCRIPTION: The increasing use of aircraft in the U. S. Air Force with internal storage of munitions has introduced a challenging requirement for the development of future weapons systems. The available volume for these munitions has decreased dramatically with no reduction in the required performance of the munition (e.g., lethality and accuracy); an example of a weapon system designed with these constraints in mind is the Small Diameter Bomb (SDB) [1]. The same general constraints also apply to submunitions and all other miniaturized munitions applications.

One of the challenges associated with decreasing volume and increased performance demands is the generation of heat by electronics in a confined space [2, 3]. As temperature increases, semiconductor-based electronics begin to lose function and can ultimately fail. Compounding the problem, the volumetric power generation increases linearly with the inverse volume while other heat transfer properties, such as the heat transfer coefficient between a heat sink and a confined air volume, scale differently with characteristic dimensions and are strongly dependent on geometry. An example is free convection between two adjacent planar surfaces; the scaling varies strongly with the fluid flow properties (including temperature) and is highly nonlinear (approximately scaling with the tenth root of the wall separation) [4].

System thermal management for electronic systems is generally accomplished through a combination of passive design (i.e., optimizing the layout of the boards, integrated circuit elements, supporting structures, etc.) and active cooling. However, the limited available volume (typically around 500 cm^3) and large number of required critical components creates a significant challenge for miniaturized munitions: only a limited number of configurations are possible that maintain the designed functionality. Electronics in miniaturized munitions are thus approaching a critical threshold where the power density exceeds the ability to effectively manage the heat flow with conventional solutions.

An additional complication is the need to implement this solution in a cost-effective and easily-maintained manner. The design impact of the system(s) designed for this SBIR, such as the system weight and power requirements, needs to be minimized to maintain a broad applicability and remain a viable solution for a variety of munitions systems.

This SBIR thus seeks to identify novel, cost-effective, efficient thermal management solutions capable of dissipating up to 50 W of total thermal power in tightly-packed (< 5 mm spacing) electronics in completely enclosed small volumes (< 500 cm^3 total volume in a cylinder of 5 cm diameter) without modifying the electronics themselves. Specific approaches can include active or passive heat transfer schemes. Likewise, introduction of novel materials or geometries are encouraged. A successful design will be simultaneously optimized for performance and design impact.

PHASE I: 1) Design effective thermal management solutions for electronics confined in small spaces. 2) Analyze the performance of the system using representative operational conditions and simulated electronics.

PHASE II: Characterize and optimize system operation in simulated operational environments.

PHASE III DUAL USE APPLICATIONS: A successful demonstration of this technology has broad applicability to munitions and other military technology areas, including ground, air, and space vehicles. There is great potential for dual-use of this scheme in commercial robotics, aeronautics, and space electronics.

REFERENCES:

1. Lok, J. J., 2004, “Small size, massive consequence,” Jane’s Intl Defense Review (01 Dec 2004).

2. Ibrahim, A. M., 1992, “Fabrication, testing, and evaluation of high-thermal-conductivity, lightweight polymer composites reinforced with pitch-graphite fibers as heat sinks for high-density packaging applications” Intl SAMPE Elect Conf, 6, pp. 556-567.

3. Beasley, K. G., 1992, “Composites for thermal management in U.S. Navy's electronic packaging”, Intl SAMPE Elect Conf, 6, pp. 568-577.

4. Bejan, A., 2001, Heat Transfer, Wiley, New York, pp. 335-397.

KEYWORDS: Thermal management, heat transfer, temperature, electronics, heat generation, conduction, radiation, convection, munitions, missiles, bombs.

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AF06-162 TITLE: Identification of Integrally Bladed Rotor (IBR) Damping

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Accurately measuring the structural damping of an IBR or blisk, for design and maintenance of aircraft engines.

DESCRIPTION: Due to funding and scheduling limitations, current testing for different IBR damping techniques and treatments has been forced to be accomplished simultaneously on a single IBR. Much like IBRs in service, the rotors become mistuned and the modal response is highly coupled. There is no accurate, reliable method for extracting the individual contributions of each damping treatment to the response of its applied blade. At best, engineers can only measure the change in amplitude from current instrumentation. This amplitude reduction is not an accurate method to determine the damping effectiveness of a given treatment. Develop the technologies that will facilitate the accurate measurement of damping effectiveness and response amplitude of engine hardware. It is of importance that the technology be robust enough to measure rotating hardware in environments representative of a turbine engine. The approach must also incorporate damping, amplitude, and frequency for results to have value. The technologies developed and demonstrated under this proposal will provide a quantitative identification of response amplitude and damping of IBRs enabling better design and maintenance practices for both future and legacy engines. Studies have shown that it is also possible to detect cracked or failing engine hardware by measuring the change in structural damping. Detection of failing engine hardware is critical for both test and service engines.

PHASE I: Demonstrate the feasibility of an approach to measure the response and damping effectiveness of an academic IBR with multiple treatments simultaneously applied to an academic IBR at a bench level.

PHASE II: Demonstrate an approach to measure the response and damping effectiveness of an engine IBR with multiple treatments simultaneously applied to engine hardware in a rig level test.

DUAL USE COMMERCIALIZATION: Phase III goals will involve the transition of the technology as a design and inspection tool for both commercial and military applications. Military and commercial applications of this technology include the design, maintenance, and damage detection of hardware for turbine engines.

REFERENCES: 1. Feiner, D. M., and Griffin, J. H., “A Completely Experimental Method of Mistuning Identification in Integrally Bladed Rotors,” Proceedings of the 8th national Turbine Engine High Cycle Fatigue Conference, Monterey, CA, 2003.

2. Mignolet, M. P., and Lin, C. – C., “Identification of Structural Parameters in Mistuned Bladed Disks,” ASME Journal of Vibration and Acoustics, 119, pp. 428-438, 1997.

KEYWORDS: integrally bladed rotor, blisk, damping, mistuning, response, veering, mode shape

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AF06-163 TITLE: Thermal Barrier Coatings (TBC) Lifing Technologies

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and demonstrate accurate, quantitative lifing methods for thermal barrier coated engine components to maximize the use life of such systems.

DESCRIPTION: Despite the development of advanced, high-temperature materials, engine designers and users will continue to depend on TBC systems to ensure engine hot section component durability and life. There are no accurate, reliable methods for tracking and predicting the remaining durability and remaining life of thermal barrier-coated components, so many parts are being retired at arbitrary intervals rather than for cause.

Develop technologies that 1) ensure the gathering of data relating to TBC structural integrity, 2) provide for the fusion, accuracy, and transmission of data to external data processing systems, 3) analyze the data obtained from 1) and 2) versus expectations to create the information being provided to the engine maintainers, and 4) package the information so that engine maintainers can make well-informed hardware decisions. These technologies may include, but are not be limited to, the following areas of interest:

- Built-in, quantitative materials-condition-sensors which are capable of withstanding/operating under engine conditions.
- Development and validation of improved TBC damage progression/life prediction models that can handle inputs from the materials-condition-sensing systems.
- Real-time, quantitative materials-condition sensing systems with capability for remote sensing/data transmission from the thermal barrier-coated component to an external data processing system and/or engine control system.
- Modifications to coating fabrication processes to incorporate smart sensing systems that can be interfaced with external data processing systems and serve as a means for quality assurance during coating fabrication as well as materials-condition monitoring in the fielded components.

The environment of the commercial turbine is not the same as the military system and changes should be made to reflect those differences.

PHASE I: Provide proof of concept system that demonstrates the feasibility of the approach. Development of an analytical life prediction system. Validation of that system in initial specimen tests. Original equipment manufacturer (OEM) TBC specimens would demonstrate relevance.

PHASE II: Conduct a rig level test validating the approach as an effective means to monitor/inspect/determine TBC health in a relevant environment. The analytical system will be applicable to an OEM design system.

DUAL USE COMMERCIALIZATION: Commercial applications of these methods include the procurement and maintenance of thermal barrier-coated components for ground, sea, and air-based propulsion and power generation systems. Government uses of this technology are the same, but also include the ability to provide logistical support for our military forces.

REFERENCES: 1. Trubelja, Mladen F., Nissley, David M., Bornstein, Norman S., and Marcin, Jeanine T. D., "Pratt & Whitney Thermal Barrier Coating Development," in 1997 Conference Proceedings of the Advanced Turbine

Systems Annual Program Review Meeting, http://www.netl.doe.gov/publications/proceedings/97/97ats/ats_pdf/ATS5-9.PDF

2. Coatings for High-Temperature Structural Materials: Trends and Opportunities. Washington, D.C. : National Academy Press, 1996. ISBN: 0309053811

KEYWORDS: thermal barrier coating, life prediction, oxidation, TBC, turbines, hot section, creep.

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AF06-164 TITLE: Development of Hydrocarbon-Based Solid Oxide Fuel Cells (SOFCs)

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Produce a high-temperature fuel cell that is capable of internal electrochemical conversion of aviation logistic (JP-8) fuel.

DESCRIPTION: Solid oxide fuel cells (SOFCs) are devices which permit the electrochemical conversion of chemical fuels to electricity. Solid ion conducting electrolytes require elevated temperatures (> 500°C) to generate sufficient ion mobility. To date, the development of SOFCs have primarily focused on using either hydrogen or syngas due to the incompatibility of the current material for sustained hydrocarbon oxidation. This limitation must be resolved prior to the consideration of fuel cells for power-dense applications, such as auxiliary power units (APU) for aircraft and unmanned aerial vehicles (UAV). Fundamental internal hydrocarbon reforming studies on SOFC electrodes have been limited in scope. Furthermore, a comprehensive study of the oxygen/hydrogen ion mobility mechanism in binary or ternary anode formulations has yet to be performed. This topic seeks to examine the phenomenon associated with these issues to identify an appropriate anode formulation which promotes the direct conversion of aviation logistic (JP-8) fuels, as well as demonstrate the capability of the proposed solution at the multicell level. One of the main problems that prevent a sustained direct oxidation in SOFCs is the tendency of anodes to catalyze carbon formation. Sulfur tolerance is also another important aspect when using hydrocarbons leading to catalyst deactivation. Computational methods which seek to examine the fundamental properties of JP-8 oxidation of various anode compositions are encouraged. Optimal architecture of the catalytic surface and anode components must be considered. Efficiency will be based on the number of electrons liberated per molecule of fuel. Modeling efforts shall provide an effective description of the chemical kinetic and reaction pathway interactions of the logistic fuel on the catalytic surface.

PHASE I: Demonstrate an appropriate anode formulation for promoting an efficient direct electrochemical conversion of logistic fuels.

PHASE II: Experimentally validate the appropriate anode formulation to completely optimize the catalyst formulation. Investigate flow fields for reactant diffusion as well as properly designed multicell configurations shall be done at the conclusion. Required Phase II deliverables shall include a multicell stack which demonstrates the proposed concepts to be delivered to AFRL/PRPS.

DUAL USE COMMERCIALIZATION: Anticipated dual use applications include aircraft APUs and diesel-fueled auxiliary power units in both the military and commercial aviation industry.

REFERENCES: 1. Fuel Cell Handbook, 5th ed., U.S. Department of Energy, NETL, Prepared under contract DE-AM26-99FT40575 (2000).

2. Gorte, R.J., and J.M. Vohs, "Novel SOFC Anodes for the Direct Electochemical Oxidation of Hydrocarbons," J. Catalysis, 216, pp. 477 (2000).

3. Maurice, L.Q., H. Lander, T. Edwards, and W.E. Harrison III, "Advanced Aviation Fuels: a look ahead via a historical perspective," Fuel, 80, pp. 747-756 (2001).

KEYWORDS: solid oxide fuel cells, catalysis, electrochemistry, computational modeling and simulation, direct oxidation, direct solid oxide fuel cells, direct fuel cell

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AF06-165 TITLE: Low-Weight, Low-Cost Sensors and Low-Overhead Processing Algorithms for Damage Detection in Aircraft Disk and Blade Propulsion Turbomachinery

TECHNOLOGY AREAS: Air Platform, Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop alternate/lower cost/lower weight/higher temperature/less processing-intensive sensors/algorithms for fighter propulsion system prognostic health management (PHM) blade and disk applications.

DESCRIPTION: PHM technology for damage detection in blades has undergone significant development in recent years. Advanced blade health techniques for on-engine applications include, inductive, microwave and active optical systems. These non-intrusive technologies measure small blade displacements (1 micron) and resonant mode frequencies up to 10Khz. The interferometric measurements or magnetic flux distributions are used to provide frequency, phase, displacement, and timing information. Signal processing is accomplished at locations distant from the sensor. Alternate lower cost and lower weight sensors using less processing intensive algorithms are desired. The sensors must operate in the engine compressor (1200 F) or turbine (3600 F) temperature environment. Algorithms employed must provide results at appropriate update rates for the engine system (1Hz for monitoring and 30Hz for control). Processing capability can be estimated by considering state-of-the-art gate array devices and microcontrollers as a baseline. Development of advanced material acoustic, piezoelectric, electromagnetic, and optical devices is appropriate. Micro-Electrical-Mechanical-System (MEMS) approaches for implementation are also appropriate. This topic should first focus on achieving these goals for blade health. The second objective would be to also apply blade health or similar technologies to the disk cracking issue.

PHASE I: Determine feasibility of providing alternate/lower cost/lower weight/higher temperature/less processing-intensive sensors/algorithms for fighter propulsion system PHM blade/disk health applications. Identify most promising combination of sensors/algorithms to achieve the desired approach.

PHASE II: Develop, validate and demonstrate a final application for the recommended combination produced in Phase I. Demonstrate the capability of the prototype equipment on a fighter propulsion blade and disk test cell.

DUAL USE COMMERCIALIZATION: Potential military and commercial applications include ground and shipboard turbines and unmanned air vehicles.

REFERENCES: 1. Haase, Wayne, Roberge James K., "Detection and Characterization of Blade/Disk cracks in operational Turbine Engines," IEEE Aerospace Conference, Big Sky, Montana, 2003.

2. Wade, Richard A., “A Need-focused Approach to Air Force Engine Health Management Research,” IEEE Aerospace Conference, Big Sky, Montana, 2005.

KEYWORDS: diagnostics, prognostics, high-cycle fatigue, useful remaining life, lade health, PHM

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AF06-166 TITLE: Accessory Health Management Based on Very High Frequency (VHF) Characteristics

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop advanced PHM capabilities for propulsion system/accessory components, based on VHF (25 to 1000kHz) characteristics, to provide health assessments/remaining life predictions.

DESCRIPTION: To fully enable the predictive element of any prognostics and health management (PHM) concept, there has to be a capability to relate detected incipient fault conditions to accurate useful life remaining predictions for any point in time. The key to accomplishing this is being able to understand incipient fault-to-failure progression characteristics for the component and/or subsystem of interest and having realistic and verifiable prognostic models.

The systems and components of interest in this topic are gas turbine engine propulsion system and rotating accessory components (such as pumps, generators, and motors) with particular reference to those on the main thrust engine and lift fan. It is important that the user be able to diagnose faults accurately and predict failures and life remaining of these components to ensure safety, maximize chances of mission success, generate high availability, and reduce costs. This may be accomplished through the merging of an understanding of the component's particular physics of failure, analytical models, physical models, statistical techniques and actual failure experience data.

Develop, demonstrate, and apply these advanced prognostic and useful life remaining techniques in support of the predictive element of PHM on main thrust engine and lift fan accessory components. There appears to be useful diagnostic and prognostic information embedded in VHF vibration signatures (25 to 1000kHz). Plans to work with an aero-engine original equipment manufacturer (OEM) to develop and integrate the resulting technologies would be essential. Once they are mature, it should be possible to read the resulting principles and techniques across to many other aircraft rotating mechanical system components.

PHASE I: Investigate, analyze, and define the benefits of using VHF vibration information for PHM. Define advanced analysis techniques/sensors/system architecture needed to relate diagnostic/prognostic capabilities to VHF characteristics of fighter propulsion systems/accessory components.

PHASE II: Develop and demonstrate a prototype VHF data acquisition and analysis capability based on these advanced techniques for fighter propulsion system/lift fan accessory components. Assess the application boundaries, accuracy, and limitations for these prototypes. Provide recommendations on specific fighter applications, e.g., in-flight, ground-based, test cell instrumentation, etc.

DUAL USE COMMERCIALIZATION: Potential commercial and military applications include health management for all types of gas turbine engine.

REFERENCES: 1. Wade, Richard A., "A Need-focused Approach to Air Force Engine Health Management Research," IEEE Aerospace Conference, Big Sky, Montana, 2005.

2. Jonathan S. Litt, Donald L. Simon, Sanjay Garg, Ten-Heui Guo, Carolyn Mercer, Richard Millar, Alireza Behbahani, Anupa Bajwa, and Daniel T. Jensen, "A Survey of Intelligent Control and Health Management Technologies for Aircraft Propulsion Systems," Journal of Aerospace Computing, Information, and Communication, Vol. 1, December 2004.

KEYWORDS: diagnostics, prognostics, VHF vibration techniques, useful remaining life, PHM, EHM

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AF06-167 TITLE: Sensor and Control for Active Combustion Pattern Factor Systems

TECHNOLOGY AREAS: Air Platform

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a conceptual design of a control system for pattern factor control.

DESCRIPTION: Turbine temperature margins, in advanced engines, are large to accommodate performance over a wide operating range, aging phenomenon, life, and design characteristics. However, wide margins impose a significant performance penalty. A major reason for existing margins is the inability to design and control optimal combustion pattern factor. Pattern factor is a combustor system design parameter which describes the turbine inlet temperature pattern in terms of the peak temperature and the average thermodynamic temperature relative to the burner temperature rise. Pattern factor may be used to describe variations from engine-to-engine in a fleet, or the hot streak generated by a defective fuel atomizer during the life of an engine. The design intent is to achieve uniform temperature, equalizing the peaks generated behind an atomizer. Regardless of how the combustion system is designed, or the number of tests conducted in the development phase, the engine manufacturer cannot know the pattern factor in any specific engine that is shipped. It is likely that some of these engines have pattern factors that even exceed the design goal, reducing the expected life of the hot section. Once in service, the atomizer and combustor conditions deteriorate with no means of determining the degraded spray pattern or the effect on the temperature pattern. An opportunity exists for the reliable detection of abnormal pattern factors to provide reduced fuel flow through the offending fuel nozzle, hence reducing the peak temperature. Combustor pattern factor control is one of the most promising technologies to meet the Versatile Affordable Advanced Turbine Engines (VAATE) intelligent engine goals. Effective pattern factor control requires advances in several technology areas including, reliable sensing of turbine temperature, accurate detection of hot streaks and precise control of the fuel flow to reduce/eliminate these hot streaks. It is appropriate to evaluate high-temperature sensing approaches. Investigation of networked multisensor approaches to measure flow distortion is appropriate. Development of conceptual fuel control algorithms is recommended. Expect requirements for hardware with moderate (100Hz) frequency capability to modulate fuel flow. Although this concept is applicable to future propulsion systems in the VAATE perspective, it also applies to legacy and helicopter engines. Recommend support and collaboration with a turbine engine company. In the next 20 years, there is more opportunity to reduce sustainment costs in legacy aircraft than in new aircraft. Potential benefits include reducing peak turbine inlet temperature (T4) uncertainty, power density improvement, extended turbine blade life, reduced life-cycle cost, and improved combustor lean blowout performance. The conceptual design should consider the turbine engine environmental constraints.

PHASE I: Development of a conceptual design of flight-worthy combustion pattern factor sensors and control. An evaluation of the technologies required for control strategy and nonintrusive sensor hardware such as passive optics should be accomplished considering turbine engine environmental constraints.

PHASE II: Design, fabricate, and test a prototype implementation employing the technologies investigated in the phase I effort. Fabrication of a prototype combustion pattern factor control is reasonable.

DUAL USE COMMERCIALIZATION: Potential commercial and military applications include aircraft, ground-based turbines, instrumentation and test equipment.

REFERENCES: 1. Jaw., L. and Mink G., "Intelligent Engine Study," paper presented at the 2003 ISABE (International Symposium on Air Breathing Engines) September 2003.

2. Lovett J., Kiel., B., and Brogan, T., "Development Needs For Advanced Afterburner Designs," AIAA,40th Joint Propulsion Conference, July 11-14, 2004, Fort Lauderdale, FL.

KEYWORDS: active control, combustion control, control optimization, turbine engine control, combustion system, pattern factor, combustion sensors

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AF06-168 TITLE: Thermal Barrier Coating (TBC) Process Condition Monitoring

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Improve TBC process reliability by monitoring process conditions.

DESCRIPTION: In spite of the turbine engine users' increasing dependence on a reliable TBC to maintain their components' durability and life, the process of applying this coating is still subject to variables that are not all that well understood, and are therefore not entirely under the control of the processor. This process variability is especially problematic when coating complex shapes such as turbine airfoils or combustor nozzles. A previously funded intelligent manufacturing program in the early 1990s highlighted the need for the incorporation of condition sensors into the production process to facilitate the development of a more reproducible process. The goal of this program is to define, demonstrate, and validate sensors that can be used on production equipment. Examples of sensors that would be of interest are 1) part temperature (during preheating and during coating), 2) deposition flux, and 3) deposition pressure. The anticipated benefits of this technology include improved coating reliability, lower acquisition and maintenance costs, reduced rework, and increased capacity. Since this program involves the coating manufacturing equipment, it is highly recommended that the development team include a coating manufacturer as an active participant.

PHASE I: Determine technical feasibility of integrating existing operating condition sensors into the TBC manufacturing process.

PHASE II: Produce a pilot production process incorporating these sensors.

DUAL USE COMMERCIALIZATION: The potential military applications for this technology include both the original equipment manufacturing and depot maintenance refurbishment of thermal barrier coated components for existing and advanced fighter, bomber, and helicopter engines. The potential commercial applications include manufacturing and end-user refurbishment of thermal-barrier-coated components in commercial aircraft and ground-based power generators.

REFERENCES: 1. Yanar, N. M., Pettit, F. S., and Meier, G. H., “Effects of bond coat processing on the durability of thermal barrier coatings,” Material Sciences Forum, Switzerland, Vol. 426-432, part 3, pp. 2453-2458, Trans Tech Publications, 2003.

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4. Leger, A. C., Wigren, J., and Hansson, M. O., “Development of a process window for a NiCoCrAlY plasma-sprayed coating,” Surface & Coatings Technology, 1998 , Vol. 109, No. 1-3, pp. 86-92, October 10, 1998.

5. Novak, R. C., “Processing aspects of plasma sprayed ceramic coatings,” Journal of Engineering for Gas Turbines and Power, Transactions of the ASME, Vol. 110, No. 4, pp. 617-620, Oct 1988.

KEYWORDS: thermal barrier coating, TBC, thermal barrier coating process, manufacturing process control, sensors, condition monitoring, quality assurance

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AF06-169 TITLE: Smart Ceramic Matrix Composite (CMC) Technologies

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop CMC turbine engine monitoring components for tracking the durability and life of turbine engine components at operating conditions.

DESCRIPTION: For years, engine designers and users have realized that the engine cycle efficiency tends to improve with increasing overall pressure ratios. Taken far enough, this can, in turn, drive up the hot section (combustor and turbine) temperatures until high-temperature-capable CMC materials become an attractive candidate. However, in addition to their much vaunted high specific strengths, high-temperature-capable CMC materials are very sensitive to thermalmechanical stresses, and to local flaws in the fibers and matrix. Thus, the present inability to accurately monitor these conditions is also limiting our ability to track and predict the remaining durability and remaining life of CMC components, with the result that original equipment manufacturers (OEMs) and users alike are very reluctant to take advantage of the high temperature capabilities of CMC materials.

Develop technologies that 1) ensure the gathering of data relating to CMC structural integrity, 2) provide for the fusion, accuracy, and transmission of the data to external data processing systems, 3) analyze the data obtained from 1) and 2) versus expectations to create the information being provided to the engine maintainers, and 4) package the information in a form that will enable the engine maintainers to make well-informed hardware decisions. These technologies may include, but are not be limited to, the following areas of interest:
• Built-in, quantitative materials-condition-sensors which are capable of withstanding/operating under engine conditions.
• Development and validation of improved CMC damage progression/life prediction models that can handle inputs from the materials-condition-sensing systems.
• Real-time, quantitative materials-condition sensing systems with capability for remote sensing/data transmission from the thermal barrier coated component to an external data processing system and/or engine control system.
• Modifications to coating fabrication processes to incorporate smart sensing systems that can be interfaced with external data processing systems, and serve as a means for quality assurance during fabrication as well as materials-condition monitoring in the fielded components. The technologies developed and demonstrated under this topic will

include accurate, quantitative lifing methods that will enable the engine users/maintainers to maximize the use life of their CMC engine components.

PHASE I: Produce a proof of concept system that demonstrates the feasibility of the CMC component health/condition monitoring approach.

PHASE II: Develop a prototype CMC health/condition monitoring system and perform a demonstration rig test of the system at near-engine conditions.

DUAL USE COMMERCIALIZATION: Commercial applications of these methods include the procurement and maintenance of CMC components for ground-based, sea-based, and air-based propulsion and power generation systems. Government uses of this technology are the same, but also include the ability to provide logistical support for our military forces.

REFERENCES: 1. Schulz, Mark J., Sundaresan, Mannur J., Ghoshal, Anindya, and Pai, P. Frank, "Active fiber composites for structural health monitoring," Proceedings of SPIE - The International Society for Optical Engineering, Vol 3992, 19000306-19000309, Society of Photo-Optical Instrumentation Engineers, Bellingham, WA, USA, pp. 13-24, 2000.

2. Blanas, Panagiotis and Das-Gupta, Dilip K, "Composite piezoelectric sensors for smart composite structures," 19990922-19990924, IEEE Dielectrics and Electrical Insulation Society, Proceedings - International Symposium on Electrets, Delphi, Greece, pp. 731-734, 1999.

3. Sundaresan, M. J., Pai, P. F., Ghoshal, A., Schulz, M. J., Ferguson, F., and Chung, J. H., "Methods of distributed sensing for health monitoring of composite material structures," Composites - Part A: Applied Science and Manufacturing Vol 32, No 9, September 2001, pp. 1357-1374.

4. Nenov, T. and Nenova, Z., " Multifunctional temperature sensor," Proceedings of 23rd International Conference on Microelectronics (MIEL 2002), IEEE Electron Devices Soc., IEEE-Solid-State Circuits Soc, 12-15 May 2002, Nis, Yugoslavia, Cat No 02TH8595, Vol 1, pp. 257-260.

KEYWORDS: ceramic matrix composite, CMC, high-temperature sensors, instrumentation, condition monitoring, health management, turbine engines, turbines, combustors, augmentors, exhaust nozzles

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AF06-170 TITLE: Energy Harvesters/Storage System for Onboard Power for Remote Micro-electromechanical Systems (MEMS) Sensors/Devices with Long Mission Times

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an energy harvester system to provide power for remote sensors. Significant lifetimes considered would range from minutes to months to permanent installations.

DESCRIPTION: Utilizing modern MEMS techniques, it is possible to make very small, inexpensive sensors. It is desirable, if not necessary, to provide very small power systems for these devices to perform practical missions because delivering vehicle power can be prohibitively expensive or heavy. Even though the power systems need to be dimensionally small, they need to function for a significant period of time. This topic seeks to couple energy storage devices with energy harvester devices, or some other innovative approach that can provide onboard power for these small devices over extended periods of time. The warfighter needs this power to monitor the health of vehicle systems in locations where is it is impractical or impossible to provide wire power or communications. This would be useful to monitor systems not connected to databuses or power systems, and to provide an easier retrofit capability on legacy vehicles. This technology could also provide similar capabilities in civilian vehicle system monitoring technologies. The prime consideration must be deliverable hardware, a working energy harvester or energy generator combined with an energy storage system and a clear demonstration of a manufacturable device, component or system that improves the existing technology either through exceptionally high performance (maximum output 2 watts), improved lifetime (active lifetime > 1 year), significantly reduced cost (< $100.00), or significantly reduced weight (weight < 50 grams).

PHASE I: Define the proposed concept, predict the performance of the proposed design, and through analysis and testing, demonstrate performance over a significant period of performance. Plans should be prepared to demonstrate how the devices could be made robust enough for field use.

PHASE II: Provide an operable prototype component or system that is completely suitable for the intended application. Identify suitable open architectures for communication if not already built into prototype.

DUAL USE COMMERCIALIZATION: This technology is applicable to health monitoring technologies for new and legacy vehicles in the aerospace, transportation, and space industries.

REFERENCES: 1. David M. Ryan, Rod LaFollette, and Linton Salmon, "Microscopic Batteries For Micro ElectroMechanical Systems (MEMS)," Proceedings of 32nd IECEC, 97-8, 97136, Honolulu, HI, (1997).

2. J. B. Bates, D. Lubben, and N. J. Dubney, “Thin Film Li-LiMn2O4 Batteries,” Proceedings of the Tenth Annual Battery Conference on Applications and Advances, Chem Abstr, 122, 19238h, (1995).

KEYWORDS: MEMS, micro-, power, battery, energy harvester, surveillance, sensors

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AF06-171 TITLE: Health Management for Gas Turbine Engine Accessory Components

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop effective and efficient systems to manage the health of gas turbine engine accessory components in real time.

DESCRIPTION: Much research effort has been applied to the problems of symptomatics (condition monitoring), diagnostics, and prognostics of the major gas turbine engine turbomachinery components (which include disks, blades, and main bearings) and also to general engine health. This is to be expected because these components are expensive to maintain, and their failure frequently has safety implications. However, it is the minor (external) electrical, hydraulic, and pneumatic accessory components, such as valves, pumps and actuators, whose degradation, faults, and failures lead to the majority of events that compromise mission success and availability, and less research attention has traditionally been focused on these. The perception is that they are relatively inexpensive and easy to change, where in reality their overhaul costs mount up and nowadays whole engines may be changed in a shorter elapsed time.

Low overhead techniques are needed that could reliably confirm the health of these accessory components, foresee when they were heading toward failure, and then alert maintainers so that pre-emptive action could be taken. Such capabilities could enhance mission success by pre-empting in-flight component failures. They would also revolutionize availability/mission readiness by improving mission reliability and enhance maintainability (by providing better information for problem diagnosis and planning). In other words, commanders could designate specific weapons systems for missions in the confidence that they would not crew-out; they would not need to hold assets as backups and so would maximize the use of inventory; and such components could be changed before they failed, and at a time convenient to the operational organization.

This topic is searching for innovative, reliable, low-overhead techniques that could identify the early signs of failure of gas turbine engine accessory components identified above. Proposals may focus on a range of components. Solutions should aim not to rely upon significant off-board support, but might, for instance, apply novel algorithms to existing signal inputs and outputs of the accessory components, or low-cost sensing devices that may easily be retrofitted.

PHASE I: Develop proof-of-concept techniques and algorithms for the effective and efficient real-time health management of engine accessory components.

PHASE II: Develop accessory health management techniques and algorithms toward demonstration (probably a combination of on-engine and simulation) so that a product may be produced that can be integrated into a real gas turbine engine.

DUAL USE COMMERCIALIZATION: Potential commercial and military applications include gas turbine engine systems for aerospace usage and ground-based support equipment.

REFERENCES: 1. Wade, Richard A., “A Need-focused Approach to Air Force Engine Health Management Research,” IEEE Aerospace Conference, Big Sky, Montana, 2005.

2. Jonathan S. Litt, Donald L. Simon, Sanjay Garg, Ten-Heui Guo, Carolyn Mercer, Richard Millar, Alireza Behbahani, Anupa Bajwa, and Daniel T. Jensen, “A Survey of Intelligent Control and Health Management Technologies for Aircraft Propulsion Systems,” Journal of Aerospace Computing, Information, and Communication, Vol. 1, December 2004.

KEYWORDS: gas turbine, aero engine, accessories, externals, ancillary components, health management

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AF06-172 TITLE: Probabilistic Analysis of Military System Development Program

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Perform a detailed statistical analysis of the system development and demonstration (SDD) program for a military gas turbine engine.

DESCRIPTION: The qualification of a new military gas turbine engine involves the fabrication and assembly of 10 or more prototype hardware sets and thousands of engine test hours. The cost of a current engine development programs is becoming a prohibitive factor in deciding whether to develop a new engine. One possible approach to reducing costs is to rely more on comprehensive, advanced three-dimensional (3-D) modeling analyses, such as computational fluid dynamics (CFD) analysis, and less on actual hardware tests. If this approach is to be viable and credible, these models will need to be highly accurate. The principal focus of this activity will be to determine the level of accuracy required, and as a consequence of the level of accuracy, how many test articles are required. The hypothesis would be that the results of the SDD program ensure that the engine will meet or surpass all operational requirements in fielded service. Determine the accuracy requirements of the performance prediction models comprising a virtual engine test cell.

PHASE I: Formulate the methodology that expresses the military engine SDD program as a statistical hypothesis test.

PHASE II: Produce a reliable, documented software tool to specify the performance validation activities required in a SDD program for a military gas turbine engine using a virtual engine test cell concept. Apply the analytical processes developed in Phase I to the complete spectrum of test requirements in a SDD program.

DUAL USE COMMERCIALIZATION: The Federal Aviation Administration Certification Process for civil commercial aviation is very similar to the SDD program for a military gas turbine engines, and the processes developed would directly apply.

REFERENCES: 1. May, R. J. and Smith, Maj. M. F., "Development Concept for Advanced Fighter Engines," 83-1298, 19th Joint Propulsion Conference, Seattle, WA, July 1997.

2. Skira, C.A., "Reducing Military Aircraft Engine Development Cost through Modeling and Simulation," RTO/AVT Symposium, Paris, France, 22-25, April 2002.

KEYWORDS: system development and demonstration (SDD) program, virtual engine test cell, engine development program, gas turbine engine, computational fluid dynamics (CFD), performance validation

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AF06-173 TITLE: Exploration of Lithium-Ion (Li-Ion) Battery for Space Application

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Design, develop, and test Li-Ion battery technology to demonstrate tolerance to overdischarge and improvements in life-limiting characteristics such as cycle iterations and calendar time.

DESCRIPTION: Space radar payload systems are expected to be operational for a minimum of 10 years. Batteries are typically the heaviest and most life-limiting component within the satellite power system. Li-ion technology has demonstrated a significant weight advantage over presently used batteries, but improvements in cycle and calendar life are required to transition the technology to widespread use onboard military satellites. Low earth orbit (LEO) satellite programs require over 30,000 cycles, at low depth of discharge, and geosynchronous earth orbit (GEO) programs require 10 to 20 years of battery life. Long-term cycling and long calendar life have yet to be demonstrated in Li-ion systems. There are fundamental questions pertaining to the stability of the materials, corrosion, and parasitic degradation reactions that still need to be answered before guaranteeing long-term stability. Life-limiting mechanisms need to be identified and investigation of new materials to extend performance lifetimes is required to achieve the desired lifetimes. For example, premature cell failure can occur after an inadvertent overdischarge, or overvoltage on charge can significantly reduce usable capacity. Propose and incorporate solutions into experimental cells of at least 2 ampere-hour size cells to demonstrate potential improvement. Initial experiments may be performed on cells of capacity less than 2 ampere-hours. However, the final test samples of Phase I shall be at least 2 ampere-hours. Propose a test plan to verify life cycle.

PHASE I: Identify life-limiting mechanisms of Li-ion battery technology for military satellite applications.

PHASE II: Incorporate and iterate the best identified solutions to enhanced life to the Li-ion system. Fabricate and test cells to demonstrate (project) enhanced life time. Conduct a design analysis to scale up the improved cell chemistry to at least 50-ampere-hour capacity. Perform life cycle test for suitability in military space application.

DUAL USE COMMERCIALIZATION: This battery power system has a great potential for commercial and military satellite applications.

REFERENCES: 1. Handbook of Batteries, Third Edition, McGraw Hill, Linden and Reddy, New York, NY, pp. 34.1-35.90, 2002.

2. Paul Bauer, "Batteries For Space Power Systems," NASA-SP-172, Washington, D.C., 1968.

KEYWORDS: space-based radar, spacecraft, space power supply, space battery, satellite power system, satellite, Lithium-ion batteries

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AF06-174 TITLE: Power and Aeropropulsion

TECHNOLOGY AREAS: Air Platform

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 innovative technologies that provide improvements in
small air vehicle propulsion devices, electrical power systems, thermal management techniques and power generation.

DESCRIPTION: The Propulsion Directorate pursues and solicits innovative ideas offering performance advances in engines along with their subsystems. Of special interest are small (less than 200-pound thrust/horsepower) engines with improved affordability, performance, reliability, endurance, and fuel consumption characteristics. We need to understand the propulsion system design trade space. Propulsion options and their subsystems for assessment include internal combustion and gas turbine engines, fuel cells, electric motors, and energy storage.

Successful proposals shall deal with developing innovative solutions to improving the performance in small UAVs and their subsystems leading to design, fabrication, and full-scale ground demonstration of one or more engine configurations. Performance goals are increased propulsion effectiveness, reliability and affordability. Specifically, a 70% increase in thrust/airflow, a 30% decrease in specific fuel consumption, a 45% reduction in cost, and a 50% increase in energy density storage over state-of-the-art. Payoffs expected are a 20% increase in range, a 30% increase in payload and a 100% increase in loiter times.

Offerors are strongly encouraged to establish relationships with suppliers of the aerospace systems relevant to their research in order to facilitate technology transition. Proposed efforts shall emphasize dual-use technologies that clearly offer commercial as well as military applications. Proposals emphasizing commercial off the shelf technologies adaptation to military applications are also encouraged.

PHASE I: Develop the innovative concept and perform analyses and subscale testing to demonstrate the feasibility of the proposed technology. Modeling and simulation is encouraged to guide the research.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

DUAL USE COMMERCIALIZATION: New and innovative propulsion and power technologies are equally applicable to both military and commercial aircraft engines and power generation and distribution systems.

REFERENCES: 1. Jeffrey Stricker, "Turbine engine affordability (fighter-aircraft engines)," 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002.

2. Joseph Zelina, Jeffrey Ehret, Robert Hancock, W. Roquemore, Dale Shouse, and Geoffrey Sturgess, "Ultra-compact combustion technology using high swirl for enhanced burning rate," AIAA Paper 2002-3725, 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002.

3. Tim Edwards and Michael L. Meyer, "Propellant requirements for future aerospace propulsion systems," AIAA Paper 2002-3870, 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002.

4. Jonathan R. Smith, Paul G. Batish, Steven A. Brandt, and Scott A. Morton (USAF Academy, Colorado Springs, CO), "A student developed sizing methodology for electric powered aircraft applied to small UAVs," AIAA-2000-5536, 2000 World Aviation Conference, San Diego, CA, Oct. 10-12, 2000.

5. Thomas J. Mueller and James D. Delaurier, "Aerodynamics of Small Vehicles," Annual Review of Fluid Mechanics, 2003, 35:89-111.

KEYWORDS: turbine engines, internal combustion engines, UAVs, electrical power systems, thermal management, fuel cells, UAVs, capacitors, batteries

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AF06-175 TITLE: Nanoparticle Synthesis and Coating for Exchange Coupled Permanent Magnets

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: Demonstrate the technologies involved in producing advanced exchange-coupled permanent magnets, including nanoparticle and nanolaminate synthesis, coating technologies, and consolidation techniques.

DESCRIPTION: With the ever escalating power needs in both current and future air and space vehicles, there has been an increased emphasis in producing very power dense electrical machines for use as motors, generators, actuators, etc. A promising new technology to produce these very power dense machines is exchange-coupled permanent magnets. Theory suggests that a 2 times increase in energy product up to >100 MGOe is possible for room temperature nanocomposite permanent magnets [1] and as high as 30 MGOe for high-temperature (450 °C) nanocomposite permanent magnets. These new high-power-density magnets are also expected to play an important role in commercial devices such as hard disk drives.
Pursuing these goals, it is necessary to move from the current, somewhat poorly defined, nanoscale morphology to spatially and compositionally engineered nanostructures. An expected benefit to using this design approach is the exploitation of magnetocrystalline and shape anisotropy to produce previously unattainable magnetic properties. Materials of particular interest are nano-particle sized Nd-Fe-B, Sm-Co, a-Fe, and Fe-Co. Nanolaminate approaches

combining these materials are also applicable. It is expected that it will be necessary to coat the hard magnetic nanoparticles with very thin layers of soft magnetic material in order to achieve the highest energy products. Finally, these nanoparticulates will need to be consolidated into fully dense permanent magnets without adverse effects to the microstructure that the exchange coupling depends upon.

PHASE I: Demonstrate concept approach to producing spatially engineered exchange spring materials be they particulate blends, nanolaminates, or coated particle consolidations.

PHASE II: Fabricate fully dense, high-energy-product permanent magnets suitable in size and quality. Full characterization of the magnetic material performance is expected to show advantages of using these fabrication processes over more conventional approaches.

DUAL USE COMMERCIALIZATION: There are numerous commercial applications including electric vehicles, commercial aircraft, high-density data storage, imaging technologies, sensors, traveling wave tubes, and telecommunications devices, just to name a few. Military applications are similar to commercial uses but also adds high-speed, high-power-density electrical actuators, motors and generators.

REFERENCES: 1. R. Skomski, "Aligned two-phase magnets: Permanent magnetism of the future," J. Appl. Phys. 76 (10), pp. 7059-7063, 15 November 1994.

2. E.F. Kneller and R. Hait, "The Exchange-Spring Magnet: A New Material Principle for Permanent Magnets," IEEE Transactions on Magnetics, Vol. 27. No.4, pp. 3358-3600.

3. D. Lee, J. S. Hilton, S. Liu, Y. Zhang, G.C. Hadjipanayis, and C.H. Chen, "Hot-pressed and Hot-Deformed Nanocomposite (Nd,Pr,Dy)2Fe14/-Fe-based Magnets," IEEE Transactions on Magnetics, Vol.39, No. 5, pp. 2947-2949, September 2003.

KEYWORDS: permanent magnets, high-energy product, nanocomposite, exchange-coupled magnets, nanoparticle synthesis, nanoparticle coating, nanoparticle consolidation, magnetocrystalline anisotropy

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AF06-176 TITLE: Combustion Evaluation Device for Hypersonic Propulsion

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and demonstrate methods for obtaining combustion validation data for kerosene-based fuels in well-controlled one-dimensional (1-D) and/or two-dimensional (2-D) environments.

DESCRIPTION: There is an interest in using kerosene-based fuels for hypersonic aircraft, and AFRL's HyTech scramjet research has focused on liquid JP-7 as a scramjet fuel. There are several potential operational benefits associated with the use of liquid hydrocarbon fuels; however, there are problems that must be solved before these fuels can be used effectively. Computational fluid dynamics (CFD) simulations are important for reaching a practical vehicle design. Combustion data for liquid hydrocarbon fuels and secondary products associated with primary fuel cracking are essentially nonexistent. Data sets for kerosene-based fuels, including but not limited to JP-7, are sought as well as data for cracked and partially cracked fuel derivatives. The most relevant studies in this area have been performed with subsonic, continuous flow reactors where auto-ignition delay times as a function fuel/air composition, inlet air temperature, inlet pressure, fuel/air ratio, and free stream velocity have been performed. These studies have preheated the fuel and used gaseous injection at relevant temperature and pressure conditions for scramjet engines. Additional measurements are sought for kerosene-based fuels over the 700 to 2000 K temperature range and 0.5 to 3 atm pressure range. Measurements of interest in addition to auto-ignition delay times include, but are not limited to, formation rates of primary radical species (OH, H and O), formation of smaller hydrocarbons, and CO formation and subsequent oxidation to CO₂. 1-D and 2-D temperature and species concentration profiles along the relevant reactor dimensions are also sought. Priority is given to gaseous injection of preheated kerosene-based fuels. Liquid injection studies are needed and should follow successful completion of gaseous injection studies. Studies involving liquid injection should provide a measurement of droplet size distributions and droplet vaporization rates.

PHASE I: Develop an experimental capability and diagnostic approach that captures the important kinetic behavior in the supersonic combustion regime. Provide proof in principal measurements benchmarking the system performance and provide numerical studies to simulate operating conditions where necessary.

PHASE II: Perform a series of experiments to augment the existing database of measurements of combustion phenomenon for kerosene-based fuels over 700 to 2000 K and 0.5 to 3 atm. Spatially resolved major species concentration and temperature profiles are to be provided. Work involving liquid injection needs to characterize the droplet size distributions and to provide droplet vaporization rates.

DUAL USE COMMERCIALIZATION: Military applications include scramjet propulsion systems for hypersonic air vehicles. Commercial benefits include reduced time, risk, and cost for developing hypersonic propulsion capability for commercial space flight using liquid hydrocarbon fuels.

REFERENCES: 1. Colket, M. B. and Spadaccini, L. J., “Scramjet Fuels Autoignition Study,” Journal of Propulsion and Power, Vol. 17, pp. 315-323, (2001).

2. Siminski, V. J. and Wright, F. J. “Research Methods of Improving the Combustion Characteristics of Liquid Hydrocarbon Fuels,” AFRL TR-72-24, Vol. 1-2, (1972).

3. Samuelson, S. and McDonnell, V. “Correlation of Ignition Delay with Fuel Composition and State for Application to Gas Turbine Combustion,” AGTSR Subcontract Number 00-01-SR084CS, 2003.

4. Freeman, G. and Lefebvre, A. H., "Spontaneous Ignition Characteristics of Gaseous Hydrocarbon-Air Mixtures," Combustion and Flame, Vol. 58, pp. 153-162, (1984).

KEYWORDS: hypersonic, scramjet, chemical kinetics, combustion, supersonic combustion, liquid hydrocarbon fuels, ignition, extinction

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AF06-177 TITLE: Reduced-Order Stability Model for Combustion Systems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate physics-based models for the prediction of flame stability to give design engineers the capability to screen combustion systems in turbine engine combustors and augmentors.

DESCRIPTION: Combustion stability has been a major concern in combusting systems since the days of Rayliegh and Rejki. Combustion systems in gas turbine engines, such as main combustors and afterburners, have suffered from stability issues since the advent of the gas turbine. These systems continue to suffer from problems to this day. Modern combustion system stability design tools rely on 50-year-old empirical stability correlations to evaluate new concepts for stability. Several advances in technology over the last 20 years have provided a unique opportunity for the construction of more robust stability models. The advent of highly accurate instrumentation provides engineers with unparallel capability of understanding the sensitivity of various combustion parameters on flame stability. Advances in computational power manifested in faster machines, and such computational fluid dynamics (CFD) techniques as large eddy simulation (LES) and dynamic modeling allow for highly accurate simulations of combustion phenomena. The amount and accuracy of the data that advanced diagnostics and CFD can provide enable a new level of understanding and make it possible to construct detailed stability models that are based on the precise flow physics of unsteady combusting flows. Reduced-order models, derived from the CFD and experimental database to predict the local fluctuations in the flow and temperature field that can lead to localized fluctuations in the performance characteristics with sufficient accuracy, are preferable. This reduced-order modeling could be applied for arriving at novel design techniques that offer greater potential for mitigation of catastrophic events in combustors and augmentors.

PHASE I: Determine key sensitive parameters for a new physics-based reduced-order model for predicting combustion stability in gas turbine combustion systems. Analysis of available CFD and experimental tools and data sets to arrive at advanced reduced-order models is encouraged.

PHASE II: Develop a robust reduced-order stability model. The use of CFD and experiments with advanced instrumentation to ascertain key data of sensitive parameters to populate the new reduced-order model stability model is highly desirable. Validation of a new stability model is the focus of the Phase II program.

DUAL USE COMMERCIALIZATION: Military applications for this technology include gas turbine engines. Commercial applications include the automotive industry and power generation industries.

REFERENCES: 1. Rijke, P., L., 1859, Ann. Phys., Lpz, 107, 339.

2. J.W.S. Rayleigh, The Theory of Sound, NY, NY, Dover Publications, 1945 re-issued.

3. DeZubay, E. A., “Characteristics of Disk-Controlled Flame,” 1950, Aero Digest, pp. 54-57.

4. King, C. R., “A Semi-empirical Correlation of Afterburner Combustion Efficiency and Lean-Blowout Fuel-Air-Ratio Data with Several Afterburner Inlet Variables and Afterburner Lengths,” NACA RM E57F26.

5. J.P. Hathout, A.M. Annaswamy, M. Fleifil, and A.F. Ghoniem, "Model-based active control design for thermoacoustic instability," Combustion Science and Technology, 132, pp. 99-138, 1998.

KEYWORDS: flame stability, lean blowout, combustion instability, thermoacoustic instability, chemical kinetics, resonance, screech, rumble

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AF06-178 TITLE: Prognostics for Switch-Mode Power Supplies (SMPS)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an algorithm and/or model that accurately predicts useful remaining life and time to failure for switch-mode power supplies (SMPS).

DESCRIPTION: The more-electric aircraft (MEA) concept has led directly to an increase in electrically driven utilities. Also, many uninhabited aerial vehicles (UAVs) have 100 percent electrically driven utilities. Virtually all of these systems use a SMPS. For these applications, accurate prognostics are important technologies, since they may not have extensive redundancy built in. There are several reasons to integrate prognostics into the SMPS units. Data such as current and voltage waveforms is critical to achieving accurate diagnostics and is readily accessible to the SMPS controller. Also, the integration of certain prognostic algorithms into the SMPS may simplify the updating of these algorithms. Finally, a prognostic system for SMPS would allow for a reduction in weight and volume because fewer redundant systems would be required. This can yield very positive benefits in aircraft that are weight and volume limited.Ideally, the system will be able to utilize existing available parametric data and interfaces already in place. Innovative ideas are sought to apply prognostic capability to SMPS units. Create the conceptual design and predict the performance of the proposed design through analysis, preliminary modeling, and simulation. The design concept should address the integration or segregation of control and prognostic software if partitioning of control and maintenance critical software is desirable.

PHASE I: Explore the feasibility of new concepts through analysis and/or small-scale testing. Include such considerations as methods to update software, and the cost of processing and communication. All concepts should be scalable or flexible designs that can support various mission applications.

PHASE II: Provide detailed design and prototypical device or hardware demonstrations. Models and/or simulations, validated by demonstrations and which fully capture the relevant physics, are typically expected. A clear definition of failure modes would be expected as well as the ability to meet required operational lifetimes.

DUAL USE COMMERCIALIZATION: SMPS are very pervasive in present-day military and commercial aircraft. Future aircraft will have increasingly prolific SMPS installations. Accurate prognostics of SMPS would be a very strong candidate for transition for these platforms.

REFERENCES: 1. IEEE Standards Coordinating Committee 37 on Reliability Prediction, "IEEE Guide for Selecting and Using Reliability Predictions Based on IEEE 1413," ISBN 0-7381-3363-9, 19 February 2003.

2. Keller, Kirby, Del Amo, Ana, and Jordan, Brett, "Aircraft Electrical Power Systems Prognostics and Health Management (AEPHM)," Presented at the 2004 SAE Power Systems Conference, Paper # 2004-01-3162, November 2-4, 2004.

KEYWORDS: switch-mode power supplies, prognostics, IEEE 1413, solid-state device prognostics, buck converter prognostics, boost converter prognostics, dc-to-dc converter prognostics, reliability of aircraft power supplies, weight of redundant power supplies

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AF06-179 TITLE: Advanced Composite Analysis Capability for Advanced Manufacturing Methods

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop advanced numerical capability to properly model complex geometric structures composed of continuous fiber-reinforced composites (FRC).

DESCRIPTION: For years, engine designers and users have realized that the engine cycle efficiency tends to improve with increasing overall pressure ratios. High engine pressure ratios are, in turn, driving up materials temperatures, leading to consideration of higher temperature-capable composite materials as attractive alternatives to the more conventional metallic structures. As reinforcements for these composite structures, continuous fibers are generally preferred over other types, such as particles or chopped fibers, due to their superior ability to strengthen the composite along the fiber’s principal axis. Thus, unidirectional fiber architecture will strengthen the composite in one direction, while a three-dimensional (3-D) fiber architecture will strengthen it in multiple directions. To take advantage of the evident strengths of these composite materials, a great deal of care must be put into the design and analysis of the fibrous preform that will be used as reinforcement in the composite structure. Greater care is required because, beyond merely providing a scaffolding for the matrix (filler) material, the preform can have a major effect on the ability of the composite structure to withstand thermalmechanical stresses.

This effort will focus on the development of an analytical tool that can be used to enable the manufacturer to design and analyze various types of fiber architecture (e.g., braiding, weaving, winding, stitching) and predict their effects on the composite structural properties. It is strongly recommended that the offeror work closely with at least one composite materials vendor and at least one engine manufacturer.

PHASE I: Determine the feasibility of developing a numerical method for analyzing a range of fiber architectures and their effect on the composite structural properties.

PHASE II: Develop an analytical system that can be used by a composite materials manufacturer to design and model fibrous preforms and to predict their effect on composite structural properties.

DUAL USE COMMERCIALIZATION: Commercial applications of these methods include the procurement and maintenance of composite components for ground-based, sea-based, and air-based propulsion and power generation systems. Military uses of this technology are the same, but also include the ability to provide logistical support for our military forces.

REFERENCES: 1. Symposium on Polymer and Composite Materials Processing Polymer Composites, Vol. 24, No. 2,
Society of Plastics Engineering, April 2003.

2. Chou, T. -W., "Designing of textile preforms for ceramic matrix composites," Key Engineering Materials, Switzerland, Vol. 164-165, pp. 409-414, Trans Tech Publications, 1999.

3. Singh, D., Singh, J. P., and Sutaria, M., "Effect of fiber architecture on mechanical behavior of SiC(f)/SiC composites," Department of Energy, Washington, DC, Report Number ANL/ET/CP-90956, CONF-970111-8, Jan 1997.

4. Shekar, V. and GangaRao, H. V. S., "Composites with 3-D stitched fabrics," International Journal of Materials & Product Technology, Vol. 19, No. 1-2, pp. 188-199, Inderscience Enterprises, 2003.

5. Yun, H. M., Gyekenyesi, J. Z., and DiCarlo, J. A., "Effects of 3D-fiber architecture on tensile stress-strain behavior of SiC/SiC composites," Ceramic Engineering and Science Proceedings, Ceramic Engineering Sciences Proceedings, USA, Vol. 23, No. 3, pp. 503-510, American Ceramic Society, 2002.

KEYWORDS: fibrous preforms, fiber architecture, composites, fabrics, textiles, ceramic composites, polymer composites, organic composites, numerical analysis, geometric structures

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AF06-180 TITLE: Long-Endurance Power Systems for Small Unmanned Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a high-efficiency power solution which enables long-duration power for a small, hand-launched, reconnaissance UAVs.

DESCRIPTION: Small, hand-launched UAVs are a critical tool with which airmen maintain battlespace awareness and ensure force protection. Currently, primary batteries are used as the primary power source resulting in maximum mission duration of around 1 to 2 hours. However, these batteries represent a rather significant logistical consideration because they are expensive and must be replaced every flight. Secondary batteries are currently being fielded in order to reduce these requirements; however, improvements are needed. Conventional UAVs require nominally 120 to 170 W continuously at either 12 or 28 V with peak loads around 300 W during ascent. Battery weights typically are about 1 kg. Battery compartments usually range in the tens of cubic inches. Weights and volumes can be exceeded if components can be integrated into the airframe and mission duration can be increased.

Innovative solutions are sought to increase the mission duration 2 to 3 times the current capability through development of advanced technologies including lightweight fuel cells, hybrid power units, and multifunctional advanced structural/power technologies. Alternatively, an advanced UAV design can be proposed for accomplishing the required objectives. During the Phase I effort, the anticipated performance of the proposed design should be thoroughly estimated through calculation and verified through demonstration of a bread board system. At the conclusion of this phase, the contractor shall present a design which demonstrates how the power system will be incorporated into a UAV and demonstrate that they are capable of producing a prototype device. Significant evidence of the contractor's ability to commercialize the proposed device will also be required at the conclusion of Phase II.

PHASE I: Identify a conventional UAV platform and present a logical methodology for dramatically increasing the mission duration and power generation capability.

PHASE II: Produce the long-endurance prototype power source and demonstrate its applicability in a hand-launchable UAV. Show that the power source is readily manufacturable, safe, and will improve on existing technology through high performance and improved robustness.

DUAL USE COMMERCIALIZATION: Commercial applications include small portable power for first responders, remote site applications, and various recreational activities. Military applications include force protection, power systems for dismounted soldier applications, and applications within homeland security.

REFERENCES: 1. S. Hossain, J. P. Thomas, et al., "Custom-Designed Lithium-ion Pouch Cells for Unmanned Micro-Air Vehicles," Proceedings of the 41st Power Sources Conference 14-17 June 2004, pp. 282-285.

2. Lijun Gao, Zhenhua Jiang, and Roger A. Dougal, "An Actively Controlled Fuel Cell/Battery Hybrid to Meet Pulsed Power Demands." Journal of Power Sources 130 (2004) pp. 202-207.

3. P. Hendrick, D. Muzzalupo, and D. Verstraete, "A Fuel Cell Propulsion System for a mini-UAV," Presented at the Micro Air Vehicle Workshop, Germany 22-24 September 2003, Report #EOARD-CSP-03-5073 (X5-X5), July 2004.

4. Terrill B. Atwater, Louis P. Jarvis, and Peter J. Cygan, "Hybrid Power Source for Objective Force Warrior," US Army Communications Electronics Command (CECOM),Research, Development, and Engineering Center (RDEC), Fort Monmouth, New Jersey 07703-5000.

KEYWORDS: UAVs, long-endurance power, hybrid electric power, small portable power, battery, fuel cell, multifunctional materials, battlespace awareness, force protection, power systems

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AF06-187 TITLE: Advanced Composite Blade Design

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: Develop unique and innovative techniques for attachment of organic matrix composites (OMC) to titanium 6/4 for a hybrid metal/OMC first-stage compressor fan blade.

DESCRIPTION: Composite blades are currently in use in commercial high-bypass-ratio engines. To date, advanced military fighter engines are not fielded with composite fan blades. Reasons for this are that military engines typically experience higher speeds, temperatures, and loads than their commercial counterparts. Investigations concerning the use of OMCs in fan blades have been attempted, but have not yet been put into production. From these investigations, two main concerns have arisen. First, an OMC blade typically cannot withstand a bird strike. Second, exposed composite leading edges are susceptible to other foreign object damage (FOD) and erosion damage.

Focus on highly innovative design approaches and processing to solve those aforementioned problems. For this effort, the dovetail and root of the blade will remain titanium. The remaining airfoil section of the blade is where the implementation of OMCs should occur. Attachment techniques of the composite portion to the titanium root and dovetail should minimize the amount of post cure bonding as much possible. Metal alloys may also be used in the airfoil portion of the blade (i.e., titanium leading edge) if deemed necessary. Extensive use of finite element analysis (FEA) for strength, forced response, damping, impact analysis, cost modeling, and experimental testing will be required. Extensive knowledge of composite resins (Bismaleimides, polyimids, etc.) and available manufacturing methods (resin transfer molding, resin film infusion, braiding, laminates, etc.) will also be required. Temperature requirements will be in the 300°F range.

PHASE I: Develop and evaluate an innovative methodology for incorporating OMCs into current compressor blade design.

PHASE II: Demonstrate full implementation of the designed methodology into the manufacture and testing of this hybrid blade design.

DUAL USE COMMERCIALIZATION: Dual use applications are directly related to all military engines and their commercial counterparts. If successful, this technology lends itself to large-scale implementation for all engine applications.

REFERENCES: 1. Salemme, C.T. and Murphy, G.C., "Metal Spar/Superhybrid Shell Composite Fan Blades, Final Report," Contract NAS3-20402, August 1979.

2. Freiedrich, L.A., "Impact Resistance of Hybrid Composite Fan Blade Materials, Contractor Report," Contract NAS3-17789, May 1974.

3. Winters, W.E., "GR/PMR-PI Composite Ultra High Speed Fan Blade Fabrication and Evaluation," Technical Proceedings, Society of the Plastics Industry Inc., 32nd Annual Conference, 8-11 February 1977, Washington D.C., Section 15-3, pp. 1-5.

KEYWORDS: organic matrix composites, composite, fan blade, composite structures, gas turbine engine, hybrid structures

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AF06-188 TITLE: Ignition and Efficient Combustion of Alternative Scramjet Fuels

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate methods for efficient ignition and sustained combustion of alternative fuels in scramjet engines.

DESCRIPTION: There is an increasing interest in considering alternative fuels for hypersonic aircraft. AFRL's HyTech scramjet research has focused on liquid JP-7 as a scramjet fuel. NASA has typically assumed that liquid hydrogen will be the fuel preferred for launch vehicle applications. Other fuels, particularly methane, have the potential to resolve many complications associated with storing hydrogen fuel, while offering increased thermal capacity and gravimetric energy density compared to a jet propulsion (JP) fuel. With all of the potential benefits, there are problems that must be solved before these fuels could be used effectively. First, a method for reaching the required conditions for efficient, sustained combustion needs to be developed. For example, the ignition delay is far too long for neat methane to be used in a practical scramjet engine; the attendant difficulty in lighting the fuel at expected engine operating conditions would need to be solved. A plasma torch, catalyst, fuel additive, and dual-fuel system are some options that could be considered to enhance the combustion of fuel candidates such as methane. Second, changes in the fuel composition prior to injection into the combustor can be expected in using the fuel as the scramjet engine structure's primary heat sink. The impact of such changes on the combustion process must be identified and evaluated for consistency with the ignition aids used to support the combustion of the neat fuel. The target fuel would have a heat sink improvement from JP-7 to approach the heat sink performance of methane.

PHASE I: Develop an analytical procedure for alternative scramjet fuel. Focus on methods that enable initiating and sustaining combustion, with an ignition delay near ethylene and combustion efficiencies greater than 80 percent. Establish an acceptable level of solid carbon formation in the heat exchanger.

PHASE II: Validate the analytical procedure by igniting and sustaining supersonic combustion using the alternative fuel(s), ultimately in a scramjet test rig. Focus on improving the ignition delay with the performance of ethylene as a goal and fully understanding endothermic properties of the fuel and any additives. Characterize the properties especially with respect to endothermicity.

DUAL USE COMMERCIALIZATION: Military: This will make methane an acceptable fuel for scramjet/hypersonic propulsion and potentially become an alternate fuel for rockets.
Commercial: An additive of this type could be used as a cetane enhancer for diesel fuels. Improving the hydrocarbon cracking reaction could also substantially lower the cost of ethylene production by reducing the temperatures at which it is produced.

REFERENCES: 1. Albegov, Shikhman, Vedeshkin, and Vinogradov, "Experimental Research of Pre-Injected Methane Combustion In High Speed Subsonic Airflow," AIAA Pub. 6940, pp. 1-11, (2003).

2. Bingham, Dahl, Glatzmaier, Lewandowski, Pitts, Tamburini, and Weimer, "Thermal Dissociation of Methane Using A Solar Coupled Aerosol Flow Reactor," Department of Energy Hydrogen Program Review, (2000).

3. Cerven, Davis, and Solomon, "The Use of Methane as a Fuel for Hypersonic Propulsion," AIAA Pub. 2769, (1995).

4. Colket and Spadaccini, "Scramjet Fuels Autoignition Study," Journal of Propulsion and Power, Vol. 17, pp. 315-323, (2001).

5. Engel, Hitch, and Wickham, "Additives to Increase Fuel Heat Sink Capacity," AIAA Pub. 3872, pp. 1-11, (2002).

KEYWORDS: hypersonic, scramjet, methane, ethylene, liquid hydrocarbon fuel, catalysis, pyrolysis, ignition, combustion

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AF06-189 TITLE: Electrical Contacts and Packaging for Diamond and Diamondlike High-Power Devices

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop high temperature, robust (Schottky and Ohmic) metal contacts and packaging solutions for diamond and diamondlike materials.

DESCRIPTION: Chemical vapor deposition (CVD) diamond is an attractive material for use in high power and high temperature electronic applications for passives, electromechanical devices, switches, integrated circuits, sensors, and heat sinks and the cost of the material is becoming increasingly competitive for high payoff niche applications. Diamond-based devices have applications in hybrid and integrated power systems that are integral for the power management and control of a wide range of equipment such as military aircraft engines, directed energy weapons, industrial machinery, and automobile engines and are an enabling technology for robust high temperature (< 250° C) electronics. Stable, robust, metal-diamond contacts and compatible high temperature packaging solutions are critical to the successful realization of diamond-based devices. Innovative approaches are needed to spatially distribute current uniformly through an Ohmic connection at the diamond metal interface, reduce the electric field enhancement at interfaces in high voltage and high power applications, and is robust at high temperatures. Metal (multilayer) contact systems should provide good adhesion to the substrate; possess high electrical conductivity, robust diffusion barrier properties, and a final metal layer that is wettable and at minimal stress when used at high power and high temperature applications. Issues that need to be addressed include but are not limited to: surface flashover, adaptation of material combinations with respect to their coefficient of thermal expansion, diffusion barriers, migration, thermal stability of materials used; oxidation resistance, and resistant to forming intermetallic phases, and reliability testing. It is appropriate to consider doping techniques for diamond, thin-film refractory metal diffusion barriers, as well as novel solders, and interconnection techniques.

PHASE I: Examine various material combinations through modeling and simulations to determine a viable candidate for high power and high temperature metal contacts to diamond. Perform feasibility testing and outline functional packaging schemes.

PHASE II: Demonstrate a reliability and robustness in high power and high temperature (< 250° C) environments of a diamond/metal contact system and package.

DUAL USE COMMERCIALIZATION: High power and high temperature diamond-based components have applications for power management, control of military aircraft engines, directed energy weapons, industrial machinery, well logging, and automobile engines.

REFERENCES: 1. M. Werner, O. Dorsch, H. Baerwind, E. Obermeier, C. Johnston, P. Chalker and S. Romani, "The effect of metallization on the ohmic contact resistivity to heavily B-doped polycrystalline diamond films," IEEE Transactions on Electronic Devices, Vol. 42, No. 7, pp. 1344-1351, (1995).

2. M.A. Nicolet and M. Bartur, "Diffusion Barriers in Layered Contact Structures," Journal of Vacuum Science & Technology, Vol. 19, No. 3, pp. 786, (1981).

3. R.W. Balluffi and J.M. Blakely, "Special Aspects of Diffusion in Thin Films," Thin Solid Films, Vol. 25, pp. 363, (1975).

KEYWORDS: diffusion barrier, metal contacts, surface flashover, high power, high temperature, diamond, packaging

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AF06-190 TITLE: Development of Computed Tomography (CT) Software Techniques for Detecting Aging of Rocket Motors

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop statistical and imaging analysis techniques to compare multiple CT images of solid rocket motors taken at different times.

DESCRIPTION: X-ray CT is the nondestructive inspection technique used to monitor aging and surveillance of solid rocket motors. CT is the only method available to actually look inside the solid rocket motors and verify structural integrity. The ability to detect changes in defects and subtle changes in the solid rocket motor constituents over time is essential in determining how the rocket motors are aging. A method is needed to provide the ability to compare baseline data with data acquired from motors at future times, both statistically and visually in an image of the changes. The proposal should include numerical/statistical methods to show what has changed in the rocket motor images and a way to show these changes on an image of the motor. Additionally, the prototype should have the capability of comparing an entire rocket motor data set at time A with a data set at time B, both statistically and visually. Develop software prototype that can show differences between data sets by subtracting results of each data set and displaying the difference in such a way to show what has changed in the rocket motor over time. Medical CT image processing represents the current state of the art. However, the X-ray energy used in medical CT is vastly lower than the energies required for the inspection of solid rocket motors. In addition, the “materials” of interest in medical CT, flesh and bone, are significantly different from the constituent materials of solid rocket motors. These major differences either render the medical CT processes useless for the applications of interest to the Air Force or they are severely limited in application. Data to support this development effort, in terms of images and image characteristics, are available from this topic’s sponsoring organization at Hill AFB. UT.

PHASE I: Identify and develop comparative methods and develop scientific methods and techniques to compare CT data sets acquired at different times by the same large industrial CT system on the same large solid rocket motors.

PHASE II: Demonstrate that the prototype or new methods and techniques can perform comparative analysis on actual CT data sets acquired at different times on the same solid rocket motors by the same CT system.

DUAL USE COMMERCIALIZATION: Image analysis techniques have vastly improved for medical Computed Axial Tomography (CAT) scan systems. Similar techniques can be used to make improvements to industrial CT systems, such as the ones the AF uses on Intercontinental Ballistic Missiles. These improvements would be beneficial for any industrial CT system. Although the military application would be for solid rocket motors, this technology could be used on any system that produces digital data.

REFERENCES:
1. Bossi, R.H., Nelson, J.M., “X-ray Computed Tomography Standards” (1994), Materials Directorate, Wright Laboratory, Wright-Patterson AFB, OH.

2. ASTM E1441-97, “Standard Guide for Computed Tomography (CT) Imaging” (1997), West Conshohocken, PA.

KEYWORDS: Computed Tomography, nondestructive inspection, comparative analysis, solid rocket motors, aging and surveillance, CT images

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AF06-191 TITLE: Improved Computed Tomography(CT) Imaging of High Z Materials

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop software techniques to improve the CT imaging of High Z Materials in CT reconstructions.

DESCRIPTION: X-ray CT is the nondestructive inspection technique used to evaluate integrity and monitor aging and surveillance of large solid rocket motors. CT is the only method available to actually look inside the solid rocket motors and verify structural integrity. Currently, images are reconstructed using a filtered backprojection algorithm. The presence of high Z materials, typically metal components, in the locations to be imaged result in data with noise levels as high as 50%. The ability to detect changes in defects and subtle changes over time due to aging in the solid rocket motor constituents is already limited by the sinogram generation technique and the reconstruction method used. The significant noise levels resulting from the presence of high Z materials in the image render these processed useless. Improvement of resolution and contrast sensitivity and reduction in noise is the solution to the problem. In order to detect changes in visible defects requires noise levels in the range of 10% or less. To detect changes due to aging requires images with noise levels significantly less than 10%.

PHASE I: Develop improved alternative reconstruction algorithms and sinogram modification techniques that are superior to the existing method and techniques.

PHASE II: Evaluate the prototype on actual CT data acquired from large industrial CT systems on solid rocket motors by direct comparison of the prototype to the existing methods and techniques.

DUAL USE COMMERCIALIZATION: Improvements in CT imaging of High Z Materials will be beneficial in any industrial CT system. The military application would be implemented into CT systems used for inspecting large solid rocket motors.

REFERENCES:
1. Bossi, R.H., Nelson, J.M., “X-ray Computed Tomography Standards” (1994), Materials Directorate, Wright Laboratory, Wright-Patterson AFB, OH.

2. ASTM E1441-97, “Standard Guide for Computed Tomography (CT) Imaging” (1997), West Conshohocken, PA.

KEYWORDS: Computed Tomography, nondestructive inspection, Image reconstruction, solid rocket motors, Filtered backprojection, High Z Materials

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AF06-192 TITLE: Small Launch Vehicles Providing Responsive and Affordable Spacelift

TECHNOLOGY AREAS: 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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative propulsion technologies that enable responsive and affordable Small Launch Vehicle (SLV) Spacelift solutions.

DESCRIPTION: Both Small-Satellite (Small-Sat) and Common Aero Vehicle (CAV) payloads are showing increasing promise in improved mission capability. Small-Sat and CAV payloads will need a complementary responsive and affordable SLV capability. Propulsion systems tend to drive cost and operational schedule. Innovative technologies are being sought that address SLV responsiveness and cost reduction in the area of propulsion, including manufacturing, integration, and operations. Highly operable propulsion technologies will make possible the future acquisition and operation of a responsive and cost-effective SLV-based system capable of capturing TacSAT and Joint Warfighter Space (JWS) small responsive payloads (up to 1,000 kg or 2,200 lbs). Address technology risk mitigation plans for high-risk component(s) in meeting improvements to responsiveness and/or cost reduction. Responsive SLV requirements include the necessity to be maintained by blue-suit labor, achieving alert status within 24 hours from call-up, launching within 2 hours from alert status once execution order is received, and re-launching within 24 hours. Affordable SLV requirements include a total recurring launch cost less than $7.5M, excluding payload integration costs.

PHASE I: Develop a propulsion system technology requirements base and a supporting sub-orbital vehicle conceptual design. A bottoms-up approach may help to identify enabling propulsion technologies.

PHASE II: Demonstrate critical component technologies that address launch responsiveness and/or cost reduction possessing sufficient design information to fabricate, integrate, and operate the selected high-risk component(s). Refine the design of the sub-orbital vehicle.

DUAL USE COMMERCIALIZATION: Dual use applications include target vehicles, sounding rockets, low-cost upper stages, Ballistic Missile Replacement (BMR) and strap-on boosters. Enabling technologies that evolve from this program are directly traceable to a new responsive and low cost SLV for both commercial and military applications.

REFERENCES:

1. Isakowitz, Steven J., Joshua Hopkins, and Joseph P. Hopkins, Jr. International Reference Guide To Space Launch Systems. 4th ed. AIAA, 2004.

2. Sutton, George P., and Oscar Biblarz, Rocket Propulsion Elements. 7th ed. John Wiley & Sons, 2001.

3. Wertz, James R., and Wiley J. Larson, eds., Reducing Space Mission Cost. Microcosm/Kluwer, 1996.

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

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AF06-193 TITLE: Advanced Rocket Propulsion Technologies

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 advanced space propulsion concepts and components or strong/lightweight materials, energetic ingredients, or physics based models that enable significant advances in rocket propulsion technology.

DESCRIPTION: The Air Force is seeking efforts that will make a significant contribution to meeting or surpassing the goals of the national Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. The IHPRPT program's goal is to double the performance of rocket propulsion in the application areas of boost, orbit transfer, spacecraft and tactical applications by improving specific impulse, thrust to weight ratio, and mass fraction. The goals for Phase III of the IHPRPT Program are; for Boost and Orbit Transfer applications, Reduced Stage Failure Rate 75%, Reduced Hardware and Support Costs 35%, Improved (engine) Thrust-to-Weight 100%, Improve (motor) Mass Fraction 35%, Improved Isp (8% solid propellant systems, 3% cryogenic propellant systems, 17% hydrocarbon propellant systems) improved Mean Time Between Removal (for reusable engines) to 100 missions, Improve motor service life prediction capability 50%; for Spacecraft applications, Improve total Isp /(propulsion mass with propellant) or (Itot/Mwet) (75% for electrostatic propulsion systems and 1250% for electromagnetic propulsion systems), Improve bipropellant or solar thermal propulsion system Isp 20%, Improve Energy Density 70% for monopropellant propulsion systems, Improve Mass Fraction of solar thermal propulsion systems 35%; for Tactical Propulsion Systems, Improve Delivered Energy 15%, Improve (propulsion system) Mass Fraction (30% or 10% for propulsion systems with or without thrust vector control or throttling respectively). These improvements are being pursued within current or projected environmental considerations and are consistent with safety and life cycle cost constraints. The technology for each application area is divided into five technology areas including integrated propulsion demonstrators. The proposals may address any one or any combination of these five technology areas appropriate for the scope of an SBIR proposal:

• Propellants: solids (includes bond liners), liquids, hybrids, gels

• Propellant Management Devices: insulated cases, small tanks, feed systems, bladders, turbomachinery, thermal protection systems, pressurization systems

• Combustion and Energy Conversion Devices: nozzles, gas generators, preburners, injectors, igniters, combustion chambers, electric propulsion

• Controls: actuators, controllers, ordnance devices, valves, health monitoring systems

• Demonstrators: the integration of the above component technologies into propulsion systems (e.g., cryogenic/hydrocarbon/solid/hybrid boosters, electric propulsion devices, monopropellants, tactical motors) to demonstrate achievement of IHPRPT goals

In addition to more conventional approaches to these problems advanced novel propulsion concepts are also desired. These include devices, and supporting technologies for high-thrust and high-performance propulsion for launch vehicles and space propulsion. Research areas include, but are not limited to, high-density and high-temperature plasmas coupled to high-efficiency electromagnetic accelerators; novel high-strength materials, low-weight conductors, innovative conversion cycles, radiator technology, and advanced thermoelectric materials.

PHASE I: Perform physics based performance predictions and/or exploratory experiments to show that the concept proposed is potentially feasible and of benefit to the AF.

PHASE II: Using the results of Phase I define which AF objectives are being pursued and conduct comprehensive physics based analysis and/or definitive experiments to demonstrate that the proposed concept can be developed to meet these objectives.

DUAL USE COMMERCIALIZATION: For the purposes of delivering satellites to orbit the launch vehicles required by the military are also used by commercial satellite service providers. Improvements in launch vehicle cost-per-pound-to-orbit will directly increase commercial satellite service provider revenue. In addition, these technologies can enable domestic launch vehicle providers to recapture commercial global launch market share. In doing so the launch cost of both military and commercial launches will be further reduced.

REFERENCES:
1. Glaittli, Steven R, "IHPRPT Phase I Solid Boost Demonstrator: A Success Story," MEETING PAPER, AD-A408384;AFRL-PR-ED-TP-2001-125; AIAA Paper 2001-3451, 2001.

2. Steel, S, "Ceramic Materials for Reusable Liquid Fueled Rocket Engine Combustion Devices," AMPTIAC Quarterly Vol.8,no.1,pp.39-43.2004. Http://amptiac.alionscience.com/pdf/AFPQ8_1.pdf

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4. Cannizzo, Lou F, Development of New Energetic Materials for Advanced Solid Rocket Propellants," MONOGRAPH, AD_A407949; AFRL-PR-ED-TP-1998-081, 1997.

5. Chapman, L; Crease, G; Friant, J; Grabowski, R; Schmidt, E, "Testing of an Advanced Liquid Hydrogen Turbopump," MONOGRAPH, AD-A409850;AFRL-PR-ED-TP-2000-150, 2000.

KEYWORDS: Rocket Plume, Rocket Engine, Rocket Propellants, Satellite Propulsion, Beamed Energy Propulsion, Boost Transfer, Orbit Transfer, Plasma Propulsion, Nuclear Propulsion

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AF06-194 TITLE: Innovative Rocket Propellant Ingredients

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.

OBJECTIVE: Develop and characterize new (emphasis on new) higher energy density liquid rocket propellant ingredients (or propellants) with acceptable physical properties.

DESCRIPTION: The DOD requires higher performing propellants for use on space access and satellite systems, however, simultaneously attaining higher energy and density while maintaining acceptable physical properties is an extremely challenging goal. Current propellants and/or ingredients are incapable of imparting the desired performance and insensitivity. SBIR proposals should be geared toward liquid propellants or their ingredients. The proposal should identify, synthesize, and characterize new liquid propellants (fuel, oxidizer, monopropellant) to increase the energy and density of liquid propellants and achieve acceptable propellant characteristics for its intended application. The emphasis of this SBIR is on new compounds. The performance of new propellants significantly exceed IHPRPT phase III propellant objectives (i.e. +4% Isp hydrocarbon, +70% density-isp spacecraft).

PHASE I: Develop and identify candidate compounds and predict their performance. Design research strategies and experimental approaches to synthesize promising new ingredients or key intermediates. Prepare sufficient quantities in laboratory scale to permit necessary stability and sensitivity testing.

PHASE II: Develop and refine scale-up synthesis procedure for new compounds. Evaluate candidate propellant, ingredient, and/or formulations containing the new characterized ingredients in aging, compatibility, rheology, thermal stability, toxicological, sensitivity and performance characteristics as applicable for its intended use. Deliverables include top 3-5 candidates.

DUAL USE COMMERCIALIZATION: Propellants and or ingredients developed would be similarly applicable to military and commercial launch vehicles and satellite propulsion systems.

REFERENCES:
1. Advanced Energetic Materials, National Research Council of the National Academies assessment, ed. R. L. Atkins, The National Academies Press, Washington, DC, 2004, pp.5-15.

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KEYWORDS: Solid Propellants, Energetic Materials, Monopropellants, Bipropellants, Solid Propellant Ingredients.

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AF06-195 TITLE: Electrically Conducting Polyhedral Oligomeric Silsesquioxane (POSS) Kapton Polyimides

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: To provide electrically conducting POSS Kapton polyimides with improved charge dissipation and retention of transparency and physical strength properties of nonconducting POSS Kapton Polyimides.

DESCRIPTION: POSS research is a rapidly evolving area of dual-use technology development. It provides innovative materials to military and industrial users. The technology pursuit has been nationally honored by both the Air Force and industry.
Kapton polyimides are used extensively in spacecraft thermal blankets, solar concentrators, and space inflatable structures. Atomic oxygen (AO) in lower earth orbit (LEO) causes severe degradation in Kapton, resulting in reduced spacecraft lifetimes. Copolymerization of POSS into polyimide systems dramatically increases the lifetime of these materials by producing a self-passivating silica layer protecting underlying Kapton upon exposure to AO. In fact, 20 weight % POSS Polyimide has an erosion yield that is 2.2% of the erosion yield for space certified Kapton after exposure to an Oxygen-atom fluence of 8.5 x 10^20 O atoms cm^-2.
Another serious factor to consider in the space environment is spacecraft charging. Above 90 km in altitude molecules comprising the Earth's atmosphere can be ionized by solar radiation, producing positively charged ions and free electrons. These charged particles are the natural space plasma and exist in all spacecraft orbits. Spacecraft charging is a significant problem since electronic systems are sensitive to electrical anomalies, and spacecraft surfaces are damaged through electrical arc discharges. This problem has brought about the loss or damage of a number of satellites and the production of anomalous instrument data. There is a continuing need to develop and certify greater varieties and ranges of electrically conductive thermal control coatings for flight hardware utilization.

There is an industry-wide need for space survivable conducting Kapton. It is a general requirement that this material is achieved with an innovative additive to the POSS Polyimide polymer matrix, or modification to the POSS Polyimide polymer matrix that will impart electrical conductivity with a minimum value of 10^-8 siemens, which is enough to dissipate charge in space, without sacrificing thermal and mechanical properties or resistance to atomic oxygen. Also required is the provision of three conducting (6 in. by 6 in. , 2 mil thick) POSS polyimide films containing 0, 10, 20 weight % POSS monomer, making 18 6 in. by 6 in. films total. Also required is a plot of absorbance versus wavelength (from 200 to 900 nanometers) for the conducting 0, 10 and 20 weight % POSS Polyimide films. These materials must act as a thin flexible film bendable without crease damage.
Thermal and mechanical properties of current POSS polyimides, as well as details of atomic oxygen erosion studies, will be provided upon request. Edwards AFRL will provide a POSS dianiline monomer if needed.

PHASE I: Develop and demonstrate a prototype POSS Kapton polyimide with minimal conductivity of 10^-8 siemens and optical transparency (in the ultraviolet/visible wavelength range) similar to Kapton. Provide 3 (6 in. by 6 i, 2 mil thick) conducting Kapton polyimide films containg 0, 10, and 20 weight % POSS

PHASE II: Establish performance parameters through experiments and prototype fabrication of a space grade conducting 10 and 20 weight % POSS Polyimide. Provide physical, optical, and mechanical characterization before and after simulated lower earth orbit and geosynchronous orbit exposure. Deliver 3 films each (25 in. by 25 in., 2 mil thick) of conducting 10 and 20 weight % POSS polyimides.

DUAL USE COMMERCIALIZATION: These are improvements of a critical class of materials (polyimides) used in hundreds of military and commercial applications.

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KEYWORDS: POSS Polyimides, electrically conducting polymers, spacecraft charging, polyhedral oligomeric silsesquioxane (POSS), satellites, Kapton

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AF06-196 TITLE: Propellant Ingredients for Solid Rocket Motors

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop higher energy density solid propellant ingredients that possess acceptable physical properties for higher performing solid propellants for SC and BMD applications.

DESCRIPTION: The DoD requires higher performing solid propellants for use on space access and strategic missile systems. Current energetic ingredients are unable to provide the performance needed to meet the performance goals of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase III goals. These propellants must simultaneously possess higher energy and density while maintaining acceptable hazard, mechanical, and processing properties. The research areas may include, but are not limited to, the following: identification, synthesis, and characterization of new ingredients (e.g., fuel, oxidizer, plasticizer, binder, and/or burn rate modifiers) to increase the energy and density of formulated solid propellant mixtures while meeting other required attributes (e.g., hazard classification, lifetime, cost, performance); development of improved (e.g., scale, yield, cost, synthesis pathway modeling) energetic ingredient synthesis methods. This capability will support current and future DoD ballistic missile and space launch applications. The proposed technology development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign capability. To increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM technology development efforts to the maximum extent possible. In the following phases sufficient new ingredient quantities will be obtained in laboratory scale to allow determination of structure and permit necessary ingredient stability and sensitivity tests to be conducted.

PHASE I: Identify potential candidate ingredients, sensitivity models, and/or synthesis methods and screen them based on their theoretical performance and other parameters. Design research strategies to synthesize and characterize the key properties of promising new ingredients.

PHASE II: Develop, refine and demonstrate scale-up synthesis process for new compounds to be evaluated in formulated propellant development. Evaluate advanced propellant formulations with the new characterized ingredients in aging, compatibility, mechanical property, thermal stability, sensitivity and performance characteristics for solid propellant applications. Deliver ingredients and formulated samples.

DUAL USE COMMERCIALIZATION: Potential applications would be in commercial and military space access and strategic systems used in technologies associated with satellites.

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2. “Request for S&T Representatives for Directed Energy Weapon, Energetic Materials, and Cruise Missile/Cruise Missile Defense Assessments,” Memorandum for Assistant Secretary of the Army (Acquisition), Logistics and Technology), Assistant Secretary of the Navy (Research, Development and Acquisition), Assistant Secretary of the Air Force (Acquisition), signed by Stephen. A. Cambone (Under Secretary of Defense for Intelligence) and Ronald. M. Sega (Director, Defense Research and Engineering), Jan. 28, 2004.

KEYWORDS: Space Access, Strategic and Tactical Missiles, High Energy Density Materials, Solid Propellants, Energetic Binders and Plasticizers, Insensitive Munitions

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AF06-197 TITLE: Navigation-Grade Microelectromechanical Systems (MEMS) Inertial Measurement Unit (IMU)

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a navigation-grade, MEMS-based IMU which significantly reduces size, weight, power, and cost and improves reliability compared to today's navigation-grade IMUs.

DESCRIPTION: Gyroscopes and accelerometers are the critical components in an IMU. A promising approach to gyroscopes and accelerometers is MEMS technology. The goals of navigation-grade performance (gyro bias <0.005 deg/h and accelerometer bias <25 micro-g) and tiny size (<20 cc), weight (<30 g), power consumption (<100 mW), cost (<$1200/unit) and life of vehicle reliability that MEMS can potentially provide for an IMU open up a wide range of applications to the Air Force. A navigation-grade MEMS IMU would provide improved guidance and navigation for missiles, munitions, manned and unmanned air and space vehicles of all sizes, dismounted soldiers, and micro-robots as well as position, velocity, and attitude referencing for helmet-mounted cueing systems and antennas and targeting sensors on various ground, air, and space platforms. A novel approach to the MEMS gyroscopes, MEMS accelerometers and IMU architecture, including packaging, electronics, and software, is desired to develop and produce a navigation-grade MEMS IMU.

PHASE I: Identify the critical technology challenges, synthesize advanced designs, perform concept feasibility analysis, and define the Phase II approach. Phase I risk reduction studies and experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Produce and demonstrate a navigation-grade MEMS IMU to the fullest extent practical, given available allocated funds.

DUAL USE COMMERCIALIZATION: Military application: A navigation-grade MEMS IMU has the potential to positively impact military and civilian applications. Such an IMU would provide a highly reliable, small size and weight, low-power, and low-cost solution to current and new navigational and reference requirements for myriad platforms.

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KEYWORDS: guidance, navigation, control sensors, electronics MEMS IMU Gyroscopes and accelerometers

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AF06-198 TITLE: <u>Network-Centric Warfare Connectivity for Electronic Attack</u>

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop simulation tools for rapidly evolving/integrating/demonstrating network-centric warfare connectivity technologies for electronic attack in a collaborative, capability-based battlespace.

DESCRIPTION: Network-centric warfare connectivity technologies must provide seamless connectivity of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) across the sea, land and space interface. As a result, the warfighter will have access to a coherent tactical picture which enables rapid access to mission critical information and time sensitive targets. Existing research methodologies for demonstrating and analyzing network-centric technologies are time-consuming, non real-time and require extensive and costly flight testing. Real-time battlespace simulation provides a cost-effective methodology for rapidly evolving, integrating, and demonstrating network warfare connectivity technologies to enable capability-based combat operations for electronic attack. Approaches leading to the creation of innovative, dual-use simulation methodologies and technologies that enable the development and evaluation of network-centric warfare connectivity architectures and technologies for aircraft are sought. The goal of this research is to develop simulation(s) to evolve affordable dual-use man virtual combat simulation technologies that will reduce the cost and time required to develop network-enabled , widely distributed sensor technologies for combat operations. Research areas of interest would include real-time simulation technologies and software tools for analyzing proposed sensors, next-generation communication systems, and battlespace management needs. Appropriate software tools could include the capability to characterize and evaluate C4ISR topologies relative to platform, sensor, mission, function, and distribution. The dual-use simulation technology base established by this research can be applied to developing advanced networked sensors for both commercial and military aircraft. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing and demonstrating the required man/hardware-in-the-loop virtual combat simulation technologies. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE I: Define affordable dual-use virtual combat simulation methodologies and technologies for evolving/integrating/demonstrating network-centric warfare connectivity technologies.

PHASE II: Implement and demonstrate the critical network-centric warfare connectivity man/hardware-in-the-loop virtual combat simulation concepts/technologies.

PHASE III DUAL USE APPLICATIONS:
Military Application: Virtual combat simulation concepts increase the productivity of network-centric warfare connectivity research and will be implemented in government laboratories and ranges to mature net-centric concepts.
Commercial Application: Network-centric simulation technologies can be applied to novel wireless architectures, communication topologies, and other control systems. Simulations will reduce development time to the market.

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KEYWORDS: Network-Centric, Connectivity, Simulation, Battlespace.

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AF06-199 TITLE: Real-Time Digital Receiver Rapid Prototyping Testbed

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop real-time, simulation technologies for digital receiver rapid prototyping testbed.

DESCRIPTION: Digital receiver technologies provide a key technology base for successfully implementing real-time system of systems concepts for airborne electronic attack (AEA) operations. Current research methodologies for evolving digital receiver technologies are time consuming and require extensive/costly open-air range testing. Open-air range productivity is low because there are so many uncontrollable variables coupled with the inability to quickly make changes during the actual flight test. Existing research facilities do not have the real-time simulation capabilities to evolve and mature digital receiver technologies in the laboratory. Today's generation of RF simulators exhibit simulation byproducts (due to hardware, processor or software limitations) that are averaged out and ignored or removed by conventional analog receivers. These "glitches" are easily seen by newly-developed digital receivers and make accurate analysis of capability improvements impossible. Thus, currently available laboratory RF emission simulators cannot provide the required fidelity and real-time signal environment generation capability. Approaches are sought that lead to the creation of innovative, dual-use simulation methodologies and technologies to develop testbeds to enable real-time digital receiver rapid prototyping and characterization. Research areas of interest for this topic include ultra-wideband signal generation strategies (hardware and/or software), very low amplitude, low noise, signal generation technologies, as well as innovative instrumentation technologies to verify simulator parameters unique to digital receiver prototyping and characterization. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE I: Conduct research required to identify the critical technology challenges, synthesize advanced simulation/simulator methods, perform concept feasibility analysis and define the Phase II approach.

PHASE II: Implement and demonstrate the critical real-time simulation technologies required for digital receiver rapid prototyping.

DUAL-USE COMMERCIALIZATION:
Military Application: Simulation Technologies for digital receiver systems will improve government laboratories and ranges to evolve digital receivers for combat aircraft.

Commercial Application: Simulation technologies to accelerate digital receiver research reduce costs for commercial telecommunication and satellite markets. Laboratory demos of digital receiver concepts significantly reduces the risk, cost, and time to the market place.

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5. Tsui, James, "Digital Techniques for Wideband Receivers," Raleigh, NC, SciTech Publishing, Inc., 2004.

KEYWORDS: Digital Receiver, Simulation, Rapid Prototyping, Airborne Electronic Attack, AEA

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AF06-200 TITLE: Digital Receiver Geolocation Technology Simulation

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop simulation technologies for evolving/maturing novel geolocation capabilities.

DESCRIPTION: The digital receiver technology revolution will dramatically improve the ability to precisely locate radio frequency (RF) emitters through the application of new geolocation techniques such as those involving precise time difference of arrival, RF carrier or pulse repetition frequency (PRF) Doppler shift analysis, and phase interferometers. These new techniques can be applied using receiver(s) on a single aircraft or on multiple platforms to improve performance. Current research methodologies for evolving digital receiver geolocation capabilities require extensive and costly open-air range testing. Open-air range productivity is low because there are so many uncontrollable variables and an inability to make changes during the actual flight test. Research facilities do not have the real-time simulation capabilities needed to evolve and mature geolocation technologies in the laboratory. Currently available laboratory RF threat environment simulators do not provide the required fidelity to accurately simulate the parameters needed to develop ultra-precise direction finding and geolocation capabilities. Approaches are sought that lead to the creation of innovative, dual-use laboratory simulation methodologies and technologies to enable the development of geolocation technologies for single and multiple-aircraft. Research topic areas of interest include off-boresight (as well as traditional on-boresight) antenna modeling and novel simulation techniques to demonstrate benefits gained by combining effects from coordinated, geographically separated receivers. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE I: Conduct research required to identify the critical technology challenges, synthesize advanced simulation/simulator methods, perform concept feasibility analysis and define the Phase II approach.

PHASE II: Implement and demonstrate the critical simulation technologies required for developing, evolving, maturing, and evaluating digital receiver geolocation technologies in a laboratory environment.

PHASE III DUAL-USE APPLICATIONS:

Military Application: Digital receiver simulation technologies can be implemented in government laboratories and ranges to develop/mature digital receiver geolocation capabilities for military aircraft.

Commercial Application: Industries such as telecommunications and law enforcement for locating RF sources. Geolocation concepts can be evolved in a laboratory to reduce risk/cost and time to insert technology into the marketplace.

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KEYWORDS: Geolocation, Digital Receiver, Simulaation, Synthetic Battlespace.

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AF06-201 TITLE: Simulation Technologies to Rapidly Evolve EA Sensor Resource Management Concepts

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop simulation technologies to rapidly develop/evolve/mature/demonstrate electronic attack (EA) resource management concepts.

DESCRIPTION: Advanced military platforms possess multiple sensors to perform diverse combat missions. The platforms are increasingly required to operate in a system of systems environment that emphasizes different capabilities as the mission unfolds. One sensor, the EA system, typically consists of a digital receiver and high-power transmitter. This EA system is utilized to detect, characterize, identify, geolocate, and jam (or target) threat radars. Next-generation EA systems will be required to attack advanced radar threats with sophisticated coherent and high-power noise countermeasures. Dynamic receive/transmit schemes will be required to optimize the search and transmit functions of the sensor and reduce spectrum interference. In addition, single and multi-platform countermeasures techniques should be used in a way that minimizes severe interference with friendly communications and data links. Simulation technologies are sought that can rapidly develop/evolve/mature/demonstrate intelligent EA sensor resource management concepts to meet system of systems operational requirements. This is a challenging research area because of the dynamic environment and the need to balance multiple objectives (geolocation, countermeasures techniques, ground moving target indication (GMTI) multilateration, etc.). Phase I risk reduction demonstrations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE I: Identify the critical technology challenges, synthesize advanced methods, perform concept feasibility analysis.

PHASE II: Implement and demonstrate the critical simulation technologies required to rapidly develop/evolve/mature/demonstrate EA sensor resource management concepts.

PHASE III DUAL USE APPLICATIONS:
Military Application: Electronic Attack sensor resource management concepts are force-multiplier technologies to improve EA effectiveness and eliminate electronic fratricide.

DUAL USE COMMERCIALIZATION: Resource management applications include cellular comm., predictive maintenance for manufacturing and process controls systems and homeland security (perimeter anomaly detection, border protection, etc).

REFERENCES:

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KEYWORDS: Electronic Attack, Resource Management, Simulation

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AF06-202 TITLE: Integration of Risk Analysis into Acquisition Cost, Schedule, and Performance Evaluation Tools

TECHNOLOGY AREAS: Materials/Processes, Weapons

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVES: (1) Develop and demonstrate a new tool that supports functional analysis and performance evaluations (systems engineering activities) of EO technologies in a system of systems operationally representative environment via architectures and including quantification of risk impacts to streamline the number and type of tools required. (2) Effectively demonstrate how this new tool can also be integrated with applications for cost and schedule evaluation (that also include risk impacts) to evaluate trades in requirements to plan capability developments.

DESCRIPTION: The timely development of affordable EO detector and laser technologies, and the subsequent transition of the technologies to the warfighter, is becoming critical to sustaining the Air Force's global technical superiority. In the current environment of declining budgets it is imperative to have engineering tools that will allow informed decisions to be made that will allocate valuable resources to the right technology developments. These decisions are currently delayed or constrained by our ability to evaluate EO technologies in the broader operational context of netcentric warfare (which requires architectures) and against competing requirements for cost and schedule which requires the ability to understand and quantify the impacts of uncertainty. A new EO technology, risk assessment, systems engineering tool will be invaluable in allocating scarce Air force resources in the laboratory as well as in system development.

Currently, cost, schedule and performance risk assessments for the exploratory and advanced developments of new EO technologies are mostly qualitative in nature. These qualitative risk assessments are not easily and effectively transitioned into the program planning process of a system. The evaluation of these uncertainties is also done mostly through other software applications which require more effort and time to complete. A new EO technology, risk assessment, systems engineering tool is needed that allows for quantification of the uncertainties or risks with the MS & A of expected performance. Examples of elements that will determine the risks of the development are type of material, availability of material, materials growth techniques, materials purity, signal processing, thermal properties, and cooling approaches. Once the elements are identified, metrics with uncertainty ranges or distributions must be determined. These element metrics, their uncertainties and their distributions should be incorporated into the new EO technology, risk assessment engineering tool. Systems engineering is an iterative process and sustaining iterations of requirements evaluations through multiple tools is not practical and has often led to the exclusion of uncertainty impacts with "point estimate" results. Impacts of the risks on achieving performance objectives can then be integrated directly into cost and schedule applications with similar capability to iterate trades on potential changes. This is needed to answer critical information the warfighter and milestone decision authority require: what capability (performance) can be delivered at what time (schedule) at what cost with a well understood level of risk. This tool must be compatible with and integrated into at least one system program management tool such as Dynamic Insight. Successful integration of this new engineering tool will allow complete and consistent management assessment of the EO technology risks on system performance, cost and schedule. Complete and consistent assessments of the technical risk of EO technology developments on program success are critical in the early states of system development where the integrity of program planning is crucial.

PHASE I: Develop a concept of an engineering tool for new EO technology that will support the use of architectures and quantitatively incorporate risk metrics, with associated uncertainty ranges and distributions for new technologies, into the system level program management tools. Identify a concept for integrating the new tool into a system level program management tool, and identify a proof of feasibility demonstration of the engineering tool.

PHASE II: Design, develop, and demonstrate an EO technology, risk assessment, systems engineering tool and approach to integrate with a system acquisition cost/performance/schedule/risk tool. Detail plans for the Phase III effort. This may include developing a more generic version of the tool for other technologies and/or integration with a system level program management tool.

DUAL USE COMMERCIALIZATION: The developed and integrated tools can be used for any military or commercial acquisition where new EO or similar technology is to be integrated into any new or existing system.

REFERENCES: Air Force Policy Memo 03A-02, Subject: Agile Acquisition Implementation.

KEYWORDS: Risk Assessment, Cost Estimates, Schedule Asssessments, Performance Evaluations, Integrated Risk Assessments, Decision Space.

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AF06-203 TITLE: Automatic Self-Tasking for Dynamic Sensor Management

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and demonstrate algorithmic methods enabling automatic self-tasking for distributed sensor systems.

DESCRIPTION: In tactical targeting situations, it is becoming increasingly important to manage distributed, heterogeneous sensing on a time line consistent with the target's operational cycle to achieve reliable target acquisition. This process management activity will require improved dynamic sensor management that anticipates the incremental discovery and accrual of information derived from exploitation of the sensor collections. Dynamic sensor management in concert with fusion will require process flow control capability that is both proactive and reactive. Proactive control strategies that can compensate for instability will require process flow models that references collection value model. Unlike the open loop planning problem of sensor resource management, the dynamic problem requires a capability for automatic self-tasking in response to changes in situation estimates.

Increasing use of distributed sensor systems can provide challenges in dynamic sensor management. Heterogeneous capabilities of in situ sensors together with standoff sensors can offer unique capabilities for Intelligence Surveillance Reconnaissance (ISR). Considerable work has been done on Resource allocation and management of sensor to achieve coverage tasking. However, the challenge is how a sensor field can manage automatically its own tasking consistent with (ISR) mission and confluence of user needs from multiple echelons. This will require an automatic self-tasking capability to compensate for sensor coverage gaps due to resource limitations, scheduling conflicts, and uncertainty in collection value. Variation in collection value may arise due to interaction with environmental conditions (e.g., weather, terrain, foliage, etc.) and sensor performance.

The self-tasking could originate from commander's policies for information-gathering, preliminary sensor exploitation reports, predictive assessments of requirement satisfaction tasking in terms of planned collection schedules, and indications of partial satisfaction or reliability of the collection plan. An adaptable workflow management capability will be required. This topic seeks to develop technology that enables adaptable workflow management and self-tasking of a distributed sensor system that accounts for dynamic resource allocation limitations, and variability in information value of sensor collections, to include: Modeling system components and controls at adequate level to facilitate concept validation; Develop algorithmic methods; Demonstrate the methods developed using a simulation and test; Analyze test results and determine technical feasibility of approach for realistic military surveillance and targeting missions.

PHASE I: Identify a focus problem generally representative of a military surveillance and targeting mission and the sensory assets used to conduct them. Model system components and controls at adequate level to facilitate concept validation. Develop algorithmic methods. Demonstrate the methods developed using a simulation and test. Analyze test results and determine technical feasibility of approach for realistic military surveillance and targeting missions.

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.

PHASE III DUAL USE APPLICATIONS: Over the last 2 decades, diverse sensing applications such as video surveillance, automated manufacturing, and intelligent traffic control have experienced similar growth and challenges as witnessed in military domains. Methods developed under this effort would provide a foundation for self-tasking of these systems as well.

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KEYWORDS: Sensor Resource Management, Dynamic Tactical Targeting

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AF06-204 TITLE: Long-Duration, Eye-in-the-Sky Monitoring for Airfield Threat Detection

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a UAV system that provides automated persistent monitoring of remote airfields.

DESCRIPTION: The ability to scout around an airfield, if implemented in a way that is transparent to the forces that use it, would significantly reduce the risk of treats/intrusions from small enemy forces with portable weapons. A UAV that is remotely launched and that can stay aloft for long periods of time with little or no user intervention, either through very efficient flight or a self-refueling capability, is sought. The system should broadcast visual/IR data to any ground troop equipped with an appropriately instrumented PDA within a 1-km radius of the vehicle. A protocol should be developed whereby the vehicle can be commanded to investigate a region, or provide more data about suspected activity detected during a standard search pattern. Image stabilization and zoom capability, either through optical methods or low-altitude hovering flight, should be built into the system design. Low cost is the primary requirement followed by flight duration, and simplicity of operation and maintenance. However, these requirements must be balanced against the mission requirements. A valid concept must consider the proper balance between on-board and off-board processing as well as communication requirements. For example, automatic imagery change detection can cue operators to intruders. The design should decide where change detection processing occurs based on on-board processing and communication cost, weight, and power. One extreme is to put all processing in a ground based processor but communication bandwidth limitations and subsequent latency could be prohibitively large. Another system consideration is the ability of sensors to produce exploitable data. In particular, sensors must have enough field of view to give the operator good situation awareness but also have enough resolution to track individual intruders. Another sensor issue is whether fixed or gimbled sensors should be used. Fixed sensors which cannot be pointed are cheaper and lighter but require the UAV to maneuver more to maintain track and thus consume more fuel. Gimbled sensors can be pointed to allow the system to maintain track on targets with less maneuvering but gimbled sensors cost and weigh more.

PHASE I: Phase I tasks should establish concept feasibility. Tasks could include: 1) Define technical goals for eye-in-the-sky monitoring systems; 2) Develop a system concept to meet the technical goals; 3) Identify primary technology advances required; 4) Perform initial design tradeoff studies; 5) Simulate hardware/algorithms; 6) Develop a plan for phase II, including flight tests to be performed. For any trade studies to be performed, data should be identified.

PHASE II: Given the low cost of purchase and operation of small UAVs (less that $10K), the outcome of Phase II could be a flying prototype that demonstrates feasibility of essential eye-in-the-sky monitoring system technical concepts and goals. Phase II activities might include: 1) Simulation based analysis 2) Further trade studies 3) Prototype sensor system development; 4) Definition of improvements needed for potential Phase IIIs.

PHASE III DUALl USE APPLICATIONS: Potential opportunities for transition of this technology include the commercial sector and military programs that would benefit from sustained presence of airborne surveillance. Opportunities for developing commercial applications of the technology include remote/environmental sensing, security in remote areas, search and rescue support, and entertainment/news applications.

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KEYWORDS: UAV (Unmanned Air Vehicles), Video tracking, Dismount tracking, EO/IR sensors, remote airfield protection, Registration

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AF06-205 TITLE: Multiband Array Radiators

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: The requirement for a multiband radiating element that can be configured for operation within a multiband array. Emphasis will be placed on element size and manufacturability.

DESCRIPTION: This effort will develop a multiband radiator element which is suitable for use in a multiband phased array. The design of the wideband radiating element shall be such that frequency coverage of all or a subset of the 11/15/20/30/44 GHz frequency bands will be provided. The radiating element polarization should be adjustable with an objective goal of providing linear, dual linear and/or circular polarization. Design emphasis shall focus on radiating elements that can be incorporated on or within thin structures suitable for airborne communication installations. The trade space will include radiator frequency coverage, instantaneous bandwidths, axial ratio (for circular polarization), manufacturability, element depth (thickness and/or protrusion above a ground plane surface), and efficiency. Radiator designs that have merit will be analyzed in detail.

PHASE I: Numerous multiband radiator element design options will be considered, evaluated and compared. The maximum array spacing constraints will be defined to set the radiator dimensions. A prototype will be built and its performance properties will be measured to validate predicted performance.

PHASE II: The element performance within the array will be studied. The effects of mutual coupling will be analyzed. A small subarray will be fabricated and its performance properties will be measured to validate the theoretical and numerical predictions. Iterations to the designs will be identified, and implemented as necessary and feasible. The results will be summarized in a Phase II report.

DUAL USE COMMERCIALIZATION: Commercial industry is interested in developing multiband apertures for satellite communications. Greater capability in a smaller volume is advantageous for commercial air transport as well as for small mobile communication users.

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KEYWORDS: algorithms, spectral, hypercube, wideband radiator, traveling wave element

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AF06-206 TITLE: High-Efficiency Extremely High-Frequency (EHF) Power Amplifiers

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Demonstrate improved performance EHF power amplifiers using 3-D Microfabrication

DESCRIPTION: As reconnaissance capability grows, transferring information to the battlespace from a distributed set of reconnaissance assets requires increasing amounts of bandwidth. In addition, low-frequency bands are now being employed for a large variety of military and nonmilitary applications. This has led to an increasing need for EHF communication antennas. However, the power amplifiers often limit the cost and the performance of EHF antennas. Increased power output levels of EHF power amplifiers will increase the overall performance of satellite communications (SATCOM) systems by increasing the data rates of channels, allowing intelligence to pass to disadvantaged terminals for distribution of information to lower levels within the battlefield environment.

Recent developments in 3-D microfabrication technology allow the design of high-performance EHF components. This presents the possibility of improving the performance of EHF power amplifiers by integrating passive components with active semiconductor chips. In addition, 3-D microstructures can be used to improve thermal dissipation. This effort will investigate the advantages of these approaches when applied to EHF power amplifiers. The power output of these 3-D power amplifiers should be > 1.2 watts with an input power of 300 milliwatts. In addition, the power-added efficiency should be greater than 15 percent with linearity sufficient to support Gaussian minimum shift keying (GMSK), quadrature phase shift keying (QPSK), 8-phase shift keying (PSK), 16-quadrature amplitude modulation (QAM), filtered symmetric differential phase-shift keying (FSDPSK), differential QPSK (DQPSK), and 8- differential PSK (DPSK) modulation modes over an operating temperature range from –40 to +80 °C. Radiation goals include total dose of 300 K rad (Si) and single event latchup immunity greater than 90 MeV/mg/cm^2

PHASE I: Design a 3-D microfabricated power amplifier at 20.2-21.2, 43-45, or 50 GHz. Simulations of both electrical and thermal properties shall be performed.

PHASE II: Prototype power amplifiers shall be built and characterized based on the Phase I results.

DUAL USE COMMERCIALIZATION: Commercial applications include local multipoint distribution service (LMDS), multichannel multipoint distribution service (MMDS), and automotive radar.

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KEYWORDS: millimeterwave, power amplifiers, 3-D MERFS, EHF, microstructure, MEMS

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AF06-207 TITLE: Ground-Based Radar Performance Improvements

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Investigate methods of improving the accuracy, responsiveness, and mission completeness of ground-based radar systems.

DESCRIPTION: Current and future ground-based radar platforms must ensure near-100 percent kill rates to preclude potential catastrophic homeland attack. As such, the accuracy, completeness, and responsiveness of capabilities associated with target acquisition, tracking, and identification is critical. Performance-enhancing algorithms can do much to assist in this activity for target discrimination and classification using neural net and physics-based techniques; for target acquisition using coherent/noncoherent integration; for tracking using Doppler velocity and super resolution; and for accurate hit/kill assessment via mitigation of special effects such as ionospheric disturbances or countermeasures The proposal should evaluate all of the above techniques and other developing technologies with emphasis on the above capabilities.

PHASE I: Develop and demonstrate the applicability of performance-based algorithms for target acquisition and tracking. A variety of performance-enhancing algorithms will be researched. Promising algorithms will be simulated.

PHASE II: Expand the algorithm development from Phase I to address target discrimination, classification, and hit/kill assessment. Document the algorithm implementation. The results will be summarized in a Phase II report.

DUAL USE COMMERCIALIZATION: Commercial industry is interested in developing target discrimination for robotic applications. There is synergy as well in the algorithm development for security systems, collision avoidance, and tactile sensors.

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2. Cooperman, R.L., "Tactical ballistic missile tracking using the interacting multiple model algorithm," Information Fusion, 2002, Proceedings of the Fifth International Conference on the 8-11 July 2002, referencing Volume 2, pp. 824 – 831.

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KEYWORDS: missle,tracking,target,acquisition,neural networks

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AF06-208 TITLE: Adaptive Signal Processing to Counter Jamming

TECHNOLOGY AREAS: Sensors

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop the capability to utilize an adaptive signal processing techniques(s) to counter jamming/interference with varying bandwidth.

DESCRIPTION: There is a plethora of papers in the literature on narrowband adaptive signal processing but there is an increasing need to counteract interferences in wideband environments due to improving technologies that enable the employment of systems with wider bandwidth. Currently, narrowband adaptive algorithms are based on narrowband assumptions and using these narrowband algorithms in a sufficiently wideband systems will result in significant performance degradation. The main goal of the program is to develop wideband adaptive algorithms as well as strategies and techniques that attenuate interferences with varying bandwidths and center frequencies while preserving the desired signal. A scenario of interest is to assume that we have a wideband system with M array elements, with a bandwidth to center frequency ratio greater than 0.2, and N interferences with different bandwidths and center frequencies spread throughout the system's operating frequencies. Commercial applicability of the above is manifested in the potential to adapt these new technologies for both atmospheric and space private sector support and capabilities.

PHASE I: Develop strategies and algorithms, which may be based on existing algorithms, to attenuate interferences in scenarios similar to the one described in the description. For example, one potential wideband adaptive approach to counter interferences with varying bandwidth is to partition the received signal into multiple narrowband channels and then apply conventional narrowband adaptive processing techniques on these narrowband channels. It is expected that the contractor will rigorously simulate the proposed algorithms in Matlab for selected scenarios to demonstrate algorithm performance; extend the analysis to develop, demonstrate and utilize state-of-the-art hardware that can improve the interference mitigation performance of the algorithms developed in this phase.

PHASE II: Expand the work in phase I to include: algorithm fine tuning for performance and algorithm refinement into a form that is suitable for implementations in high speed FPGAs; derive theoretical performance bounds for various system parameters; and if available, test simulated algorithm using real data; demonstrate the feasibility of implementation by programming the algorithm into a state-of-the-art commercially available FPGA demonstration board and determine its performance in such an environment. The Phase II deliverables shall include the following: a detailed mathematical description of the algorithm; characterization of the theoretical and simulated performance of the algorithm; a state-of-the-art commercially available FPGA demonstration board with the proposed algorithm implemented in its firmware; test results and comparison of measured versus simulated performance of the algorithm over a bandwidth-to-center frequency ratio of 0.2 or greater, as described above.

DUAL USE COMMERCIALIZATION: Military application: The new tools and approaches developed under this effort will be directly applicable to current and future military surveillance systems. In addition, the commercial industry is interested in developing adaptive signal processing techniques to mitigate non-intended jamming.

REFERENCES:

1. "Quantitative testing research of surveillance radar anti-jamming performance" by Shen Gui-ming; Zhu Wei-hua; Radar, 2001 CIE International Conference on, Proceedings , 15-18 Oct. 2001 Pages:255 - 259

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KEYWORDS: Adaptive Signal Processing, Jamming, Interference

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AF06-210 TITLE: Hyperspectral Algorithms for Anomaly Detection

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: To develop algorithms for hyperspectral systems and pseudo imaging spectrometers that are capable of rapid processing of raw MASINT information from a full hypercube or hypercube chip response

DESCRIPTION: Spectral imaging sensors record the intensity and spectra of every point of an observed scene and can be applied to military reconnaissance, surveillance, and targeting missions.
Raw 3-d data from the scene (x, y, wavelength) is typically multiplexed on the 2-d sensor focal plane array and requires some form of signal processing to extract the wavelength and position. Subsequent samples are used to

gather the time evolution and form the hypercube. Hyperspectral Information from a full hypercube currently takes more than 4 hours to process and from a hypercube chip more than 20 minutes. Algorithms are required to reduce the processing time for anomaly detection and identification from operator specified parameters on an entire hypercube to less than 1 hour and an entire hypercube chip in less than 1 minute.

Payoff/Warfighter impact: Increased capability for situational awareness and updated intelligence.

PHASE I: Select methods and algorithms that can rapidly process raw information from a full hypercube or hypercube chip. The method or algorithms will have the ability to discriminate anomalies within the processed data.

PHASE II: Develop a complete suite of algorithms that takes raw sensor data from a hypercube, rapidly processes it and provides anomaly detection. The algorithm will have the ability to update and maintain a dynamic event library for future use in anomaly detection. The algorithms should be able to detect and separate multiple events for proper cataloging.

PHASE III DUAL USE APPLICATIONS: These algorithms could be applied in any work environment involving hyperspectral sensing or spectral analysis. Possible applications include real-time mineral exploration, hazardous waste remediation, rapid counterfeit currency detection, and counter-drug detection.

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2. A.K. Brodzik, R. Tolimieri. , “Gerchberg-Papoulis Algorithm and the Finite Zak Transform.” Proc. SPIE, vol.4119, p.1084-1093 , 2000
C.E. Caefer, S.R. Rotman, J. Silverman. , “Algorithms for Point Target Detection in Hyperspectral Imagery.” Proc. SPIE, vol.4816, p.27-29, 2002

KEYWORDS: Algorithms, Spectral, Hypercube

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AF06-211 TITLE: Two-Color Infrared (IR) Simulation Tools

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a dynamic, real-time, high-fidelity, two-color IR scene generation and sensor emulation for IR missile warning system (MWS) applications.

DESCRIPTION: The major challenge in developing an operationally useful IR MWS is maintaining a high probability of detection in high clutter with a minimum number of false alarms. A major source of false alarms is sun reflections and sunlit objects. A method to remove false alarms caused by the sun is to use two-color discrimination techniques. Two-color discrimination techniques offer great promise, but maturing this technology is a major challenge and will be expensive. The ability to realistically evaluate and mature the two-color IR MWS systems and their algorithms in a laboratory environment is required to successfully develop these technologies. Currently available laboratory IR simulators provide the capability to generate high-fidelity single-color IR scenes and emulate single-color MWS sensors in real time, but cannot provide the required fidelity and real-time signal environment generation capability needed to mature two-color IR sensor systems. Approaches are sought that lead to the creation of innovative, user-friendly, dual-use simulation methodologies and technologies utilizing a two-color capability to develop, evaluate and mature the two-color MWS and their algorithms. Phase I risk reduction demonstrations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE I: Define the simulation technology necessary to test current and future two-color MWS systems. Define a design approach to develop a two-color simulation capability.

PHASE II: Implement and demonstrate the critical simulation technologies required for developing, evolving, maturing, and evaluating missile warning system sensors and algorithms in a laboratory environment

DUAL USE COMMERCIALIZATION: Military application: A high-fidelity two-color IR scene generator and sensor emulation for MWS applications has applications for maturing missile warning technologies in many DoD and contractor test facilities.

Commercial application: A two-color scene generator has commercial application for developing and demonstrating IR sensors for use by firefighters and search and rescue teams looking for disaster victims or accident survivors.

REFERENCES: 1. Ultraviolet scene simulation for missile approach warning system testing
Giza, Robert H. (Amherst Systems Incorporated); Acevedo, Paul A.; Bliss, John D.. Proceedings of SPIE - The International Society for Optical Engineering
1997. Vol.3084; p.282-291

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KEYWORDS: two-color IR MWS, MWS testing, system of systems testing, multispectral testing.

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AF06-212 TITLE: Indium Antimonide Substrate Growth for Affordable Large-Format Mid-Infrared (IR) Imagers

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a manufacturing technology to produce low-cost, high-quality 6-inch-diameter indium antimonide (InSb) substrates.

DESCRIPTION: A specific fighter program is the Department of Defense's (DoD) focal point for defining affordable next-generation strike aircraft weapon systems for the Navy, Air Force, Marines, and our allies. The focus of the program is affordability−reducing the development cost, production cost, and cost of ownership of the family of aircraft. The specific goal of this program is to reduce the cost of megapixel IR detector assemblies used for fighter aircraft support and protection. Many other government programs require compact InSb focal plane arrays (FPAs) which operate in extreme environments while providing high-definition IR images.

InSb is an important semiconductor for IR detector applications in the 3- to 5-micron atmospheric window, and there has been significant interest in large-area InSb focal plane arrays. The demand for larger diameter InSb is following the same trends as other semiconductor materials wafers such as silicon, GaAs, InP, etc. Critical driving factors for increased wafer diameter include the ever accelerating need for larger focal plane array size and the reduction in processing cost by fabricating more die per wafer.

Chip processing is largely performed at the wafer level, so a logical way to keep costs down and realize economies of scale is to build more chips on a larger wafer. To meet this need, this solicitation focuses on the development of undoped 6-inch-diameter InSb, rather than the more established 2- and 3-inch-diameter single-crystal boules.

InSb Focal plane array are over 10 times greater in area than required 5 years ago. Array sizes have increased from 250 by 250 to 1K by 1K and customers are now designing 2K by 2K formats. This larger (2K by 2 K) format corresponds to one array per 100-mm (4-inch) or 75-mm (3-inch) wafer. A 150-mm (6-inch) InSb substrate will allow four 2K by 2K arrays on one wafer.

Thus, an increase from 100 mm (4 inch) to 150 mm (6 inch) in diameter will create a 2.25 times increase in surface area that translates into a fourfold increase in yield for 2K by 2 K FPAs. This is based on the number of arrays that will fit in the largest square aperture of each wafer. The increase in die yield is anticipated to reduce manufacturing costs on the detector side of the processing.

This solicitation is intended to provide the technology advantage for advanced FPAs and IR systems that will benefit from the timely availability for large-diameter InSb substrates for military and commercial high-precision circuitry.

To achieve larger 150-mm-diameter InSb substrates, specific issues need to be resolved for achieving and maintaining superior electrical results with the wafers. The Phase I program seeks to identify and implement crystal growth requirements, including equipment scaling, pull rates, temperature gradient consideration, final wafer thickness, inherent resistivity distribution with associated material characteristics, and polishing considerations. The ultimate goal of the solicitation is to decrease the cost of 2048 by 2048, or larger format, mid-IR imagers for DoD applications. Modify conventional cutting and polishing methods to minimize breakage of very fragile 6-inch-diameter InSb wafers. Identify the requirements, provide required modifications, and implement prototype 150-mm (6-inch)-diameter InSb substrates for use in electrical testing. Basic device fabrication as an end task for Phase I is encouraged.

PHASE I: Develop new technology for manufacturing InSb wafers that are 6 inches in diameter, double the current standard size, which would enable up to 6 times as many FPAs to be produced.

PHASE II: Implement larger diameter substrate process control guidelines and InSb lot specifications. Manufacturability and verification of large-diameter processing ability in this phase will be demonstrated by lot-to-lot statistical process control (SPC) implementation and advanced FPA fabrication.

DUAL USE COMMERCIALIZATION: The InSb wafer market worldwide has a market cap of approximately 3 million dollars. Demand for this material will grow at approximately 15 percent annually over the next 5 years. The military subcontractor community has maintained a keen interest in larger diameter wafers since it would provide a significant cost savings at the customer level. The homeland defense and security has also heightened the demand for IR materials.

REFERENCES: 1. Tevke, Ahmet ; Besikci, Cengiz ; Van Hoof, Chris ; and Borghs, G., “InSb infrared p–i–n photodetectors grown on GaAs coated Si substrates by molecular beam epitaxy,” Solid-State Electronics, Volume 42, Issue 6, June, 1998, pp. 1039-1044.

2. Rogalski, Antoni, “Infrared detectors: status and trends,” Progress in Quantum Electronics, Volume 27, Issue 2-3, 2003, pp. 59-210.

KEYWORDS: infrared, focal plane array, substrates, InSb

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AF06-213 TITLE: Low-Cost, High-Performance Inertial Rate Sensors

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and test low-cost, high-performance inertial rate sensors for attitude determination, optical system line of sight (LoS) determination, and use in precision inertial reference units (IRUs).

DESCRIPTION: Proposed surveillance systems, such as Space-Based Infrared System High (SBIRS High) and Space-based Surveillance and Tracking System (STSS), require extremely high-resolution LoS stabilization and extremely accurate inertial pointing. High-performance inertial rate sensors are needed to provide absolute inertial line of sight knowledge and the necessary low-frequency sensor information to support the control system LoS stabilization for the pointing and tracking system. These inertial rate sensors are typically the highest-cost components in IRUs and attitude determination and guidance systems. Reducing the costs of these sensors without loss of performance will be the goal.

PHASE I: Develop a preliminary design for a low-cost, high-precision inertial rate sensor. Modeling, simulation, and analysis (MS&A) of the design must be presented to demonstrate offerer's understanding of the sensor's physical principles, performance potential, scaling laws, etc.

PHASE II: Complete the critical design of a prototype inertial rate sensor, including all supporting MS&A. The contractor will fabricate a minimum of two, preferably four, devices and perform characterization testing within the financial and schedule constraints of the program to show the level of performance achieved compared to stated Government goals.

DUAL USE COMMERCIALIZATION: Military application: The work will be done with a commercial company to develop a sensor product line and an integrate IRU product line based on the new inertial rate sensor technology developed in Phase I and II. A low-cost, high performance sensor IRU has the potential to positively impact military and civilian applications.

REFERENCES: 1. IEEE Standard 528-2001: IEEE Standard for Inertial Sensor Terminology

2. IEEE Standard 529-1980 (R2000): IEEE Supplement for Strapdown Applications to IEEE Standard Specification Format Guide and Test Procedure for Single-Degree-of-Freedom Rate-Integrating Gyros

KEYWORDS: Gyroscope; rate sensors; inertial reference unit (IRU); inertial navigation system (INS); acquisition, tracking, and pointing (ATP); inertially stabilized platform; and, beam control

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AF06-214 TITLE: Low-Profile Tamper Detection Sensors

TECHNOLOGY AREAS: Materials/Processes, 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.

OBJECTIVE: To develop tamper detection sensors undetectable to a reverse engineer.

DESCRIPTION: The Anti-Tamper - Software Protection Initiative (AT-SPI) Technology Office is charged with developing technologies to prevent/delay the exploitation of critical program information (CPI). Of particular concern is the need to protect critical design elements or manufacturing processes. Anti-tamper technology development efforts must balance the need to protect critical technologies from exploitation, with the need to minimize the impact of anti-tamper technology application on system performance, operations and maintenance, and cost.

Detection of tamper events is key to the protect/detect/react paradigm of anti-tamper technology. If a reverse engineer detects a tamper sensor, he can often work around it to extract useful design and performance information from hardware and software. If the detection function is disabled, the reaction feature will fail to protect the targeted critical technology. Tamper sensor(s) must be capable of detecting tamper events and cue anti-tamper reactions without significant false alarm rates that can degrade overall system reliability and maintainability. Successful sensors would be able to detect whether a protected circuit is in an operational environment or a laboratory environment, and trigger appropriate protection reactions. Finally, self-powered sensors would eliminate the need for batteries or other latent power sources.

AT-SPI is interested in sponsoring research for low-profile anti-tamper sensors. The effectiveness of these devices can be measured in terms of metrics such as shelf life, active or passive, compact packaging, detect ability to a reverse engineer, difficulty for a reverse engineer to disable once discovered, design flexibility to incorporate into an anti-tamper design, voltage and current characteristics under relevant environmental extremes, susceptibility to tampering (reverse engineering) techniques, cost to incorporate into a protected circuit, difficulty in manufacturing, and operations and support (including reliability-and-maintainability) impacts.

PHASE I: 1) Research current technologies and reverse engineering tools and techniques
2) Requirements analysis
3) Develop a preliminary methodology
4) Develop a preliminary design document that includes measures of effectiveness criteria.

PHASE II: 1) Update the system design based on government feedback
2) Refine the methodology and perform small lot prototype runs for three package configurations
3) Perform sensor testing in relevant environmental extremes for significant durations
4) Deliver detailed results of attacks and protection effectiveness, to include attack trees, processes, times, and similar data.

DUAL USE COMMERCIALIZATION: Development of long-life, environmentally stable, low-profile tamper detection sensors would be marketable in both the DoD and commercial sectors. These devices would be applicable to the vast market of consumer electronic devices, enabling protection of proprietary information.

REFERENCES: 1. Huber, Art (Lt Col, USAF), and Scott, Jennifer, “The Role and Nature of Anti-Tamper Techniques in U.S. Defense Acquisition,” Acquisition Review Quarterly, Fall 1999, pp. 355-368.

KEYWORDS: trigger, sensor, self-powered, low profile, anti-tamper, reverse engineering

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AF06-215 TITLE: Lightweight, Miniature Sensor Payload for a Mini-UAV

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a lightweight (less than 4 kilograms) sensor system for surveillance. Capable of standoff ranges of 100 m or more and provide functionality not present in a visible light (video) sensor. Stress heavy development of a sensor that employs an RF sensor to augment the system.

DESCRIPTION: Ubiquitous sensor platforms offer the potential for total battle-space awareness. A key component of an ad-hoc sensor network involves the use of mini-UAV based sensors released in a localized area for surveillance. Visual sensors, such as small cameras, have been and are being exploited to 'look ahead' for awareness. Exploitation of other portions of the electromagnetic spectrum, such as the microwave and mm wave in the RF spectrum, is the next area crucial to further success of UAV sensor systems and requires innovative and exploratory research to advance. The RF spectrum offers the potential for developing a highly effective, lightweight sensor system capable of imaging, detection, tracking, and identification of targets for use on a mini-UAV platform.

Ability to provide near all weather surveillance in dust, fog, rain, and other obscurants which generally degrade the capability of optical sensors is needed. Development of a RF sensor which can mitigate these environmental factors is needed.

A ground station which controls and receives data from the mini-UAV must be included in the development for delivery at the end of the program. The UAV and ground station must be demonstrated at a government facility prior to completion of the project. The demonstration must show the ability to process and display images and other data taken by the sensor package. It is expected this equipment should be available commercially now and is only required to show the capability of the developed RF sensor system.

PHASE I: Develop a bench-top system and demonstrate its capabilities using appropriate laboratory equipment. The RF sensor package, including power source, must weight less than 4 kilograms and occupy a volume not more than 20 by 20 by 10 cm.

PHASE II: Further develop the sensor package to be an air-worthy sensor system and install it on a mini-UAV. Develop the ground station to accommodate field conditions suitable for demonstration of a complete sensor system. Onboard electronics should process the data collected by the sensor to minimize the required down-link bandwidth to the ground station.

DUAL USE COMMERCIALIZATION: The sensor developed as part of the project can also be used to improve surveillance of private facilities, especially in locations not conductive to visual monitoring. This has applications for Homeland Security, commercial security, and monitoring of areas when human presence is either not desirable or safe (e.g. in the presence of toxic chemicals, etc…).

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3. R. Wright, "Mini UAV Sensor Suites," http://www.dtic.mil/ndia/night/Wright.pdf.

KEYWORDS: Sensor, Surveillance, Image

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AF06-216 TITLE: Coatings for Millimeter Wave (MMW) Electronics

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop and demonstrate protective coating materials for millimeter wave (MMW) systems.

DESCRIPTION: In an effort to meet the size, weight, and power-along with cost (SWAP-C) requirements for future large-area, high-performance electronics, one area that will provide significant gains in meeting these challenges is alternative packaging approaches where the traditional hermetic package is replaced with a hermetic-like protective coating. This will be especially true in large-area, flexible MMW assemblies where arrays of electronics will be assembled without packages. This will also be the case where one's application requires conformal electronics such as on the leading edge of a wing or on the side of a fuselage where the system is limited by size and weight and there is no room for conventional hermetic packaging. These systems will still require environmental coatings for protection but the coating process will need to be accomplished using non-conventional approaches. The most promising concept is coatings which are either hermetic, or hermetic-like. These coatings must be low-cost, lightweight, and must not degrade the performance of the electronics that they are protecting. The coatings must be electrically, thermally, and mechanically sound. There have been efforts looking at plastic packaging for low-cost lightweight systems. One issue/concern with plastic is moisture permeability. One approach is to coat the package to keep the moisture away from the electronics. There have been some successful demonstrations of coatings such as benzocyclobutane (BCB) and silicon carbide (SiC) for circuits up to about 10 GHz; however, the effects of these coatings are not known at higher frequencies. With the coatings demonstrated to date there is a noticeable shift in frequency response; however, if the effects are well characterized, a designer can adjust the design of the circuit to compensate for the shift and actually meet the design criteria for that circuit. Today's circuits are on several types of substrates, such as GaAs, SiGe, InP, GaN, LCP, LTCC, etc. and a variety of chips which may be assembled chips first or flip-chip mounted. These circuits may also work in different environments such as ground-based systems, air vehicles, and space-based systems. The coatings developed on this effort should take these differences into consideration. These circuits should operate at 10 GHz or higher in frequency.

PHASE I: Coating materials shall be analyzed and the most promising developed and demonstrated on a single circuit such as a low-noise amplifier (LNA), power amplifier, or phase shifter. Test results should be shown before and after coating to understand the effects on electrical performance.

PHASE II: Coating materials shall be characterized and demonstrated for a system-on-a-chip (SOC) such as transmit/receiver on chip. The coatings shall be environmentally tested and shown to provide protection over the temperature range -55 0C to 125 0C.

DUAL USE COMMERCIALIZATION: Commercial applications for protective coatings of high-frequency electronics include automotive collision avoidance and communications. These coatings can be used in other package-less electronics and even wearable electronics that can be used for personal communications.

REFERENCES: 1. William D. Brown, "Advanced Electronic Packaging with Emphasis on Multichip Modules," IEEE Press, New York, NY (1999).

2. Nirod K. Das, and Henry L. Bertoni, "Directions for the Next Generation of MMIC Devices and Systems," Plenum Press, New York, NY (1997)

KEYWORDS: sensor

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AF06-217 TITLE: <u>Signature Prediction and Uncertainty Analysis for Recognition Applications</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop physics-based feature spaces and uncertainty bounds for complex targets to support target recognition and fusion applications.

DESCRIPTION: The Air Force Research Laboratory (AFRL) is actively pursuing new sensor development driven by physics-based algorithms for the detection and identification of moving and stationary targets. Exploratory research in the area of physics-based signature prediction and feature characterization of targets and background radar signature data is sought with the goal of improving synthetic aperture radar (SAR) radar sensor and processing development for target detection, recognition, and fusion applications. Innovative prediction and analysis techniques that characterize complex target scattering features are needed to allow the development of optimized processing algorithms and recognition techniques. As robust recognition algorithms must accommodate statistical variations of inputs, quantitative analysis methods for characterizing the impacts of complex target signature variability and uncertainty in signature and algorithm feature space are also required. The main goal of this research is to develop optimal signature and uncertainty characterization of complex target and background scattering phenomenology for target detection and recognition algorithm development. This topic solicits innovative solutions in the following areas: 1) radar signature prediction techniques that characterize the scattering response of target or target in natural or urban setting, 2) innovative quantitative analysis methods analysis and feature extraction techniques, and 3) portable measurement systems for data collection to support signature prediction validation. Proposals that address one or a combination of the technology areas one through three will be considered.

Innovative physics-based phenomenology modeling techniques that support the prediction of radar observables from targets are needed. Signature prediction techniques for targets and clutter backgrounds should allow an imaging simulation of coherent sensed observables over a range of aspect angles such that sensor models can be applied as a post-processing step. Three-dimensional scattering centers extracted from complex image data are an abstract data characterization of complex target scattering. Signature prediction techniques should also support the development of innovative abstractions of target and background scattering phenomenology from pre-image formation data domains. Symbolic computational electromagnetic (CEM) techniques approaches that allow an analytical derivative to be taken with respect to frequency, a spatial variable or other variables are needed to efficiently support sensitivity studies. Advanced quantitative methods and design of experiment techniques analysis and feature extraction techniques that identify stable scattering features are also needed for robust physics based algorithm development. Existing target geometry and material collection techniques for computer-aided design (CAD) modeling of complex targets are equipment and time intensive [3]. Novel techniques that use hand portable equipment to efficiently collect target geometry and material information on tactical targets are needed. Target information collection methods should consider techniques for quantifying error and uncertainties of the collected data. Portable radar signature measurement systems are also needed for focused data collections to support synthetic signature validation efforts and optimize radar processing parameters for physics based feature exploitation.

PHASE I: Address at least one of the following: 1) prototype physics-based modeling tool, 2) prototype quantitative analysis method, and/or 3) proof-of-concept target geometry/material collection system or a signature measurement system.

PHASE II: Address at least one of the following: 1) physics-based radar signature modeling tools for complex targets in terrain settings, 2) develop a physics-based detection or recognition algorithm, and/or 3) develop a computer-aided design (CAD) geometry and material collection system or portable radar measurement system.

DUAL USE COMMERCIALIZATION: Target and scene signature modeling techniques developed on this effort have applications to large area site modeling for communication system design. Feature extraction and innovative algorithm concepts have application to advanced data analysis for consumer marketing analysis.

REFERENCES: 1. Sullivan, D., D. Andersh, T. Courtney, N. Buesing, and P. Jones, “Development of SAR Scene Modeling Tools for ATR Performance Evaluation,” Algorithms for Synthetic Aperture Radar Imagery VI, SPIE, Vol. 3271, April 1999, pp. 572 – 581.

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KEYWORDS: radar modeling, computer-aided design, data collection scattering centers

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AF06-218 TITLE: Hyperspectral Identification for Collaborative Tracking

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: Develop methods for extracting stable and adapting identification of targets in high-resolution HSI, video/infrared (IR), video plus acoustic (or stand-alone acoustic), and RF sensor data.

DESCRIPTION: One current research trend in modern/future war fighting is in the area of swarms of uninhabited air vehicles (UAVs). The problem we address in this SBIR effort is maintenance of a continuous track through innovative methods such as identification evolution (as a result of fluid extended operating conditions (EOCs)) and collaborative tracking amongst multiple UAVs. Hyperspectral Image (HSI) data is the initial focus, leading up to identification across multiple sensors and sensor types. While the main objectives for target tracking are very different for ISR and weaponized air vehicles, they both rely on continuity of track. The goal is to maintain multiple tracks of targets over large areas. Sensors must dwell long enough on the targets on interest in the field of view to get enough accuracy to maintain the track over extended periods of time. In this scenario, there is typically no a priori information regarding the targets. Unlike detection processes operating on a priori information, tracking can make specific use of identifying information on confusing targets in the area to dynamically develop new features for the situation at hand. Identifying information is extracted and then used to confirm the target identify as additional reports are collected. The identifying information allows trackers to hold tracks despite long gap times between reports. The information must be extracted to maximize stability and persistence across variable EOCs. Possible directions include optimal band selection and fingerprint evolution to compensate for changing EOCs. For instance, a hyperspectral target signature at dusk can be expected to change as lighting conditions change. A key part of this research is to develop methods for reliably predicting identification evolution in order to maintain the target track. Expected challenges include identifying a wide variety of target types (dismounts, passenger vehicles, unknown targets, etc.), sampling rate issues, signature variation due to pose changes, and operating in various terrains (open, forested, mountainous, and complex urban). The identify extraction methods should lend themselves well to collaborative tracking algorithms for ISR and weaponized UAVs for rapid sense to strike in complex environments.

PHASE I: Develop and demonstrate a proof of concept and suggest new/novel techniques for extracting robust target signatures and modifying them to compensate for EOC changes. Develop a software design demonstrating the validity of the approach.

PHASE II: Characterize performance over a wide range of data, including multisource data. This effort will include further developments to meet operational requirements.

DUAL USE COMMERCIALIZATION: Known civilian application areas include commercial aviation, intelligent vehicle highway systems (IVHS) drug enforcement, and transportation systems. Military applications include surveillance of the battle space with an improved and integrated picture of the battle space among platforms.

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KEYWORDS: Collaborative Tracking, Uninhabited Air Vehicle, Multispectral, Multiple Target Tracking

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AF06-219 TITLE: Signal Processing and Exploitation for High-Dimensional Synthetic Aperture Radar (SAR)

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop, implement, test, and analyze signal processing and exploitation techniques for high-dimensional SAR data to build a foundation for improving high-confidence combat ID capability.

DESCRIPTION: The need to improve combat ID capability is driving an interest in putting more sensed information at the disposal of the image analyst and his exploitation system. Radio frequency (RF) sensors, in particular, can provide such information in all weather conditions and at standoff ranges. The additional information can be collected by single or multiple platforms and can come in the form of increased bandwidth, multiple polarizations, and enhanced apertures (e.g., wide-angle data) including interferometric and fully 2-D apertures. This information can be used to characterize a target in 3-D space and to discriminate and recognize it by parts. The sensed aperture fills only a portion of the azimuth-elevation viewing sphere (we call this the sparse-aperture problem) in which a target is characterized by its monostatic radar response across a given bandwidth. The aperture space greatly expands when considering multistatic scenarios. Two-dimensional aperture diversity comes for free in the case of targets that are moving down a bumpy path. In this case, the unknown target orientation must be extracted from the radar phase histories in order to form 3-D imagery. In high resolution applications, this can be done by tracking scattering centers through phase histories and employing geometric invariants to extract 3-D information and estimate target orientation history. Also of interest in this problem domain are cost-benefit trade studies to determine best value aperture acquisition strategies. Finally, we seek semiautomated, multidimensional data visualization and aided target recognition (ATR) components/systems that are appropriate to the needs of the human interpreter. Such ATRs may overlay 3-D sensed target representations with computer-aided design (CAD) models and may articulate those models on the fly to achieve correspondence.

This research area presents several challenges. The application of classical Fourier imaging techniques to sparse-aperture problems leads to objectionable image impulse responses (IPRs) and sidelobes that need to be controlled for improved visualization. These classical imaging techniques also are matched to point scattering responses that are persistent in aspect angle. The point scattering response assumption fails in wide-angle applications and thus must be compensated. The geometries of the transmit and receive apertures have measurement uncertainty that can degrade image quality, leading to a need for data-adaptive image focusing. Effective and efficient tracking of scattering centers through scintillating phase histories is a challenge as is the extraction of geometric invariants from noisy scattering center range histories. Approaches for matching 3-D sensed information to articulateable CAD models or derived databases is needed to support the identification task. Finally, research is needed to provide an appropriate ATR system interface of the 3-D sensed information and CAD models to the human interpreter. Develop, implement, test, and analyze at least one of the following: 1) monostatic and/or multistatic enhanced 3-D target reconstruction, 2) optimization of the 3-D reconstruction, 3) 3-D reconstruction in the multistatic passive RF case, 4) 3-D matching techniques for finding correspondence between 3-D sensed target representations and articulateable CAD models and/or derived databases, and/or 5) 3-D target reconstruction techniques for moving targets.

PHASE I: Develop a system concept for integrating a prototype 3-D aided target recognition system to be implemented in Phase II.

PHASE II: Develop, implement, test, and analyze at least one more of the items in the Phase I list. In addition, integrate and test (on a simple three-target problem) a modular prototype aided target recognition system using the components developed in Phases I and II.

DUAL USE COMMERCIALIZATION: 3-D imaging techniques developed here have application in diverse fields such as 3-D acoustics, medical tomography, geosciences, and remote sensing. Both active and passive imaging is applicable within Departments of Homeland Defense and Justice in the tracking and fingerprinting of ground and air vehicles. The matching of 3-D sensed target representations to CAD models is applicable in the area of robotics and autonomous scene understanding.

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KEYWORDS: 3-D image reconstruction, passive RF, data-adaptive focusing, polarization features, 3-D subcomponent matching, moving target focusing, 3-D visualization, bistatic/multistatic imaging, aided target recognition, combat ID technology

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AF06-220 TITLE: Passive Three-Dimensional (3-D) Imaging and Ranging

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop algorithms for extracting 3-D imagery and absolute range from visible and infrared (IR) image sequences collected from small unmanned air vehicles (UAVs) or situational awareness sensors.

DESCRIPTION: Video imagery from both visible and IR camera systems is becoming a key component of airborne reconnaissance and situational awareness systems. In many situations, image sequences are captured over time periods for which there is a large perspective change between the imaging platform and the imaged scene, due either to the motion of the airborne platform, the motion of the objects imaged (e.g., missiles or other airplanes), or both. Theoretically, this should enable the construction of a 3-D representation of the imaged scene and the estimation of its absolute range. However, practical issues such as the general motion and uncertainties in the position and orientation of the imaging platform (especially in the case of small UAVs) and changes in the visible portions of the scene with perspective limit the ability to extract this information.

The goal of this program is to develop innovative passive 3-D imaging and ranging algorithms that address these practical issues. Situations of primary interest consist of absolute ranging of detected objects in missile warning sensor imagery and 3-D imaging from close-in visible and IR cameras located on mini-UAV and micro-UAV platforms where the relative motion between the sensor and scene is general and, to some extent, unknown. In both cases, it is important that the developed algorithms are amenable to real-time or near-real-time operation using reasonable image processing hardware for tactical system environments.

PHASE I: Phase I shall include theoretical development of the proposed algorithms, implementation in a laboratory environment, and initial demonstration on test imagery.

PHASE II: Phase II should result in a refined algorithm implementation on a tactically relevant computing platform and thorough performance evaluation against an extensive set of test imagery.

DUAL USE COMMERCIALIZATION: Processing technology being developed under this research program will have application to civil and commercial remote sensing applications such as law enforcement and homeland security.

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KEYWORDS: multiple-baseline stereo, motion stereo, passive ranging

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AF06-221 TITLE: Low-Cost Day/Night Imaging Sensors for Micro/Mini-Uninhabited Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: 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.

OBJECTIVE: Develop new concepts for further miniaturization of infrared (IR) imaging cameras for day/night, airborne imaging.

DESCRIPTION: Miniaturized IR cameras have been developed and demonstrated on small UAV platforms. Even smaller UAVs are being pursued as a close-in sensing component of military reconnaissance and targeting operations. Further miniaturization of IR cameras is required to support these smaller platforms as trades between flight duration and sensor package become critical. New cameras must be capable of providing adequate radiometric sensitivity and spatial resolution under both daytime and nighttime conditions. Night operation is a driving requirement, as the imaging sensor must be able to produce useful imagery under low-light (e.g., moonlight or starlight) conditions. High-temperature thermal imaging sensors are one technology of interest, but new design concepts are needed to support the extremely stringent size, weight, and power constraints associated with micro-UAVs. The camera requirements nominally include:

Instantaneous field of view (FOV): 1.5 millirad
Size: 2.5 cm3 – 43 cm3
Weight: 10 grams – 100 grams
Power: < 1.5 watts

The goal of this program is to develop innovative miniaturized IR imaging camera concepts and components for micro-UAV platforms, including the optics, imaging sensor, and electronics. Both thermal and low-light IR sensing approaches are under consideration. The emphasis is on maintaining adequate imaging performance and sensitivity from a moving, airborne platform from a miniaturized camera package with low power requirements.

PHASE I: Phase I shall include a detailed design of the camera concept and components, including testing of key camera components in order to validate the sensing approach.

PHASE II: Phase II should result in a prototype camera system that is capable of being demonstrated from a small airborne platform.

DUAL USE COMMERCIALIZATION: Camera technology being developed under this research program will have application to low-cost, IR imaging for commercial applications such as firefighting and automotive displays.

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KEYWORDS: Infrared, UAV, Micro-UAV, Camera, Imaging

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AF06-222 TITLE: Hyperspectral Detector Enhancement Using Auxiliary High-Resolution Imagery

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: Develop algorithms for enhancing signature-based hyperspectral target detection performance in reconnaissance imagery using auxiliary high- resolution imagery.

DESCRIPTION: Hyperspectral imaging technology is being pursued for defense, civil, and commercial applications in part due to the ability to detect unresolved stationary objects based on their material spectral content. In some reconnaissance system manifestations, hyperspectral imaging sensors are bore-sighted with higher resolution panchromatic imagers to provide a combination of spectral and spatial information. Detection algorithms that have been developed for these systems, however, are based almost exclusively on spectral detection and do not exploit the fine spatial detail that is present in the auxiliary panchromatic imagery. Instead, high-resolution image chips associated with hyperspectral detections are generally left for recognition by a human image analyst.

The goal of this program is to develop innovative, signature-based detection algorithms that exploit both the spectral content of the hyperspectral imagery and spatial content of the panchromatic imagery to enhance the detection performance and relieve the image analyst workload for the system context described above. For example, assisted target recognition algorithms that filter and/or prioritize the high-resolution image chips based on the spatial content that is most consistent with the spectrally detected target signature would more effectively use the analyst's time and attention. Of particular interest are algorithmic approaches that are amenable to real-time or near-real-time operation using reasonable image processing hardware for tactical system environments.

PHASE I: Phase I shall include theoretical development of the proposed algorithm, implementation in a laboratory environment, and initial demonstration on test imagery.

PHASE II: Phase II should result in a refined algorithm implementation on a tactically relevant computing platform and thorough performance evaluation against an extensive set of test imagery.

DUAL USE COMMERCIALIZATION: Processing technology being developed under this research program will have application to civil and commercial remote sensing applications such as law enforcement, search and rescue, and border security.

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KEYWORDS: Hyperspectral Target Detection, Automatic Target Recognition, Sensor Fusion, Hyperspectral Reconnaissance, Fused Spectral/Spatial Detection

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AF06-223 TITLE: Multi-Phenomenology Sensing and Sensor Control in Unmanned Intelligence Vehicle (UIV) for ATR and Tracking of Dismounts and Vehicles

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a sensor suite using RF and EO sensors along with automatic sensor cueing, ATR, and sensor control to minimize human decision making for detection, ID, and tracking dismounts and vehicles.

DESCRIPTION: This program would develop a UAV hosted sensor suite and associated ATR and tracking algorithms utilizing multiple phenomenologies to detect, ID and track/geo-locate targets. The concept would be to assign the UAV a region of interest to continuously survey, sort through detections and output only targets of interest. The product of the sensor suite would be a data file with the location/track information and ID of the target. To accomplish this, the sensor suite must be comprised of complementary sensors for the environment and utilize sensor management, including automatic sensor cueing and automatic target recognition. For this application the region of interest (environment) will be urban and the targets of interest are dismounts and vehicles, possibly carrying improvised explosive devices (IEDs). This effort will define the optimum sensor suite for these targets of interest in this environment as well as evaluate optimum geometries for the sensors (altitude, range, speed, grazing angles, etc.) and culminate in a demonstration of the capability. It will consider active and passive sensors in both RF and EO (radar, SIGINT, LADAR, HSI, etc) and develop the appropriate ATR/ATC, tracking, and fusion algorithms.

PHASE I: The research will identify the critical technology challenges, synthesize advanced designs, perform concept feasibility analysis. Risk reduction studies and tests will be conducted to demonstrate the feasibility of the Phase II approach. Focus on defining the sensor suite and algorithm requirements.

PHASE II: The effort will integrate RF and EO sensors with intelligent sensor control including automatic sensor cueing, ATR, and tracking. It will leverage existing RF and EO hardware if possible, and will focus on demonstrating the ATR and tracking/geo-location of dismounts and vehicles using the integrated sensor data. If funding permits the sensor suite will be demonstrated in a flying test bed.

DUAL USE COMMERCIALIZATION: Intelligent sensor control, processing, and exploitation have the potential to positively impact military and civilian applications by minimizing human in the loop requirements.

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KEYWORDS: Sensor Management, Radar, Hyperspectral Imaging, Laser Radar, Laser Imaging, Global War on Terror, Irregular Threats, ATR, Tracking Dismounts, Urban Operations, Small UAVs.

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AF06-231 TITLE: Load Bearing Antenna Structure for Small Unmanned Air Vehicles (SUAV's)

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative low band radio frequency (RF) antenna concepts for small unmanned air vehicles (SUAVs).

DESCRIPTION: The Air Force has requirements for broadband low band (30 MHz to 3000 MHz) radio frequency (RF) antenna capability on SUAVs. SUAVs present a unique antenna integration challenge because of their small physical size relative to low frequency wavelengths, and, their limited payload capability. The integration penalties associated with conventional low frequency antenna designs are prohibitive for SUAVs. Innovative antenna concepts that maximize antenna size and functionality (bandwidth), yet minimize or eliminate antenna weight, volume, and drag penalties, need to be developed.

PHASE I: Demonstrate the feasibility of innovative antenna concepts that provide low band capability with none or minimal integration penalties.

PHASE II: Demonstrate a prototype antenna concept on a representative SUAV airframe. Demonstrate RF performance and mechanical integrity for the SUAV use environment. Quantify integration impacts.

DUAL USE COMMERCIALIZATION: This technology will provide efficient broadband RF performance that covers the full spectrum of commercial communications systems such as HAM radio, satellite radio, cellar phones, television, AM/FM radio, HDTV, and marine services.

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KEYWORDS: Multifunctional structures, structural excitation, impedance matching, conformal load-bearing antenna structures

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AF06-232 TITLE: High-Speed Valves for Smart-Material Based Electrohydrostatic Actuators (EHAs)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Research and develop innovative high-speed valve technologies for smart material-based pumps for electrohydrostatic actuators (EHAs).

DESCRIPTION: Under recent DoD research efforts in the Defense Advanced Research Programs Agency's (DARPA) Defense Sciences Office and the Air Force Research Laboratory's Air Vehicles Directorate (AFRL/VA), several classes of smart material-based actuators have been developed to flight control system requirements. Due to the inherent energy density of smart materials, these actuators have the potential to be lightweight, power-dense, and thus well suited for small UAV and distributed actuation applications. One successful design resulting from this research uses high speed driving elements (typically piezoelectric or magnetostrictive) as the pressurization mechanism for electrohydrostatic actuators EHAs. To date, these pump units have been successful in supplying pressure to the actuation system. However, one common finding in each of the designs involves performance limitations of the entire system due to the low bandwidth of the valving used for pressurization. The inability of valves to operate at sufficient speeds limits the overall fluid flow rate, thus reducing the output speed (and power) of the system.

Therefore, a strong need exists for innovative high-speed valve systems capable of achieving both the necessary bandwidth and flow rates for this class of actuators. Under this SBIR effort, there are two main classes of valves which could be researched:

Passive valves: Examples of passive valves include small-scale 'reed' and 'flapper' valves. At a minimum, it is expected that innovation will be necessary in both manufacturing technique and topology optimization to achieve bandwidths higher than currently possible.

Active valves: To achieve high bandwidths with active valving, innovation will be required in both the valve architecture and its control system. In addition, the weight of the active valve system is an important design consideration. Because the ultimate goal is to produce a power dense actuator, any added weight due to valve architecture and control electronics must be included in overall power density assessments.

PHASE I: Develop and demonstrate a high-speed valve concept improving on the state of the art. Current pump designs operate between 1 kHz and 10 kHz, and valve designs should operate in this range as well. Computer analysis of the valve and fluid dynamics or prototype demonstration should be included.

PHASE II: It is envisioned that a working prototype will be integrated with a smart-material based EHA sized for UAV flight control applications. Integration should include power electronics, control electronics, and physical integration of the valve assembly. The actuator system should be demonstrated in a realistic environment under representative loads, as part of a hardware-in-the-loop demonstration.

DUAL USE COMMERCIALIZATION: Additional integration testing will take place during this phase. Actuation systems, including all valve and pump assemblies will be demonstrated in a wind tunnel, and ultimately a UAV flight test. Because the end product of this effort is a complete actuation system, the technology has many dual-use applications. Examples include flight control actuation for UAV systems, utility actuation for both military and commercial aircraft, and automobile actuation applications. Because of the lightweight nature of this class of actuator, they are especially well suited for distributed actuation applications. Examples include morphing aircraft, reduced drag and performance enhancement for air and ground vehicles, and precise shape control of any conformal surface, such as large mirrors, satellite antennae, dishes, etc.

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KEYWORDS: Compact Hybrid Actuator, CHAP, Piezoelectric Pump, Magnetostrictive Pump, Electro-Hydrostatic Actuator, High-Speed Valve, Smart Materials and Structures, Actuators.

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AF06-233 TITLE: Automating Error Quantification and Reduction for Computational FluidDynamics (CFD)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Research and innovate methods for comprehensive error quantification and error control to improve the reliability and usefulness of computational fluid dynamic (CFD) analysis.

DESCRIPTION: The advent of CFD provides a potential for routine and affordable alternatives to test for the analysis of flow fields around air vehicles. Over time, robust CFD tools have been developed to support key steps in CFD practice: geometry/grid generation, flow solution, and flow visualization. These tools are necessary to generate and to inspect a CFD solution, but they do not address the question of solution quality or meaningfulness. This requires an expert user to rely upon their own experience and particular process to assess sources of error and to modify the analysis to meet accuracy requirements. This error analysis and response, if performed, is usually done by an ad-hoc process of a limited number of hand-built parameter studies focused on a few local or integrated properties. The utility of CFD analysis would increase if error were managed comprehensively, quantitatively, and, as far as possible, automatically. However, before there can be automated tools for quantified error management for CFD solutions, development is needed to pioneer systematic error assessment strategies. This requires research into comprehensive methods for assessing error, identifying its sources, and facilitating error reduction in the analysis.

There are many sources of error in a CFD simulation and many critical steps in error analysis that can be addressed with advanced research in methodology and process. In consideration of spatial error, there are opportunities to investigate and to develop innovative methods for grid quality/adequacy, grid adaptation to accuracy requirements, automated systematic global refinement, iterative convergence assessment, or other techniques for estimating and ameliorating spatial error. In regard to temporal error, research opportunities include methods for identification of solution unsteadiness, automated temporal refinement studies, quality assessment and guidance for spectral sampling, or other techniques for characterizing and improving temporal accuracy. A particular research challenge is the quantified assessment of model validity using advanced techniques, such as guidance from expert systems, critical parameter assessment, or direct comparison of varying fidelities of modeling, etc. Areas of application could include high speed physics (chemical equilibrium/nonequilibrium, rarefied/continuum, plasma dynamics), viscosity (turbulence model sensitivity, turbulent scale resolution), or other critical questions of model selection. In addition to considering individual error sources, research is needed to develop robust techniques for assessing the global accuracy of the simulation, including potential interactions between the error modes. This may require uncertainty analysis, aggregate error estimation, sensitivity studies, or other techniques to systematically quantify the global CFD error and allow comparison to the accuracy requirements.

This topic calls for research to develop and to demonstrate methodologies for making CFD error analysis more comprehensive and quantifiable. Proposals should focus on one or more critical functions and/or error sources and demonstrate new methods for managing the solution error. Because CFD is a critical enabler of air platform development, the effectiveness of these methods should be demonstrated on a DoD-relevant air vehicle or component in the subsonic, supersonic, or hypersonic regime. Although the methodologies developed may be demonstrated with any class of CFD solver, they should also be applicable to a wide range of CFD strategies.

PHASE I: Select one or more error sources and/or error analysis functions to investigate. Assess several techniques for quantifying and/or reducing the error comprehensively. Determine the most promising methodology and select an appropriate test case. Demonstrate the expected performance of the methodology on the test case selected.

PHASE II: Develop the capability to apply the chosen methodology in a general manner. Select a series of complex, relevant test cases to assess the range of applicability of the technique. Demonstrate the effectiveness of the methodology to perform comprehensive error quantification and/or error control suitable for improving CFD analysis.

PHASE III DUAL USE APPLICATIONS: This technology has both military and commercial applications because it can increase the utility of CFD analysis by providing strategies to measure and to control solution error. Reliable error quantification will yield more robust aerodynamic design of future air vehicles and provide an effective tool for better meeting air vehicle test and evaluation (T&E) requirements.

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KEYWORDS: computational fluid dynamics (CFD), discretization error , model validation, uncertainty quantification, error estimation, solution accuracy, verification and validation (V&V), grid adaptation, grid refinement

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AF06-234 TITLE: Innovative Structural Joining Concepts and Analysis Techniques

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative solutions for weight efficient, affordable structural joining concepts including analysis techniques for life prediction of structural joints subjected to elevated temperatures.

DESCRIPTION: Future aircraft structural design concepts feature a high degree of structural unitization to minimize weight, manufacturing assembly costs and signature. Current practices of assembly and maintenance drives designs toward predominately mechanically fastened assembly concepts with numerous access panels. Future structural joining concepts are envisioned to be an optimum combination of structural materials including metals, composites, functionally gradient materials, fiber metal laminates, etc. Since mechanical fasteners are frequently the location of joint failure, design concepts in this effort should focus on other means of joining. One example might be a concept such as nanoscale hook-loop fasteners with smart material actuation.

The capability to design, analyze, and produce structural interfaces that incorporate fiber reinforced compositions and/or enhanced microstructure alloys, along with transitions from monolithic alloys to these high specific-strength and stiffness systems will enable large structures and interfaces to approach the strength-to-weight efficiencies needed for aerospace vehicles conducting missions anytime, anywhere. The impact of this capability is even more significant when applied to elevated temperature structures undergoing inelastic deformations. Bringing interface and joint design, analysis, and production tools forward to meet those goals is a critical step in the process.

PHASE I: Develop innovative structural joining concepts applicable to subsonic or low supersonic aircraft and analysis methods for hybrid metallic structures under multiaxial high temperature stress states for highly loaded structure such as wing-to-fuselage joints and landing gear attachments.

PHASE II: Select the concept that leads to the most weight efficient and cost effective approach. Upgrade the analytical tools. Design a structural component, and manufacture and test the article to verify the concept. Establish the weight and cost for the concept. Or demonstrate the design, life prediction, and production methodologies on representative elevated temperature structures and interfaces.

DUAL USE COMMERCIALIZATION: Other than combat requirements for military vehicles and design criteria (for example, fighter aircraft), the basic structural joining technology advancements and the analytical techniques will be applicable to both military and commercial classes of vehicles.

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KEYWORDS: hybrid structures, metallic structures, composite structures, unitized structures, laminated structures, dissimilar materials, structural joints, aerospace structures, functionally gradient materials, fiber metal laminates, analysis methods, multi-axial stress states, life prediction, elevated temperatures

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AF06-236 TITLE: Sense and Control for Efficient Aerostructure

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Explore innovative approaches to maximize aerodynamic and structural efficiency of high altitude, long endurance (HALE) intelligence, surveillance, reconnaissance vehicles of interest to the USAF.

DESCRIPTION: A multifunctional air vehicle structure is envisioned that can sense the aerodynamic environment and the structural response to this environment, feed this information to a control system that would command devices to control the aerodynamic environment, enabling the air vehicle system to operate at efficiency levels beyond what we can achieve today. These future airframes will consist of arrays of sensors embedded within the structure to sense the aerodynamic environment and structural response, and through a closed loop control system direct arrays of embedded devices to control the aerodynamic environment and structural response.

Technical challenges with these vehicles include: maximizing laminar flow on swept wings to minimize drag; expanding the range of lift coefficient associated with the "low drag bucket;" managing flow separation on aggressive airfoil designs; controlling multiple structural modes for body freedom flutter suppression; alleviation of gust loads; managing the static aeroelastic shape of the wing for aerodynamic efficiency; and maturing innovative flow control devices (alternatives to conventional flaps) for air vehicle control and/or performance optimization.

It is anticipated that this program will focus heavily on multifunctional structure and flow control, possibly applying some intelligent control capability, but not the development of intelligent control itself. Technology approaches could include, but are not limited to, traditional flow control devices (such as pneumatic, mechanical, active, or passive) and/or adaptive structure. For example, sensing the state of the flow over a wing with areas of flow separation or premature boundary layer transition could initiate a fluidic actuator(s) or structural shape control for efficient aero performance (i.e., maximizing L/D) for the particular flight condition. Similarly, upon sensing local wing (static &/or dynamic) structural loads/deformations, an aeroelastic response could tailor the wing shape to re-distribute the loads while optimizing aerodynamic performance that enables a lighter-weight structure. The ability to sense a broad range of aerodynamic (surface pressure, shear stress, etc.) and structural state (strain gauge, accelerometer, etc.) parameters over large areas will be enabled by emerging low cost, minimally intrusive sensors, conductors, dielectrics, and data processing systems that are robust enough for structural integration and easily manufacturable and supportable. There are many examples such as "direct write" technology. "Direct write" is a family of manufacturing processes that enables the direct, computer numerically controlled deposition of conductive and dielectric materials as well as active electronic components on structural substrates in ambient environment, on highly contoured surfaces, without tooling, masks, etc. Another example is thin film technology that features a variety of sensors, conductors, and electronic devices contained in a minimally intrusive thin dielectric package. These and similar technologies will offer the opportunity to package a large number of a variety of sensors over large areas of structure. Air vehicle concepts incorporating these systems will enable revolutionary advancements in aerodynamic efficiency, airframe weight fraction reduction, and maneuverability by bringing the integration of the airframe and power/electronics communities together into truly multifunctional systems. So called smart structures technology has a long history; however we have only recently begun to explore what could be achieved if these systems were used in an active manner and how they might affect traditional design practice.

PHASE I: Demonstrate innovative sensor and/or actuation approaches for either fluidic or structural control. Prototype laboratory devices should demonstrate the feasibility of the proposed technology to accurately assess and then adequately modify the state of the flowfield and/or the structural shape. Identify application opportunities and develop analytical and/or empirical data to quantify anticipated system effectiveness and benefits.

PHASE II: Validate the feasibility of the technology in an integrated configuration, such as a wing/flap combination and demonstrate its use in either a wind tunnel or flight test of the prototype components. Actual application testing should be performed and electrical, thermal and life assessments made. System issues such as robustness, maintainability, supportability, and reliability should be also addressed. Validate system effectiveness and benefits.

DUAL USE COMMERCIALIZATION: All classes of air vehicles may benefit from this technology. This capability will ultimately be useful for improving/optimizing the air vehicle's performance via the flight control system that monitors structural loads and aerodynamic conditions. Vehicle wing structural weight can be minimized, wing flutter can be suppressed, and the wing can be mission-adaptable to achieve optimized aerodynamic efficiency (i.e., maintaining wing laminar flow, prevention of flow separation, etc.) for maximizing endurance or range. This technology could be applied on any class of air vehicle (low subsonic through supersonic), including the potential for application on rotor blades.

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KEYWORDS: flow control, adaptive structures, wing shaping, distributed actuation, flight control, feedback control

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AF06-237 TITLE: Rapid Mission Planning and Operation for Space Access Vehicles

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop creative methods and algorithms to perform accurate rapid mission planning and operation.

DESCRIPTION: Utilizing current technology, the time from the decision that a mission will be performed to the start of the mission is many months. Planners must consider the effects of failures (controls, sensor/actuators) and must determine numerous abort/reshaped/retargeted trajectories for the vehicle to follow should a failure occur.

Also, the vehicle must be in sufficiently good working condition. In all, a great deal of time and money is spent trying to ready the vehicle for a mission as thousands of simulations are run for a wide variety of cases. Unfortunately, even thousands of simulation runs cannot encompass all off nominal conditions. Hence, there is a technological gap in mission planning since it is desired to automate as much of the mission planning procedure as possible. This, in turn, might allow rapid mission turnaround with the vehicle capable of recovering from off nominal conditions that are not even considered using today's technology.

Current technology has the ability to reconfigure inner-loop control systems on-line in response to failures. However, on-line abort planning, trajectory reshaping, and trajectory retargeting are not possible using today's technology. In order to compute a new trajectory when an off nominal condition occurs, a two point boundary value problem or optimal control problem must be solved. Unfortunately, these problems require significant computation time and are thus difficult to solve in real-time. Research is required to develop algorithms that are efficient and on-line implementable so that trajectories can be computed on-line in response to any off nominal conditions.

Recently, emphasis has been placed on having the capability to perform rapid mission planning and operation in direct response to present threats. With the increased chance that threats will continue to morph and become present at a moment's notice, this ability has become even more important.

Rapid mission planning and operation (RMP&O) has as its goal rapid response – mission ready within 2 hours, 24 hours a day, 7 days a week, if technically feasible. RMP&O might involve developing algorithms to perform the following tasks:

- Develop an efficient method, suitable for on-line implementation, to update mission properties depending on:
  - Mission specific vehicle mass properties
  - Environmental concerns including vibration
  - Different required release state vectors
  - Mission specific vehicle configuration and aerodynamic properties
  - Trajectory constraints imposed by potentially degraded vehicle health
  - Range overflight concerns
  - Range control issues
  - Weather conditions
- Generate objectives, based on nominal and contingent scenarios, in flight planning and operations
- Make use of IVHM information in order to design missions that a vehicle can accomplish given its current health state or alternatively, select a vehicle from a fleet whose health state is best suited to accomplish a particular mission
- Develop an off-line process to produce high-level planning and preparation
- On-line reshaping/retargeting of trajectories in response to off-nominal conditions

Inputs to a mission planner might include information such as: mission start and end points and goal(s) of the mission (surveillance, weapon delivery, etc.). Ideally, an operator could specify the start and end points and the operations to take place, and then allow the mission planner to map out trajectories, select vehicles given the health of each vehicle, determine the amount of fuel needed, weapons, making appropriate adjustments to guidance and control parameters, and so on.

Currently, the tasks described in the previous paragraph are performed for each specific vehicle and require thousands of man hours. The RMP&O goal is to develop algorithms which can automatically perform these tasks and have a complete mission mapped out (trajectories, a vehicle selected, fuel, weapons, etc.) within a short period of time. On-line, the RMP&O algorithm should be able to adapt to failures and off nominal conditions, if physically possible.

Any RMP&O approach might include an adaptive G&C architecture to maintain vehicle attitude and outer-loop trajectory tracking under nominal and off-nominal scenarios. Additionally, failure scenarios could be identified and abort planning might be formulated to reshape/retarget the vehicle's trajectory, if necessary. Prior to flight, the RMP&O algorithm could evaluate data from system health parameters (environmental, structural, thermal, etc.) to determine the effects on ground processing, mission planning, and the flight envelope.

PHASE I: Methods are sought for generating a RMP&O algorithm that is capable of performing nominal and abort trajectory planning, providing automatic updates of vehicle properties to the reconfigurable guidance and control algorithms, creating interfaces that enable rapid mission planning by a small crew, ensuring compatibility with a concept Flight Operations Control Center, and providing interfaces with ground operations and IVHM systems to automatically generate flight plans that account for payload changes and current vehicle health. This could be accomplished through appropriate research and then the design and analysis of a RMP&O algorithm. A simplified simulation to demonstrate capabilities is desirable.

PHASE II: Develop and expand the RMP&O algorithms for a space access vehicle to include more scenarios and refine the analysis and synthesis tools. Demonstrate the advanced concepts in a high fidelity simulation.

PHASE III DUAL USE APPLICATIONS: The methods and tools developed under this effort will be applicable to a wide variety of air platforms, including current and future RLVs, civilian space access vehicles, and other autonomous air and ground vehicles.

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KEYWORDS: Rapid Mission Planning, Air Platforms, Trajectory Planning, Abort Trajectory Planning, Trajectory Reshaping and Retargeting

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AF06-238 TITLE: Unmanned Aerial Vehicle (UAV) Ground Operations Positioning System (UGOPS)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a navigation system for use as an alternative to global positiioning system (GPS) for UAVs during ground airfield operations.

DESCRIPTION: There is currently interested in technologies to enable UAVs to actively taxi with minimal supervision in formation and in environments where GPS may be denied or degraded. As UAVs move away from being remotely piloted from a video signal, technology development is necessary to safely and accurately navigate the dangers of an airfield. A UAV must still be able to stay on taxiways and avoid unintentional runway incursions without the direct visual supervision of a human operator.

Although GPS is a reliable system, the Air Force would like to pursue other avenues of ground navigation. Position determination is a primary concern, i.e., the ability of the UAV to recognize where on the airfield it is situated. The navigation system must enable the UAV with the capability to have precise recognition of taxi and runway information, including hold short lines, centerlines, and edge lines. The developed system, optimally, would require no more a priori information or airfield equipment than a human pilot. This position recognition capability must also be capable of being coupled with the intelligent software systems to then navigate appropriately on the airfield according to instructions and should enable formation taxi capability, in trail or staggered trail formation without danger of collision. It would require the aircraft to maneuver within the constraints of the taxiways/ramp area.

Close quarters taxi is also a consideration, as in the parking area for aircraft on the ramp. Only in the parking area would a less autonomous solution be considered, possibly using the available crew chiefs to aid in the beginning stages of taxi by remotely guiding the aircraft to and from the main taxiway.

The purpose of this effort is to develop and demonstrate a subset of the stated desired capabilities, such as precision position determination on the airfield without GPS. Position information should be accurate, reliable and realtime, enabling standard taxi maneuvers and speeds as well as cooperative (in network) formation taxi maneuvers. Alternatively, this effort might demonstrate the recognition of airfield markings or other visual guides and possibly the tracking of flight member aircraft sufficient for safe noncooperative (out of network) formation taxi. Significant alterations to the airfield can not be accepted, however, minimal modifications may be considered. The development of this system is also in an effort to get away from extensive, costly, time-consuming surveying of airfields as can be necessary with GPS. Concepts that involve surveying of an airfield should be able to accomplish the surveying in a thrifty and swift manner.

PHASE I: Develop and perform critical experiments on navigation concept for military airfields and evaluate considering estimated cost, any minimal alterations to airfield, UAV integration issues, and mission effectiveness. Evaluation of concept effectiveness should include comparison to piloted aircraft.

PHASE II: Build and test a prototype of the navigation concept. Test must include some form of ground vehicle for navigation. This vehicle can be anything from a remote controlled car or or gocart to a full scale commercial or passenger vehicle. Test must demonstrate accuracy and reliability of concept to achieve successful navigation of an airfield.

DUAL USE COMMERCIALIZATION: UGOPS can be used to solve any problems associated with taxiing or travel around an airfield environment. This can be as simple as a secondary system of airfield navigation used by piloted aircraft to enabling aircraft to taxi in zero visibility. The developed system also has the potential to be used for any land based vehicle, allowing marketability to the army and automobile manufacturers.

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KEYWORDS: navigation, autonomous, unmanned aerial vehicles, airfield operations, intelligent systems, sensing, global positioning system, positioning, autonomy, position recognition, taxi, guidance, control, sensors

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AF06-239 TITLE: <u>Structural Energy Storage in Air Vehicle Structure</u>

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a durable high performance multifunction structural concept that can carry airframe loads and store electrical energy in the form of capacitance.

DESCRIPTION: Concept focus should be directed at the development of designs and the related fabrication approaches to produce "capacitor structure" with very high energy density, for high voltage pulse or low voltage continuous duty applications. Concepts can be based on coaxial or flat plate capacitor configurations. Specific areas of interest include the development of advanced composite based device designs, the airframe structural integration concept, the ingress and egress method for bussing energy, EMC, and the associated airframe joining concepts. This technolgy is enabling as a power source to long endurance unmanned vehicles and/or the development of high energy weapon systems.

PHASE I: Prototype laboratory devices should be fabricated and tested for electrical and mechanical performance to demonstrate the feasibility of the proposed technology. Design approaches associated with bussing and airframe integration should be conceived and analytically characterized.

PHASE II: Validate the technology in an integrated configuration and demonstrate its use in prototype components. Testing should be performed, with electrical, mechanical, thermal and life assessments made. System issues such as mechanical robustness, maintainability, supportability, and reliability should also be addressed.

DUAL USE COMMERCIALIZATION: The proposal should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense applications. Specific opportunities exist for increased endurance of small unmanned vehicles for domestic/military surveillance. Automotive structures could use this technology as energy storage alternative.

REFERENCES: 1. Cletus J. Kaiser, "The Capacitor Handbook," ISBN: 0962852538.

2. Robert Jones, "Mechanics of Composite Material," ISBN: 0070327904.

KEYWORDS: Composite, Structure, Multifunction, Capacitor, Dielectric, Airframe, Energy Storage

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AF06-240 TITLE: Geometry Manipulation Through Automated Parameterization (GMAP)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and implement a methodology to decompose and parameterize an air vehicle model, thereby enabling configuration studies, performance analysis, and sensitivity studies for technology assessment.

DESCRIPTION: Entities throughout government, industry, and academia are currently engaged in efforts to develop new processes and methodologies to enable capability-based technology assessment. Modeling and simulation are integral tools for evaluating the impacts of advanced technologies currently in development on air vehicle performance. A geometry generation and manipulation environment has recently been developed that allows for the creation of high-fidelity, fully parametric models that can be used for follow-on analysis of varying fidelity (i.e., sizing, computational fluid dynamics (CFD), finite element modeling (FEM)). While vehicles that are created in the environment are fully parametric, vehicles obtained from external sources must be recreated to take advantage of the parameterization and analysis capabilities inherent to the environment. Additionally, geometric models that are received from external sources are not always delivered in a usable format and they must be repaired before being used for further analysis. A capability is desired whereby arbitrary geometric models obtained from contractors, academia, or other government entities can be decomposed into major components, parameterized, and recreated in a parametric fashion (consistent with the original parametric representation) such that variations to the vehicle configuration can be quickly performed. Additionally, the regenerated original and modified configuration geometries should be created in a format that will enable follow-on high fidelity analysis. This new capability would eliminate the need to rebuild the models manually and enable a significant decrease in analytical time required for technology assessment. This capability would also enable a smooth transition from complex geometric representations to first-order, parameter-based sizing and synthesis routines. This capability is one that has not been found to be available in any existing toolset and is expected to require the development of innovative methods to implement. The range of vehicles to be considered would be essentially infinite, encompassing, for example, unmanned aerial vehicles, conventionally configured transports, missiles, fighter aircraft, hypersonic cruise vehicles, reusable launch vehicles, and hypersonic re-entry systems. The project would encompass two primary tasks: importing an arbitrary geometry and breaking it up into its major components (tails, wings, etc.), followed by a parametric regeneration of the vehicle into a format that contains both the complete parametric description of the vehicle as well as a parametric, water-tight geometric representation. A wide variety of parametric variations could then be applied to the model, yielding a set of derivative configurations for follow-on analysis. It may be necessary to develop corollary capabilities to fully implement the decomposition/recomposition methodology, such as the ability to import arbitrary airfoil sections, and verification algorithms to ensure that the resulting geometric representation is truly water-tight (a requirement for most CFD). All algorithmic developments and implementation steps should be fully documented. Since the methodology would be implemented a manner that would make it applicable to any type of air vehicle, the resulting capability would be of value to virtually every government, industry, and/or academic entity, whether focused on small unmanned aircraft or long range, hypersonic bombers. The direct payoff of this effort would be a significant decrease in the cycle time required for the comprehensive analysis of a configuration, leading to an improved ability to perform capability-focused technology assessment.

PHASE I: Develop an approach to automatically determine which components of an air vehicle geometry model represent major sections (wing, fuselage, etc.) for arbitrary configurations as defined in the description and transfer parametric information associated with a model from one representation to another.

PHASE II: Implement configuration decomposition approach starting with an arbitrary model in a standard format (i.e., IGES). Develop an implementation to automatically regenerate the air vehicle model, yielding a water-tight, fully parametric version of the original geometry, as well as a complete parametric description of the vehicle. Implement a three-dimensional visualization capability.

DUAL USE COMMERCIALIZATION: The methodology and its implementation can provide value to any number of potential customers, as well as to the contractor executing the SBIR. By the end of phase II, the contractor will have developed a new capability which bridges a gap between the organizations that create configuration geometry and the organizations that need to use it. The capability will also formalize the link between configuration development and parametric analysis, as well as provide a basis for the rapid recreation of parametric geometric models in the recipients' own geometry environment. Users of this application would benefit from a reduction in analytical cycle time, as they would no longer be required to recreate vehicle models prior to analysis. Ultimately, this technology will have a significant impact on the modeling and simulation of any mechanical system such as those found in the aerospace and automobile industries.

REFERENCES: 1. Alonso, J., Martins, J., Reuther, J., Haimes, R., and Crawford, C., "High-Fidelity Aero-Structural Design Using a Parametric CAD-Based Model ," AIAA-2003-3429, 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, June 23-26, 2003.

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KEYWORDS: Geometry, Initial Graphics Exchange Specification, Parasolid, Adaptive Modeling Language, Computational Fluid Dynamics, Finite Element Modeling, Parameterization, Modeling and Simulation, Technology Assessment

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AF06-241 TITLE: Innovative Near Space (High Altitude Air) Platform Technologies

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Identify, develop, and validate innovative technologies to support systems concepts for persistent high altitude platforms. Key technology areas include propulsion, structures, and aerodynamics technologies that will enable high altitude air platform concepts to achieve an extremely long time on station.

DESCRIPTION: There has been intense, high level interest in the Air Force (AF) in the exploitation of flight altitudes of 65,000 feet and above for AF missions requiring near continuous persistence. An enabling technology that could help achieve these lofty goals would provide a great benefit in the capability area of Persistent Intelligence, Surveillance and Reconnaissance (Persistent ISR), which has a key performance parameter of “24/7” or constant time on station. Unfortunately, the difficult engineering of flight at high altitudes has not changed. Large gains in high altitude persistence will require significant improvement in the enabling component technologies that support these concepts.

Both airships and unmanned aerial vehicles (UAVs) have been advocated for persistent high altitude flight. Persistence for this topic will be defined as on-station for 120 hours, including high wind encounters. Airships use very low power at low speeds, but have trouble keeping station in high winds. They are also physically very large, requiring special hangaring consideration and ground handling, are fragile in ascent and descent, and require long transit times to station. The current state of the art for long endurance airship designs could be considered to be the Missile Defense Agency’s High Altitude Airship Advanced Concept Technology Demonstrator (HAA ACTD), which plans on achieving a month’s time on station, but has not been flown to date. Original technologies such as inflatable structures, self deploying structures, buoyancy management, elimination of control surfaces and low drag shapes may alleviate some of the issues with operating airships at high altitude.

UAVs typically have less endurance, and can also be fragile. Current state of the art UAVs built for long endurance purposes, such as Global Hawk, can achieve a time on station of 24-30 hours without refueling. Innovative concepts such as air deployment, beamed power, air refueling at high altitude, and formation flight for power efficiency may alleviate some of these issues that prevent today’s UAVs from achieving near continuous persistence.

Batteries, fuel cells, solar cells and advanced fabrics can be considered key component technologies, but have considerable investment under other efforts, so technology development should not be proposed here. However, novel integration of these technologies into a high altitude platform, such as a fuel-storing structure concept, is appropriate.

PHASE I: Identify and demonstrate the likelihood of developing an innovative enabling technology in the key areas of structures, propulsion, or aerodynamics technologies that will allow high altitude platforms to achieve flight for at least 120 hours on station and alleviate some of the issues previously listed in the topic description.

PHASE II: Develop the technology that will lead to the most effective approach in terms of allowing the vehicle to affordably achieve the desired time on station, and then demonstrate the technology in a realistic environment.

DUAL USE COMMERCIALIZATION: Commercial “spin-off” applications of these technologies include communications, surveillance, weather tracking, and even inter-planetary flight, as several planets have atmospheres that are comparable in composition to that of Earth’s stratosphere, where high altitude aircraft operate.

Phase III military uses of these technologies are similar, but more specific applications include missile defense, border patrol, and battlefield communication and networking.

REFERENCES: 1. Hunley, J. and Kellogg, Y. "ERAST: Scientific Applications and Technology Commercialization." NASA/CP-2000-209031.

KEYWORDS: high altitude, long endurance, hale, haule, airships, near space, regenerative fuel cells, thin film solar cells, solar, nuclear, structures, aerodynamics

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AF06-242 TITLE: Sensors for Electromagnetic Interference (EMI) Immune Fly-By-Light (FBL) Systems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop Aerospace / High Density / Deployable / Maintainable fiber-optic sensors for second generation fly-by-light technologies.

DESCRIPTION: The Air Vehicles Directorate is actively pursuing the use of fiber optic technology for aerospace vehicle control applications. The use of fiber optic technology can be helpful in creating systems that are resilient to Electromagnetic Interference (EMI) since the photonic elements, such as fiber, are naturally immune to these effects. Fly-by-light (FBL) flight control technology can therefore result in significant benefits to aircraft designers, not only in EMI tolerance, but also in system weight, volume, and cost, due largely to the reduction of shielding requirements. Unfortunately, much work is still required in order to make fiber optic sensors an efficient component for commercial and military aerospace FBL applications. Currently, many of the commercially available sensors are unable to measure critical system parameters, such as temperature, pressure and position, at a level of fidelity necessary for controlling aerospace motor and actuator systems. Consequently, organizations are designing and building one-of-a-kind sensors to satisfy these measurement requirements. Although these sensors serve their intended purpose, the result is a fiber optic component that cannot be used for multiple applications and, in many cases, is one that is wrought with maintenance and calibration problems. Additionally, aerospace fiber optic sensors are highly sensitive to variations in optical power throughout the system. These variations result from changes in laser power due to time and temperature effects, changes in optical losses through connectors, and modal noise due to vibration effects. This effort will develop passive, digital fiber optic sensors for commercial and military aerospace applications that meet the following technical requirements: (1) not be affected by variations in light intensity, (2) have a high degree of EMI immunity, (3) are small in size and (4) have a very fast response time (> 2 MHz) within a fiber optic network. Additionally, these sensors should be able to measure the following quantities to the following levels of accuracy: (1) current (< 1 Amp), (2) voltage (< 1 Volt), (3) temperature (< 1 degree Centigrade), (4) linear position (< .001 inches), (5) rotary position (< 1 degree) and (6) pressure (< 5 pounds per square inch). Finally, these sensors must function as an absolute rather than a relative measurement system. In other words, these sensors must be able to measure their required quantities immediately upon system activation without relying upon a known starting point or performing a set of calibration diagnostics.

PHASE I: (1) Investigate and design innovative technologies that can resolve one or more of the technical requirements and satisfy the technical specifications for fiber optic sensors. (2) Demonstrate design feasibility through modeling and simulation or the development of laboratory quality components.

PHASE II: Develop a prototype demonstration of the fiber optic sensors that were designed in Phase I. These prototypes must be consistent with the form, fit, and functional requirements for use in aerospace vehicle management systems. Additionally, these prototypes must be able to operate within the temperature, vibration, g-shock, EMI and humidity conditions experienced in an aircraft environment.

DUAL USE COMMERCIALIZATION: This technology could lead to future military application in combat unmanned air vehicles, directed energy weapon systems, and other new aerospace vehicles. Potential commercial aviation applications include commercial and business jet flight control, commercial airline entertainment systems, and reusable launch vehicles. Potential non-aerospace applications include automotive drive-by-light, industrial automation, fiber-to-the-office/home computing, dense computing, and all-optical computing.

REFERENCES: 1. Weaver, T.L. & Smith, R.H., Photonic Vehicle Management, 20th Digital Avionics Systems Conference, Daytona Beach, Fl, October 2001.

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KEYWORDS: Fiber-optics, Photonics, Multiplexing, Passive Photonic Sensors, Passive Fiber Optic Sensors, Photonic Vehicle Management System

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AF06-243 TITLE: Surface Measurements – Flow Field Correlations Resulting in Applicable Cavity Flow Field Control

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a surface measurement based closed-loop flow control system to improve or control a resonant cavity flow field.

DESCRIPTION: There exists a need to understand and utilize the relationship between fluctuating surface measurements along a generic weapon bay cavity and the corresponding cavity flow field. Developing this correlation will enable the reduction of tonal sound pressure levels (SPL) and overall sound pressure levels (OASPL) inside a weapons bay cavity.

Currently there are three distinct categories to classify weapons bay shear layer control: 1) Zero-frequency control, e.g., Spoiler, which lifts the shear layer off the weapons bay and reduces the acoustic resonance in the cavity. 2) Low-frequency control, e.g., Pulse Blowing, in which the device regularizes the growth of vortical structures in the shear layer. 3) High-frequency control, e.g. Splash Jet, Powered Resonance Tube (PRT), rod in crossflow, in which the device forces the shear layer to very small turbulent scales. All of these flow control methods currently are operated in an open loop control method where knowledge of the flow field is unknown/unutilized.

Having the ability to correlate weapons bay cavity flow fields with the fluctuating surface measurements may allow the flow control device to utilize this knowledge of the flow field. In turn, this knowledge of the flow field would allow the flow control device to effectively respond to the highly fluctuating weapons bay cavity flow field which produces the tonal sound pressure levels and overall sound pressure level but could also improve the response to off-point conditions when the Mach and/or Reynolds numbers vary.

The goal is to develop a correlation between the fluctuating surface measurements and a resonant generic weapons bay cavity flow field. Using this correlation, develop a closed loop flow control methodology that will improve the flow field, e.g., reduce tonal sound pressure levels (SPL), overall sound pressure levels (OASPL) and/or shear layer control/stabilization. This new closed loop flow control methodology developed will improve our knowledge in several key areas that are currently being examined by the U.S. Air Force, e.g., Weapons Bay and Landing Gear Noise Reduction, Flow Separation Control, and Shear Layer Control.

PHASE I: Develop and test an approach to correlate high subsonic to supersonic flow field surface measurements to a resonant generic weapons bay cavity flow field.

PHASE II: Develop and test a closed loop flow control methodology, and flow control actuator, along with correlated surface measurements that will improve the resonant generic weapons bay cavity flow field for a high subsonic to a supersonic flow field.

DUAL USE COMMERCIALIZATION: High payoff military applications include enhanced performance for most-near term platforms, i.e., Fighter Aircraft, Unmanned Combat Aerial Vehicle (UCAV), etc. Examples of potential commercial applications include commercial aircraft landing gear bay noise reduction, separation control and shear layer control.

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KEYWORDS: unsteady cavity flow field, surface measurements, closed loop flow control

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AF06-244 TITLE: All-Surface Landing Capability Development

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an advanced landing capability to land transport class aircraft on a variety of surfaces having reduced California Bearing Ratio's (CBR).

DESCRIPTION: Future mobility operations require airfield independence for tactical, Short Takeoff and Landing (STOL) transport aircraft. The ability to achieve runway independent operation without an advance-team site survey or field preparation is a critical capability. This capability allows for the rapidly and precise delivery of troops, equipment and supplies. An innovative advanced landing capability to land transport class aircraft on a variety of surfaces with reduced California Bearing Ratio's (CBR) is required. All-surface landing capability includes water, snow, sand, or sod landing and taxi on STOL fields. This will allow the aircraft to operate from austere, unprepared runways on a regular basis with minimum additional maintenance. Army vehicles being delivered are designed to operate on unprepared surfaces with CBR 4-6, if an aircraft can land on similar ground it enables drop off and pick up at locations close to the forces. To accomplish this, new technology will need to be developed integrating advanced materials and ultra-high floatation for landing. Additionally, augmentations to enhance STOL performance should be considered (jump struts, kneeling, etc). Past studies that apply include Air Cushion Landing Systems. These had ground handling difficulties and were heavy because they utilized conventional materials (rubber). Advances in materials technology and control systems may mitigate these prior shortcomings. Critical attributes for All-Surface Landing Capability include lightweight, low volume, damage tolerance, operation in thermal extremes and high reliability. Concepts may include augmentation/modification kits for existing landing gear or entirely new systems. Recent transport design studies will provide concepts for integration to focus application of capability. Government will provide information on advanced transport configurations and landing requirement to guide research.

PHASE I: Determine technical feasibility and complete trade studies comparing options for All-Surface Landing. Identifying preferred concept and produce a conceptual design for an innovative All-Surface Landing prototype considering material selection and kinematics for deployment / stowage.

PHASE II: Complete key component design, fabrication and lab characterization experiments for All-Surface Landing capability, and/or develop a landing gear dynamic model that may be used in flight control simulations.

DUAL USE COMMERCIALIZATION: The all surface landing capability developed for military applications is also applicable for use in commercial transport aircraft operations to undeveloped areas.

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KEYWORDS: All Surface Landing, Transport Landing Gear, Unprepared Landing Site, Austere Operations, Low California Bearing Ratio (CBR), Short Takeoff and Landing (STOL), Air Cushion Landing, Jump Strut

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AF06-245 TITLE: Accurate, Stable Clock for Small Low Power Anti-Jam GPS User Equipment

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop techniques for rapid direct acquisition of GPS signals after a period of days, months, or years of receiver shutdown, and apply techniques to increase anti-jam capabilities.

DESCRIPTION: Direct Acquisition of GPS signals relies on the receiver having a very small time uncertainty in order to minimize the search space. Typically, the clocks in GPS receivers degrade fairly quickly, only allowing Direct Acquisition for a small number of hours after shutdown. The aim of this research topic is to explore new and innovative ways of providing stable and accurate timing to a GPS receiver for days, months or years after shutdown, so that Direct Acquisition of GPS signals is almost always possible. Ideally, these techniques or technologies should be lightweight and inexpensive so that all GPS users can benefit from this capability. Work on, for example, chip-scale atomic clocks (CSACs) are encouraging, as they promise precision time on an extremely compact physical scale. Perhaps such CSACs could be further improved or alternate methodologies be identified and developed to make ultra-compact precision time references a reality. Other possibilities include sophisticated electronically-corrected precision oscillators, which improve the quality of crystal-based oscillators through systematic adjustments over an extended timescale.

PHASE I: Provide evidence through analysis and/or hardware demonstration that a proposed timing source technology development or adaptation decreases direct acquisition time. Develop initial concepts/designs for products using the proposed innovations, and describe a strategy for insertion into receivers.

PHASE II: Finalize detail design and breadboard or prototype a GPS time reference that can be integrated and productized into a GPS receiver.

DUAL USE COMMERCIALIZATION: Increased accuracy and stability of a timing reference could also benefit civil and commercial position location systems, as well as possible uses in communications, encryption, and data conversion.

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KEYWORDS: Atomic Clocks, Direct Acquisition, GPS User Equipment,

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AF06-246 TITLE: Sensing of Upper Atmosphere

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop improved methods for observing meteorological conditions in troposphere and lower stratosphere. Increase both spatial and temporal density of weather observations.

DESCRIPTION: Improvements in the ability to observe the atmosphere are proposed by investigating the development of an upper air sounding system that can be used over data denied and difficult to access regions.

Effectiveness of weapons systems is impacted by our ability to observe and forecast the battlespace environment. Impacts range from mission degradation (accuracy errors, temporary loss of communications) to mission failure (system malfunction, targets missed). To mitigate negative environmental impacts on friendly forces and to exploit the effect of the environment against hostile forces, United States Air Force (USAF) uses a network of weather observations feeding numerical weather prediction and system impacts models. The output of these models is used in weapon selection and overall mission/campaign planning. The accuracy of environmental models depends on observations of atmospheric parameters including temperature, pressure, wind component speeds, and humidity through the entire depth of the battlespace.

Current upper air observing systems do not allow for adequate density of observations to fully exploit weather models. Space based systems (satellite sounders) are limited by course accuracy in the vertical (severely limiting their use in predicting environmental impacts on weapons systems). In-situ systems (weather balloons, drop, and rocket sondes) are limited by the requirement for a manned station to monitor observations as they are taken. This is particularly limiting in hostile areas where the presence of the observation platform (weather balloon) could reveal the location a fixed ground station below.

Development of new types of upper air sounding systems that can be used over hostile areas and the enhancement of remote sensing technology would significantly increase the usefulness of environmental impact models in planning air, ground, and space operations.

PHASE I: Develop a better way of collecting upper air data. Outline performance characteristics and communication requirements of proposed system. Develop Concept of Operations and roadmap for most cost effective exploitation of proposed capabilities. Provide preliminary analysis of manning and logistic requirements.

PHASE II: Develop and test working prototype of proposed upper air observation system. Provide system design. Develop system views. Outline data flows and system integration plan to include security/encryption requirements.

DUAL USE COMMERCIALIZATION: The development of improved upper air sounding capability would increase the accuracy of weather prediction in support of all Department of Defense (DoD) components as well as other government agencies. Improved weather forecasting would be beneficial to the private sector and the American populace as a whole.

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KEYWORDS: Upper Air Observation, Radiosonde, Remote Sensing, Weather Data Assimilation

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AF06-248 TITLE: <u>Real-Time Specification of Battlespace Environment</u>

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Enable integrated management of RF and EO/IR sensors by predicting RF and EO/IR background clutter and combining with sensor/platform noise to nowcast/forecast signal detection limitations.

DESCRIPTION: Space situational awareness, defensive and offensive counterspace, and missile defense missions require new and evolving technologies and scientific understanding of the battlespace environment to ensure accurate detection, tracking, surveillance, and characterization of space objects and events. This effort should examine the state-of-the-art in modeling background clutter for radio frequency (RF) and electro-optical/infrared (EO/IR) clutter and leverage that knowledge to integrate sensor utilization and improve sensor management. Determine how the models can be adapted and integrated to use real-time data inputs for clutter prediction, which, when combined with sensor and platform noise, can nowcast/forecast signal detection limitations. Develop operational concepts and applications to integrate use of RF and EO/IR surveillance and tracking systems. The objective is to enable sensor utilization optimized for existing environmental conditions. Sensor management efficiencies gained by forecasting signal detection limitations based on background clutter and system noise, are applicable to commercial sector space sensors and platforms, as well as military systems.

PHASE I: Develop and demonstrate approaches for nowcasting/forecasting signal detection limitations of RF and space-based EO/IR systems based on predictions of background clutter combined with sensor and platform noise.

PHASE II: Prototype a tool demonstrating the ability to assimilate real-time data inputs in natural background clutter prediction models, and combine with system noise input, to forecast signal detection limitations for RF and EO/IR integrated sensor management. Assess the utility and anticipated improvement in data collection, analysis and timeliness.

DUAL USE COMMERCIALIZATION: The new tools and approaches developed under this effort will enable new efficiencies in sensor management applicable not only to current and future command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) systems, but to commercial imaging and communications systems, as well.

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KEYWORDS: Ground-based radar, radar clutter background models, Optical/infrared background clutter models, signal detection limitations, space-based EO sensors, space-based RF sensors, sensor management

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AF06-250 TITLE: Radar Ionospheric Impact Mitigation

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technology for near-real-time (update in 5 minutes or less), modeling of the regional ionosphere and its anomalies, for mitigation of radar ionospheric impacts.

DESCRIPTION: This research effort will develop and demonstrate new ionospheric modeling technology designed to improve correction of ionospheric impacts on the performance of ground-based space-surveillance radars (SSRs) in near-real-time. These radars, which detect and track space objects, can experience significant target location errors due to ionospheric delay and refraction of the radar signals (reference 1). Since these radars must detect and track targets essentially to the radar horizon, the minimum capability required from this effort is to accurately model the ionosphere as the radar would observe it, down to the local horizon. To correct for spatial and temporal changes in the ionosphere the required model must be able to update in near-real-time using ionospheric sensor data. Since many radars are in isolated locations, or may have requirements to operate autonomously, an additional required capability is to provide accurate ionospheric mitigation by exploiting only sensor data from the radar site, such as passive sensing of satellite signals (e.g. GPS), or occasional radar ionospheric sensing. However, the model must also be able to update using additional data from other types of sensors, such as ionospheric sounding radars, and space-borne UV sensors, and additional data from global sensor networks, since such other data may be available to the radar site.

The original radar ionospheric mitigation approach employed the Bent climatolological model (references 2-4). This 35-year-old technology is still the means employed in the many DoD SSRs today. One more recent approach used capabilities from the PRISM model (reference 5). PRISM technology has today been surpassed by 'assimilative models' which employ better physics and Kalman filtering techniques (references 6-8). However, these models are designed to map the entire global ionosphere, operate best with a very large quantity of sensors, and may be very computationally intensive. These models are not tailored for SSR application which needs to optimize modeling of very small regions using only data from a single sensor, or very few. In fact, this class of models may actually do a poorer job than PRISM in matching the ionosphere to a single sensor isolated in an isolated region since they are designed to work best with many sensors.

A significant limitation of today's ionospheric models is that they are essentially unable to represent ionospheric 'anomalies' that may be seen in the observational data, such as boundaries of neighboring ionospheric regions, or ionospheric disturbance effects. Methodologies are desired that will analyze available data to detect anomaly signatures, and upon detection of an anomaly, will adapt the model appropriately or produce for the radar an appropriate warning or overlay of the suspect area. For example, detection, at a mid-latitude site, of the ionospheric 'trough region' boundary could invoke a simple model of the trough or could generate a warning plus an overlay map setting larger errors pole-ward of that boundary. Other 'anomalies' could include gradients associated with the equatorial anomaly region, disturbances associated with ionospheric scintillations, small gradients associated with traveling ionospheric disturbances, or sudden non-climatological gradients associated with geomagnetic storms.

The goal is to develop and validate the performance of innovative and efficient ionospheric modeling approaches that are optimized for the small regions applicable to ground-based radar coverage (radius of ~2000 km at ionospheric altitudes) and somewhat beyond. These approaches must adapt a continuous modeling scheme in near-real-time (update in less than 5 minutes, ideally less than 1 minute) to be consistent with all observational data that may become available, and degrade gracefully toward a climatological representation in the absence of data. A desired capability is that these efficient modeling approaches be capable of operating on small computer platforms (e.g. current desktop workstation) shared with computationally-intensive application codes (not part of this solicitation).

Primary payoff for all DoD SSRs is improved radar detection and tracking performance by reducing error in measured target range and position. Ionospheric errors for ultrahigh frequency (UHF) radars can be hundreds of meters at lower elevation angles where the surveillance fences are located. Additional payoff is capability for improved ionospheric error mitigation in situations where previous correction approaches breakdown due to 'anomalies' in the local ionosphere. Further, capability to detect such disturbance effects will provide direct information (real-time alert) on occurrence of situations where target detection or tracking could be impacted

PHASE I: Develop and assess an improved approach to modeling the ionosphere that is optimized for regions applicable to ground-based radar coverage, for application to mitigation of radar impacts caused by the ionosphere. Assess feasibility of the solution approach, for example by using model-simulated 'truth' data techniques.

PHASE II: Develop technologies to apply the solution approach to real-world situations where non-ideal data is used, with problems such as noise and multipath. Validate performance using independent ground-truth observations, paying special attention to performance at low elevation and at the longest ranges from the radar site. Validate any capability to detect and represent ionospheric anomaly situations.

DUAL USE COMMERCIALIZATION: The core ionospheric modeling capability sought here, suitably adapted into a product-generation system, would also support tactical generation of ionospheric representations to specify high frequency (HF) communication performance in a theater. There is possible commercial application of such capability in regions (such as Australia) where specifying and short-term forecasting of HF communications is needed. The disturbance detection capabilities would support DoD theater warnings of conditions that could impact performance of global positioning system (GPS) navigation or UHF satellite communications (SATCOM). These warnings would have possible global commercial application in those countries in equatorial regions which are implementing their own version of the US Wide Area Augmentation System (WAAS) for commercial navigation, which is impacted by ionospheric disturbances.

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KEYWORDS: radar, ionosphere, impacts, total electron content, TEC, scintillation, range error, refraction error, target detection, target tracking

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AF06-251 TITLE: Electro-Optical (EO) Sensor Management

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop techniques to optimize use of the variety of EO/infrared (IR) sensors and sensing techniques available to improve sensor utilization and data collection for Space Situational Awareness.

DESCRIPTION: Space Situational Awareness requires the use of multiple types of sensors on a variety of platforms to ensure the space environment is monitored continuously. Without the ability to determine beforehand which sensors are most likely to provide the desired information, enormous amounts of data must be collected and analyzed. Sensors have unique characteristics which allow for optimization for particular scenarios, and signal detection limitations which restrict their effectiveness in other scenarios. Their platforms and the environment in which they operate, may impose other limitations on their effectiveness in particular scenarios. This effort will explore the synergy between these various sensing techniques and determine how to exploit this synergy to allow tasking in real-time, of the optimal sensors for a given mission or scenario. EO/IR sensing techniques include, ultraviolet (UV), visual imaging system (VIS), InfraRed (IR), hyperspectral, hypertemporal (a.k.a. time-frequency analysis), polarimetry, interferometry and lidar. PAYOFF/WARFIGHTER IMPACT: Minimizes the quantity of data to be collected while optimizing the quality. Reduces processing and analysis requirements, allowing more timely transfer of information.

PHASE I: Develop and demonstrate techniques for evaluating effectiveness and unique signal detection limitations of specific sensors, in real-time, based on sensor characteristics, sensor and platform noise, jitter, background clutter, etc., and applying these techniques synergistically for sensor management.

PHASE II: Prototype a tool or decision aid and operational concept demonstrating the ability to optimize for synergistic use of available EO/IR sensors with real-time tasking.

DUAL USE COMMERCIALIZATION: The tools and operational concepts developed through this effort will be directly applicable to current and future command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) systems. Commercial imagery would be able to use these tools to optimize sensor selection and utilization for specific missions. In addition, the availability of decision aids to task or reconfigure sensors in real-time would encourage the development of more flexible sensors for both military and commercial use.

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KEYWORDS: sensor management,electro-optical and infrared sensors and sensing technologies,space situational awareness,atmospheric backgrounds and clutter,decision aids,real-time updates,signal detection limitations

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AF06-252 TITLE: Advanced Algorithms for Exploitation of Space-Based Optical Spectral Imagery

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative algorithms to exploit space-based optical spectral imagery to detect, characterize and identify objects of interest.

DESCRIPTION: The Spectral Surveillance Technologies Section (AFRL/VSBYH) of the Air Force Research Laboratory's Battlespace Surveillance Innovation Center is interested in innovative techniques to optimize the performance of space-based optical spectral (visible and infrared) target-detection systems. Optimization requires the development of advanced algorithms to exploit target-to-background contrast phenomenology. Measurements have been conducted from airborne and space-based optical sensors (visible and infrared) to characterize the optical properties of the environment. It is expected that the proposal will exploit this data to explore techniques for enhanced target detection. It is expected that, as a result of this effort, new algorithms will be devised and tested. Figures of merit in assessing algorithm effectiveness include improvements in anomaly detection, materials identification and characterization, and an enhanced probability of object 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 approaches to contrast-enhancement techniques to optimize object detection in structured environments. Demonstrate the feasibility of the approaches.

PHASE II: Perform detailed analyses and demonstrate the efficacy of algorithms for target detection in structured environments. Conduct tests to assess, validate and optimize the effectiveness of the algorithms. Develop and demonstrate an automated, near-real-time, processing system using real-world data sets.

DUAL USE COMMERCIALIZATION: The novel algorithms and processing techniques developed under this effort will potentially be useful in Phase III in military systems requiring autonomous stand-off detection of targets in sensor clutter induced by scene structure, the data-collection process and spectral interferences. They will potentially also be useful for non-military applications involving autonomous detection under conditions of scene-induced and sensor-induced clutter, noise and spectral interferences. Potential commercial examples include a processing system for application in fields such as medicine, industrial processing and quality control.

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KEYWORDS: multispectral/hyperspectral imaging, adaptive data-processing algorithm(s) (for:) autonomous target detection, background suppression, clutter mitigation/suppression, target-to-background contrast enhancement, signature enhancement

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AF06-253 TITLE: Low Power GPS Signal Acquisition Using Asynchronous Logic

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Obtain substantially lower battery power and physical size for the direct GPS signal acquisition function as implemented in small handheld user equipment (UE).

DESCRIPTION: In fast-signal acquisition for equipment that receive the new modernized global positioning system (GPS) military signals, there are trade-offs between clock uncertainty, the number of correlators, and position uncertainty. Acquisition circuits that consist of large numbers of correlators based on clock uncertainty consume a disproportionate amount of power in small hand-held UE. These circuits are typically implemented in silicon integrated circuits (ICs), predominantly based on clocked-domain (synchronous) logic. While synchronous systems are efficient, improvements on the effective energy per logic operation are always desirable. Asynchronous logic (AL), which does not employ a single (global) clock domain, promises to consume substantially less battery power and semiconductor area for equivalent circuit implementation. As such, it may be possible to dramatically improve GPS implementations in user equipment, which will further increase the ubiquity of GPS in military applications.

PHASE I: This topic seeks creative use of AL to GPS receiver design and not a generic treatment of AL. Provide proof of concept of the benefits (to GPS receiver design) of asynchronous design using small correlator design segments and simulations. Compare with conventional synchronous logic techniques. Identify design methodologies and circuit analysis tools and propose a systems architecture based on asynchronous logic.

PHASE II: Provide a detailed design approach based on an acquisition algorithm using Phase 1 technology. Design and fabricate an acquisition circuit to demonstrate the benefits of asynchronous design. Create a prototype implementation in a form suitable for use in future user equipment designs.

DUAL USE COMMERCIALIZATION: GPS is a classic dual-use technology. An improved (i.e., lower power, more compact) design of circuitry capable of processing direct GPS will only improve the ubiquity of GPS, finding manifold applications and development opportunities for civil GPS codes.

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KEYWORDS: User equipment, military and commercial signals, asynchronous logic

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AF06-254 TITLE: Home-on-Jam Technologies

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Identify improved advanced home on jam (HOJ) technologies to support geolocation of GPS jamming signals and make them commonplace.

DESCRIPTION: The vulnerability of GPS User Equipment to jamming susceptibility is a perennial problem. It is advantageous to the warfighter to have the jamming sources eliminated by spatially locating them for neutralization. While there are known methods for achieving this to some degree, it is desirable to develop more robust and more compact, power efficient methods. Ideally, these HOJ methodologies could be implemented in a very small volume and power profile, possibly co-integrated with the GPS receivers themselves. Proliferation and ubiquity of HOJ approaches is the surest method to contain and counter the many low-cost antijam devices that are being developed worldwide.

PHASE I: Identify promising HOJ technology approaches whose feasibility for Phase II development shall be shown through modeling, simulation, and if possible prototype development. The approaches most favored are those with: (1) demonstrable flexibility, almost the equivalent of a software-definable radio for the purposes of HOJ, (2) extremely low-power and circuit footprint. Define figures of merit for HOJ and justify the approach chosen in terms of these metrics.

PHASE II: Demonstrate a generic HOJ technology using a van at a jamming event. The electronic components will be at a breadboard stage of development, and the van will be driven in the jamming field to demonstrate the functions of detection, geo-location, and homing guidance in real-time.

DUAL USE COMMERCIALIZATION: Military application: The offeror will seek development of a prototype HOJ device/devices that can be demonstrated to the warfighter, preferably as a hand-carried device, but if not, vehicle-mounted. Commercial application: HOJ should have other applications to analgous radio-frequency equipment such as cellular telephony and other civil/commercial applications where malicious intent could reduce effectiveness of extant radio architectures.

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KEYWORDS: GPS user equipment, military and commercial signals, M-Code, GPS Jamming Signals, Anti-Jam Technology, GPS Jamming Detection, PGM

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AF06-255 TITLE: Optical Jitter Control for Laser Communications

TECHNOLOGY AREAS: Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop high performance optical train vibration removal methods and capabilities

DESCRIPTION: Military Satellite Communications (MILSATCOM) is currently pursuing laser communications as a means of meeting the projected bandwidth requirements of tomorrow’s warfighters. Lasercom links using diffraction-limited beams for high data rates require sub-microradian pointing accuracy, but onboard satellite vibrations enter into the optical train and adversely affect pointing accuracy and stability. A fast steering mirror or other advanced beam steering device can be used to remove the induced vibration from the outgoing beam by sensing the location of the incoming beam on a position sensing device. Similarly this reduction might be achieved through the use of a lightweight low-power platform vibration isolation system capable of sustaining up to a 200kg payload. However, the capability to remove jitter from the outgoing beam is still desirable even when no incoming beam is present, perhaps by using an inertial measurement device or predictive algorithms. The performance goal should be to provide 1-microradian output jitter in the presence of up to 10-microradian RMS jitter disturbance input (0.01-100Hz) threshold, and 200-microradian disturbance objective. Additionally, some systems are envisioned to have multiple terminals that share a common aperture and fast steering mirror, creating potential conflicts between the outputs of multiple fine guidance sensors. Advanced optical jitter control algorithm development is needed to be able to seamlessly operate between acquisition and tracking modes as well as to optimally fuse multiple sensor readings and minimize the residual jitter in each outgoing beam. These algorithms also need to be robust in the presence of short periods of missing sensor data, due to beam scintillations or other interruptions. Consideration should be given to using the constrained performance capabilities of current actuation mechanism capabilities and existing or low-cost sensing components, as well as real-time computational requirements. Size, weight, and power should be minimized to reduce impact to the satellite system.

PHASE I: Develop robust optical jitter control algorithms capable of fusing data from several sensors, seamlessly switching between acquisition and tracking modes, and handling short sensor outages while minimizing outgoing beam jitter to less than 1-microradian RMS. Provide a detailed computer simulation of process capabilities, and document results.

PHASE II: Optimize the results from Phase I, and evaluate results on a test-bed using hardware in the loop real-time simulation. Test results should validate control system performance for realistic disturbance environments and component capabilities.

DUAL USE COMMERCIALIZATION: The small business will work with the MILSATCOM program managers to effectively integrate the proposed technology to the system. MILSATCOM will benefit from reduced optical jitter during laser communications, which is enabling for efficient communications. Other military applications include laser radar and beamed-power weapon systems. Results from this work will apply to future commercial and National Aeronautics and Space Administration (NASA) free-space optical communications links. Laser communications will become a major focus for commercial telecommunications if the technology is optimized to work without jitter disturbances.

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KEYWORDS: laser communications, fine steering mirrors, jitter control, control algorithms

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AF06-256 TITLE: Next Generation Programmable Gate Array

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop novel approaches for field programmable gate array (FPGA) technologies suitable for space that address the multi-generation lag in rad-hard vice commercial integrated circuit technologies.

DESCRIPTION: Field programmable gate arrays (FPGAs) are critical to future space due to ability to provide mission flexibility, lower cost (i.e., reduction of non-recurring cost as one substrate can be re-used in many different designs), faster pace (pre-fabricated parts are customized on-demand), and possibly improved reliability (i.e., in situ reconfiguration may be useful for defect circumlocution). As such, every space mission uses FPGAs in some shape or form. The options unfortunately are: (1) use commercial parts and cope with their many weaknesses or (2) use FPGAs intended for use in space and cope with degraded performance and (unfortunately in a few cases) reliability. The purpose of this topic is to find ways for realizing an FPGA or FPGA-like technology that achieves radiation hardened, single event upset (SEU)-immune FPGA capable of operating at least 500 MHz clock rate and consuming less than 0.1 microwatt per gate with a capacity of at least 10 million usable gates. Additional goals include a demonstrated reliability in worst case environments of less than one failure in one billion hours of operation, immunity from single event effects and operating temperature range of -40 degrees C to +80 degrees C.

It is clear that one cannot simply imitate extant commercial approaches to achieve this. This topic is intended to lead to new technologies and approaches that can leapfrog in some way the commercial norms. Novel expoitation is key, and offerors that simply mimic traditional architectures need not apply. Offerors should consider novel architectures, for example multi-valued logic systems, which try to extract more functionality per transistor. Threshold logic is a very powerful concept. One could consider advanced processes, such as SiGe/InP, carbon nonotubes, or molecular electronics. One could consider cellular architectures, which exploit a presently unused.third spatial dimension. Or one could examine functional domain specializations of FPGAs, such as encryption-intensive or communications-intensive architectures. These latter architectures attempt to collapse the interconnect-intensity of a standard FPGA approach by recognizing the efficiencies of building structures that are configurable for certain specific prolem domains.

PHASE I: Propose novel FPGA approach for space. Support claims that key technology developments/adaptations can advance FPGA technology for space systems. Develop initial benchmarks using the proposed innovations and describe a strategy to make a product available for space users.

PHASE II: Establish a scaled prototype implementation of a novel FPGA concept suitable for use in space. The prototype should be fabricated and tested electrically and in radiation environments.

DUAL USE COMMERCIALIZATION: The current multi-billion dollar FPGA industry closely tracks the dominant CMOS market and has largely ignored novel schemes to extract greater functionality for reasons of focus. A breakthrough from this topic could alter that dynamic.

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KEYWORDS: FPGA, programmable logic, CMOS, sea of gates, logic gate, gate count, programmability

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AF06-257 TITLE: Advanced Transmitter and Receiver (T/R) Module Technology For Space Radar

TECHNOLOGY AREAS: Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop, design and test an affordable advanced single chip transmit/receive (T/R) module for a space radar payload.

DESCRIPTION: T/R module affordability and performance are important to making space radar missions practical. Of greatest interests areT/R module designs that exploit reconfigurability for mode interleaving (e.g.,Surface Moving Target Indicator (SMTI) and Synthetic Aperture Radar (SAR)), to permit the greatest exploitation of scare resources in a constrained environment (i.e., it costs a lot of money to field every pound of mass in a space system). The advanced T/R module should have improved power added efficiency (e.g., it is believed that InP may have desirable characteristics) and low noise characteristics and improved geometry control compared to hybrid (multichip) implementations. It is the hope of this topic to foster development of a prototype scale T/R module, capable of performing a simulated laboratory test being demonstrable in a representative (space) environment.

PHASE I: Develop a preliminary design for the next generation single chip, rad-hard T/R module which supports simultaneous dual radar mode and leverages existing technology. Develop suitable figures of merit (size, weight, efficiency improvement). In the Phase 1 PROPOSAL, justify the feasibility in terms of these figures of merit and demonstrate by the end of the proposal that the chosen approaches meets these metrics through a combination of modeling, simulation, and demonstration. Address radiation effects (i.e., total ionizing dose and single event effects).

PHASE II: Develop a prototype T/R module traceable to the aforementioned figures of merit and perform a simulated laboratory test. Develop a space-borne experimental platform for supporting operational test on ground and possibly in space experiments. Demonstrate traceability to production, qualification, and radiation environments.

DUAL USE COMMERCIALIZATION: Radar has been a traditionally military technology. However, the creation of a single-chip T/R module will have a number of important commercial applications, as it will be possible to incorporate ranging in a great number of terrestrial applications, including collision-avoidance platforms in industrial settings, automatic navigation systems for robotic systems, and a number of other safety interlocks for hazardous equipment.

REFERENCES: 1. Kazemi, Hooman, Jonathon B. Hacker, H. Xin, Mike Grace, Bill Norvell, Kevin Higgins, and Michael Gilbert, "An Ultra-Low Power Integrated T/R Module for Space-Based Radar Technology," IEEE National Radar Conference - Proceedings, Apr 26-29, 2004, Philadelphia, PA, p. 6-8.

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KEYWORDS: space material, space fabrication, space design and test, space-based radar, spacecraft, space transmitter and receivers

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AF06-258 TITLE: Electronically Scanned Array (ESA) Performance Prediction Model

TECHNOLOGY AREAS: Information Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop novel approaches to near-field/far field electromagnetics modeling, improved accuracy models, and tools to simulate ESA performance prediction in a laboratory environment in support of advanced design/synthesis.

DESCRIPTION: Electronically steerable arrays (ESAs) have long been considered for many DoD applications (Synthetic Aperture Radar imaging, High Resolution Terrain Information (HRTI)), and are enablers for novel methods that couple to reconfigurable electronics architectures. They have the advantages over mechanically scanned arrays in that it is possible to sweep, reconfigure, and partition their beam patterns. Such concepts are more readily exploited when the front end processing electronics are also reconfigurable. However, the new capabilities combined with divergent requirements pose significant design challenges in ESA architectures, and better modeling approaches and tools are needed. Traditionally, the interest has been in beam linearity, beam patterns, jitter stability, switching time, power requirements, antenna gain, antenna size, frequency, bandwidths, space location, power, and channels, and second order effects such as EMI, thermal distortion and mechanical disturbances (stiffness of array vs. mass; optical metrology system and dynamic adoption of phase weights vs. cost and complexity). New methodologies are needed to permit multi-mode, rapid analyses involving parallel computation and novel heuristics (e.g. genetic algorithms) are desired to permit more rapid analysis and design. Tools should support high-level trades and ease of use, for example to permit the optimization of ESA performance with respect to affordability. Ideally, it would be possible to support very rapid design, as part of higher level tool concept, enabling mission planning to be coupled with architecture synthesis.

PHASE I: Develop improved ESA modeling and user interface approaches, validate these methodologies using suitable benchmarks as the basis of a highly-functional ESA design/synthesis tool. Focus not only on performance and flexibility but ease of use. Consider tools that support more sophisticated concepts in ESA, such as dispersed arrays, non-uniform spacing, and non-planar / random element arrangements.

PHASE II: Develop an overall ESA performance predictor simulator toolchain based on previously developed model in phase I and demonstrate model's simulation in laboratory environment. The simulator should be validated against benchmarks and empirical measurements.

DUAL USE COMMERCIALIZATION: ESA performance tools can be readily adapted to address a number of commercial applications in cellular telephony and potentially beamforming (electromagnetic and acoustic). Strides in tool throughput and ease of use will aid consider a number of these related application domains.

REFERENCES: 1. Raytheon Systems Company, "Advanced MMIC Technology," March 15, 1999, DTIC accession number 99212545.

2. Northrop Grumman Space & Mission System Corporation, Space Technology, "Advanced Spacecraft Platform Development," March 15, 2004, DTIC accession number 04221320.

KEYWORDS: space-based radar, spacecraft, electronically scanned array, modeling and simulation

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AF06-259 TITLE: Space Radar Reflector Producibility

TECHNOLOGY AREAS: Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a methodology and process for designing and producing a space-qualified reflector to use with a space radar system.

DESCRIPTION: Reflector based architectures are promising for future space radar systems due to their light weight and potential for compact packaging. However, initial surface accuracy and operational dimensional stability are fundamental driving requirements in these systems and can represent significant challenges to their manufacture. Typical precision requirements are 1/10 (threshold) to 1/30 (goal) of the operational frequency wavelength (1 mm goal for X-Band systems). Non-zero material coefficients of thermal expansion (CTE) and our inability to sufficiently thermally control the terrestrial fabrication and space operational environments have historically limited the precision to which reflectors can be made. This solicitation seeks to address the challenge of initial surface accuracy through advances in reflector repeatable precision manufacture. Perform analysis on design and producibility of a space radar reflector, select the appropriate space qualified material to fabricate and produce the reflector. Produce a prototype model of the reflector and demonstrate space deployment. Develop a space-qualified test to prove design and operational success. The reflector should be optimized for its size and operating radar frequency (RF). Affordability should be a key factor in evaluation of reflector design and producibility.

PHASE I: Study existing reflector producibility technology and leverage to develop a more advanced and robust methodology and procedure to fabricate and produce reflector. A proof-of-concept hardware demonstration is encouraged.

PHASE II: Produce a space reflector model with use of advanced fabrication and material technology as available and demonstrate space deployment for surface tolerance and transmission loss. Perform a space-qualified test to prove design and operation success.

DUAL USE COMMERCIALIZATION: Military application: Standardize design and producibility methodology for future use by commercial industries. DoD and non-DoD government agency contractors can utilize the phase III contract to procure reflector technologies in support of the government's military and commercial sector applications.

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2. Mobrem, Mehram, "Methods of Analyzing Surface Accuracy of Large Antenna Structures due to Manufacturing Tolerances," AIAA 2003-1453, 44th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, 7-10 April 2003, Norfolk, VA.

3. Meguro, Akira, Satoshi Harada and Mitsunobu Watanabe, "Key Technologies for High-Accuracy Large Mesh Antenna Reflectors," Acta Astronautica 53 (2003), 899-908

KEYWORDS: space material, space fabrication, space design and test, space-based radar, spacecraft

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AF06-260 TITLE: Satellite Programmable Frequency Transceiver

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Design and develop a programmable frequency transceiver for small, rapid development satellites.

DESCRIPTION: Current frequency allocation requirements must be staffed through each Major Command (MAJCOM), service frequency agency, national boards, and international coordination in order to be assigned a specific frequency. The frequency approval process can take over 36 months, which precludes assured knowledge of the frequency prior to procurement and integration of crystal-based transponders. Spectrum management now relies more on off-channel assignments within the SGLS band, and now is relocating some satellite services to USB. Therefore, satellite manufacturers can no longer expect a frequency assignment to conform to the availability of off-the-shelf crystals. A programmable frequency transceiver would reduce the dependency on limited off-the-shelf crystals. This effort will develop and demonstrate creative design concepts for a programmable frequency transceiver for small satellites. The transceiver should have the capability to be programmed and locked to an assigned frequency set (uplink and downlink) within the SGLS band or Unified S-Band (USB) as late as 30 days prior to launch. This innovation will enable rapid development space programs to continue space vehicle integration and test in parallel with the frequency approval process. To permit end-to-end testing with the ground system, the transceiver should provide a “default” frequency set prior to being tuned to the operating frequencies. Once a frequency assignment is complete, the satellite manufacturer should be able to program the installed transceiver through either a test port on the space vehicle or through the command path. The transceiver should enable compliance with NTIA standards, and should be compatible with SGLS and Universal Space Network (USN) communication protocols. The transceiver must be qualified to operate in a Low Earth Orbit environment for 3-5 years. Responsive space requires rapid changes of transmit and receive frequencies aboard spacecraft to facilitate quicker frequency allocation and thereby avoid launch delays and conflicts. At least two spacecraft using different frequencies will be identified by the government as candidates for flight demonstration.

Participants should submit a detailed analysis/study of system requirements and capability including issues of interface, electrical and thermal conditions, basic sizing/packaging, signal quality and stability, programming and operating reliability, unique ground support equipment and implementation risks should be considered. The proposal should clearly identify innovative designs and methods to achieve low production cost, short turn around to delivery, flexibility of design, and ease of integration and use.

PHASE I: Design an innovative, programmable frequency transceiver and implementation concepts. If possible, demonstrate basic implementation concepts. Deliver a fully detailed design package. Prototype hardware (brass or breadboard) of critical components is encouraged under Phase I.

PHASE II: Build, test, and qualify an engineering model of the programmable frequency transponder for use in at least one of the candidate spacecraft identified in Phase I. Generate appropriate documentation sufficient for a spacecraft assembler to be able to install, test and qualify the transponder within the spacecraft system.

PHASE III: Flight qualify space hardware and support assembly, integration, programming, and test of the transponder within a spacecraft. Support flight operations and evaluation of the transponder.

DUAL USE COMMERCIALIZATION: The proposed research and development effort has equal applicability to the commercial satellite domain. NASA also has multiple spacecraft that could benefit from the research. This capability provides a major benefit to the space industry as a whole.

REFERENCES:
1. "Experimenters User Guide," Space Test Program (STP), 2004.

2. "Congressional Direction, Appendix G, Space Technology Applications, STP," Public Law 106-65, Oct 5, 1999.

3. Space Experiments Review Board Web site - http://www.safus.hq.af.mil/usa/usal/serb/index.htm.

KEYWORDS: programmable transceiver, SGLS, unified S-band, space test program, frequency, responsive space

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AF06-261 TITLE: Standardized Satellite Electrical Internal Interface

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a standardized satellite electrical internal interface electronics capability to plug experimental payloads into small and micro-satellites.

DESCRIPTION: This effort will develop and demonstrate creative design concepts for a standardized electrical interface suite for space-borne experiment payloads. An innovative, standardized electrical interface suite will greatly reduce interface control issues between the spacecraft and the experiment payloads. The interface would be key to a plug and play research and development (R&D) spacecraft, decreasing the time between mission concept and final assembly. This new interface standard should be easily packaged and implemented on a variety of R&D spacecraft buses of varying size. In addition, the hardware and the software need to be able to not only connect payloads to their host spacecraft electrically, but to ensure that both sides communicate commands and data (it is likely that both sides of an interface will be issuing commands). A new standard of communications and/or languages may need to be implemented as well. It may also be prudent to make sure that the system can handle not only data, but power. This may mean either a full-blown power management and distribution (PMAD) capability or just a pass-through option (possibly made as a spacecraft designer request item). An example would be to adapt USB-2 to space application. Digital protocol requirements should address high reliability and positive control. Items such as data rates, command input rates, and command verification should also be considered. Size and weight limitations for components are a key consideration in this task. Responsive space initiatives require new standardized capabilities to plug in payloads that have the potential for immediate deployment once the technology is proven beneficial to the warfighter in the theater. This ability will greatly enhance future Joint Warfighter Space (JWS) requirements.

Participants should conduct and present analyses of the expected design, fabrication, test and behavioral impacts of an innovative standard on spacecraft, such as electrical interactions, thermal requirements, mechanical constraints, electromagnetic compatibility, etc. The design should emphasize flexibility of both mechanical and electrical interfacing with current and future R&D spacecraft designs. Potential R&D spacecraft will be identified for initial testing/demonstration.

PHASE I: Design and develop the innovative, standardized electrical interface suite. Present the performance criteria selected, identify the initial options considered, and justify the chosen approach. If possible, demonstrate the new standard electrical interface through breadboard or brassboard models.

PHASE II: Build, test, and qualify the interface suite for use on candidate R&D spacecraft. Deliver a prototype system to the AFRL with sufficient documentation for a spacecraft assembler to install, test, and qualify the system within the spacecraft.

PHASE III: Support spacecraft builder and experimenters in the implementation of the standard for at least one candidate spacecraft.

DUAL USE COMMERCIALIZATION: The proposed research and development effort has equal applicability to the commercial satellite domain. The National Aeronautics and Space Administration (NASA) also has multiple spacecraft that could benefit from the research.

REFERENCES: 1. "Experimenters User Guide," Space Test PRogram (STP), 2004.

2. "Congressional Direction, Appendix G, Space Technology Applications, Space Test Program", Public Law 106-65, Oct 5, 1999.

3. Space Experiments Review Board Web site http://www.safus.hq.af.mil/usa/usal/serb/index.htm.

KEYWORDS: standardized, electrical interface, responsive space, R&D payload communication

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AF06-263 TITLE: Space Object Characterization with Space Based Hyperspectral Imagery

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop designs for space-based hyperspectral imaging or spatial interferometric sensor payloads to characterize space objects. Include wide-area search and in situ inspection capabilities.

DESCRIPTION: Space situational awareness is an essential element of the nation's capability to operate freely in space. Current operations to observe resident space objects (RSOs) rely largely on ground-based assets. While past research has contributed to our ability to characterize RSOs, there are serious limitations imposed by ground-based viewing. Therefore, proposers are requested to develop concepts to exploit the advantages of placing optical sensors in space, which include persistent surveillance and freedom from atmospheric effects.

The Air Force is interested in innovative methods of spatially resolved and unresolved electro-optical imagery for detection, identification, classification, and characterization of manmade and natural RSOs, specifically hyperspectral imaging and spatial interferometric techniques. Spectral imaging applications include, but are not limited to, space object identification, functionality assessment, and material identification. Spatial interferometry provides several advantages over direct detection methods, including higher achievable spatial resolution and the lower cost of mirror fabrication.

The proposer will be expected to develop advanced algorithms employing spectral techniques, as well as innovative sensor designs, data-processing techniques, and modeling and simulation tools. Unlike with ground-based assets, both sensor and target will be moving, potentially at high relative velocities if both are in LEO. The proposer will therefore determine what effects this will have on the image reconstruction, both spatial and spectral, including image smearing, target rotation, etc., and develop the necessary techniques or algorithms to mitigate these effects.

PHASE I: Develop system-level designs to characterize space objects with electro-optical sensors, specifically hyperspectral imaging and spatial interferometry techniques. Determine effects of high relative motion of the target on image reconstruction, e.g. image smearing and target rotation.

PHASE II: Develop algorithms based on Phase I designs for image reconstruction and spectral signature extraction. Evaluate the algorithms using a priori knowledge from spectral libraries and satellite databases. Demonstrate effectiveness and specify range of applicability for identification and characterization of manmade and natural RSOs. Document assumptions and provide trade/risk assessments.

DUAL USE COMMERCIALIZATION: Transition the image reconstruction and spectral signature extraction into complete data reduction tools for use with an operational space-based system. This work could be used to support satellite health determination, such as after collisions with space debris or launch incidents. The techniques could also be applied to astronomical targets such as near-Earth asteroids or other Solar system objects.

REFERENCES:
1. Carroll K. A. & A. R. Hildebrand. “NESS: A Dual-Use Microsatellite for Asteroid Detection/Tracking and Satellite Tracking R&D.” 2001 Space Control Conference Proceedings, MIT/Lincoln Laboratory.

2. Matson, C. L. & K. J. Schulze. “Blind Material Identification from Spectral Traces.” 2004 AMOS Technical Conference Proceedings.

3. Piper J., V. P. Pauca, R. J. Plemmons, & Giffin, M. “Object Characterization from Spectral Data Using Nonnegative Factorization and Information Theory,” 2004 AMOS Technical Conference Proceedings.

4. Wallace B., F. Pinkney, R. L. Scott, & D. Bedard et al. “The Near Earth Orbit Surveillance Satellite (NEOSSat),” 2004 AMOS Technical Conference Proceedings.

5. P. H. van Cittert, Physica, 1, 201 (1934)

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7. P. R. Lawson (ed.), “Principles of Long Baseline Interferometry” (1999).

8. R. M. Hjellming (ed.), “An Introduction to the Very Large Array” (the VLA Green Book), Edition 2.0 (1992).

KEYWORDS: SSA, RSO, space object identification, hyperspectral imaging, spatial interferometry, characterization, spectral signature exploitation

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AF06-264 TITLE: Prognostic Models for Cryo Cooling (Heat Transfer and Heat Dissipation) Systems

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop innovative approaches (e.g., statistical tools, prognostics and physics of failure models) to predict cooling performance degradation and associated cooled avionics failures.

DESCRIPTION: In order to fully enable the predictive part of any prognostic and health management (PHM) concept, there has to be some capability to relate detected incipient fault conditions to accurate "useful remaining life" predictions for any point in time. Key to accomplishing this is being able to understand incipient fault-to-failure progression characteristics for the component and/or subsystem of interest and having realistic and verifiable prognostic models. The systems and components of interest in this topic are Cryogenic Cooling (Heat Transfer and Heat Dissipation) Systems. It is important that the user be able to diagnose faults accurately and predict failures and life remaining of these components. This may be accomplished through the merging of an understanding of the particular physics of failure, analytical models, physical models, statistical techniques, and actual failure experience data. Some level of real-time sensor and/or measurable state awareness will be a required input to these prognostic models and techniques. This effort will develop, demonstrate, and apply these advanced prognostic and useful life remaining models in support of the predictive part of PHM on Cryogenic Cooling (Heat Transfer and Heat Dissipation) Systems.

PHASE I: Define techniques/processes needed to relate "useful remaining life" predictions to detectable fault conditions in Cryo-Cooling Systems. Demonstrate technical merit of solutions proposed to detect incipient failure in Cryo-Cooling Systems and accurately predict remaining useful life.

PHASE II: Develop and demonstrate a full-scale prototype prediction system based on the advanced models, techniques, and programs demonstrated in Phase I and apply them to real-world military platform problems (e.g., Cryogenic Cooling Systems). Assess the application boundaries, accuracy, and limitations for these modeling techniques.

DUAL USE COMMERCIALIZATION: The offeror is expected to aggressively pursue primery insertion opportunities with major and second-tier defense prime contractors. Additionally, it is expected that highly refined cryocooler reliability models will find application in the design of commercial, scientific equipment having long-term cryocooling requirements.

REFERENCES: 1. Henley, Simon, Ross Currer, Bill Sheuren, Andy Hess, and Geoffrey Goodman, “Autonomic Logistics—The Support Concept for the 21st Century,” IEEE Proceedings, Track 11, paper zf11_0701.

2. Byer, Bob, Andy Hess and Leo Fila, “Writing a Convincing Cost Benefit Analysis to Substantiate Autonomic Logistics,” Aerospace Conference 2001, IEEE Proceedings, Vol. 6, pp. 3095, 3103.

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KEYWORDS: Diagnostics, Prognostics, Cryogenic Cooling Systems, JSF, Useful Life Remaining, PHM

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AF06-265 TITLE: Advanced Prognostics Technology for Digital-Based Electronic Systems and Their Components

TECHNOLOGY AREAS: Air Platform

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop statistical/prognostic/physics of failure models/techniques to define fault-to-failure progression models/provide useful life remaining predictions for digital electronic systems/components

DESCRIPTION: In order to fully enable the predictive part of any prognostic and health management (PHM) concept, there has to be some capability to relate detected incipient fault conditions to accurate useful life remaining predictions for any point in time. Key to accomplishing this is being able to understand incipient fault-to-failure progression characteristics for the component and/or subsystem of interest and having realistic and verifiable prognostic models. The systems and components of interest in this topic are digital based electronic systems and their components on board an aircraft. It is important that the user be able to diagnose incipient faults accurately and then predict failures and life remaining of these components. This may be accomplished through the merging of an understanding of the particular physics of failure, analytical models, physical models, statistical techniques, and actual failure experience data. Some level of real-time sensor and/or measurable state awareness will be a required input to these prognostic models and techniques. This effort will develop, demonstrate, and apply these advanced prognostic and useful life remaining models in support of the predictive part of PHM on aircraft digital based electronic systems and their component elements.

PHASE I: Define techniques/processes to relate useful life remaining predictions to detectable fault conditions in aircraft digital-based electronic systems and components; demonstrate technical merit of proposed solution to detect incipient failure; and accurately predict useful life remaining.

PHASE II: Develop and demonstrate a prototype of these advanced models, techniques, and programs for several specific fighter aircraft digital based electronic systems and their components. Assess the application boundaries, accuracy, and limitations for these modeling techniques.

DUAL USE COMMERCIALIZATION: Military application: Finalize these models with a major aircraft and/or engine manufacturer. Apply these modeling programs on various fighter programs

REFERENCES: 1. Henley, Simon, Ross Currer, Bill Sheuren, Andy Hess, and Geoffrey Goodman, "Autonomic Logistics—The Support Concept for the 21st Century," IEEE Proceedings, Track 11, paper zf11_0701.

2. Byer, Bob, Andy Hess, and Leo Fila, "Writing a Convincing Cost Benefit Analysis to Substantiate Autonomic Logistics," Aerospace Conference 2001, IEEE Proceedings, Vol. 6, pp. 3095, 3103.

3. Hess, Andy and Bill Hardman, Topic N03-197, Solicitation 2003.2.

KEYWORDS: Diagnostics, Prognostics, Digital Based Electronics, Useful Life Remaining, PHM

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AF06-267 TITLE: Tunable Spectral Response in Space-Based Systems

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a focal plane array with a spectral response tunable across a broad range of selected wavebands, with different sets of simultaneous wavebands emphasized for different target and scene spectra

DESCRIPTION: The ability to reconfigure a sensor in order to enhance performance and/or perform multiple missions is a very desirable attribute for future sensor systems. If a sensor system could reconfigure itself to exploit signals in the wavelength ranges from the ultraviolet (UV) through the infrared (IR) and, perhaps, into the millimeter-wave regimes, that system could support space situational awareness missions such as space object detection and identification, target discrimination, target status determination, etc., or surveillance missions such as plume-to-hard-body handover, surveillance through clouds, chemical/biological weapons detection, etc., and would be assured of operation 24 hours/day, 7 days/week, in all weather conditions and at very long distances. If this reconfiguration could be done with a single detector or detector array, the savings in cost, weight, and power consumption would be substantial. An additional powerful capability would be to have a sensor system able to act like a tunable spectral filter, i.e., be able to simultaneously detect any combination of wavelength bands, and to remain insensitive to unselected wavebands. By tuning the spectral response, different wavebands (detected simultaneously) are emphasized. The result is a signal-to-noise that is optimized for given pair of target and background spectra. Then, with known target spectra (due to varying materials on satellites or varying chemical compositions of weapons) soft-wired into the algorithms of the sensor system, spectral fingerprints can be discriminated and identified absolutely. This it the spectral analog of the spatial "matched filter" processing approach.

PHASE I: Design and develop a detector that responds to various combinations of wavebands simultaneously (as opposed to sequential wavelength-by-wavelength tuning). Regimes of interest are UV through visible, 3 through 12 microns, or 12 through 20 microns for space sensors viewing space targets.

PHASE II: Focus on fabricating, hybridizing to a readout, and characterizing a focal plane array (FPA) using the detector developed in Phase I. When the FPA performance is proven, a camera will be designed and tested with that FPA, including any cryogenics that might be required for IR detection, either pour-filled liquid nitrogen or another reliable means of cooling.

DUAL USE COMMERCIALIZATION: Military applications include target detection and reduced false alarm rate. By emphasizing target spectra shape in the detector response, lower detection thresholds are possible. In particular, spectral regions where the background scene is bright relative to the target could be excluded. In its most simple two-waveband embodiment, a tunable spectral response could be configured to emphasize different greybody temperatures, thereby providing useful remote temperature probes for critical applications that run the commercial gamut from detecting heated brake systems (trucking and railroad industries) to heat sources caused by defective circuitry in semiconductor manufacturing. In addition, for both military and commercial applications, remote sensing of chemical and biological signatures (for weapons detection or environmental monitoring) would benefit greatly from a detector with a tunable spectral response.

REFERENCES: 1. Cardimona, D. A., D. Huang, C. Morath, D. Le, and B. Klemme, “On-Demand Wavelength Tuning of Detector Responsivity for Multi-Mission Scenarios,” proceedings of the AIAA Responsive Space Conference and Workshop, Redondo Beach, CA, April 2003.

2. Cardimona, D. A., D. H. Huang, C. T. Le, H. S. Gingrich, and M. A. Serna, “Advanced IR Detector Devices and Concepts for Remote Sensing,” proceedings of the SPIE Infrared Spaceborne Remote Sensing XI, San Diego, CA, August 2003, vol. 5152, pp 316-326.

KEYWORDS: tunable detection, space object identification, space situational awareness, space surveillance, remote sensing

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AF06-268 TITLE: New Sensing Capabilities for Space Situational Awareness

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop large field-of-view, high-sensitivity infrared, visible and/or ultraviolet sensors or other innovative sensing approaches to detect and track space objects and/or Coronal Mass Ejections (CME).

DESCRIPTION: Improved capability for detecting space objects, e.g., satellites, debris, or solar ejecta requires advances in electro-optical sensing. High sensitivity, low background infrared (IR) focal plane arrays (FPA) have benefited from recent advances in increased operating temperatures, dualband (mid-wave (MW) and long wave infrared (LWIR) and dual-LWIR) capability, and high sensitivity under low background illumination. Ultraviolet FPAs have also progressed, with dark currents lowered to the point that array uniformity is limited by defects in the detector material. Advances are also required in broad-band white light sensing such as for the tracking and specification of CMEs, and the detection of proximity objects by reflected light. The tracking of CMEs, both limb and earth-directed, is critical for space weather forecasting. This topic will emphasize development of low background, thermal infrared (IR) FPAs with multi-waveband capability; high sensitivity ultraviolet FPAs; and compact, white light CME and resident space object (RSO) detector and tracking. The goal is to obtain focal planes exhibiting background limited performance at backgrounds as low as 5E10 photons/cm2–sec in the infrared, and ultraviolet FPAs having noise equivalent photon rates fewer than 10 photons per pixel per frame time, at frame rates in the 30 to 100 Hertz regime. Tracking CMEs in the inner heliosphere requires observing of phenomena that are only 0.1% as bright as the background sky. The successful Solar Mass Ejection Imager (SMEI) (reference 5) experiment demonstrated that this requires extremely innovative solutions for controlling scattered light both within the baffle system and within the imaging optical elements. This topic will also consider exploration of innovative sensing such as coherent and incoherent terahertz (THz), non-imaging sensors, which are light, small, fast, low-power, uncooled, cheap, and capable of on-chip preprocessing.

PHASE I: Explore innovations to decrease the dark current and improve the sensitivity of detectors, investigate new concepts for pixel-collocated multi-waveband capability. Develop/design instrument concepts and model or demonstrate proof-of-concept devices for innovative sensing applications.

PHASE II: Refine the most promising innovations considered in Phase I. Develop and fabricate prototype devices and evaluate their levels of performance. Validate models developed in Phase I through testing with light sources (artificial and night sky). Document potential development path for Phase III consideration.

DUAL USE COMMERCIALIZATION: Military applications of detectors include improved space surveillance capabilities, for which the ability to detect faint objects at great distances is critical. This includes early warning of potentially damaging geomagnetic storms to civilian space assets and ground systems (such as power grids). Commercial applications include industrial and auto-emission monitoring, tumor detection, environmental monitoring, manufacturing process monitoring, identification of concealed weapons and explosives, as well as the biochemical detection of viruses, such as anthrax. During this Phase, prototype or production grade articles will be made available for independent government test and characterization to verify performance.

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KEYWORDS: infrared (IR), ultraviolet (UV), visible, terahertz, focal plane array (FPA), electro-optics, remote sensing, space weather, heliospheric imager

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AF06-269 TITLE: Cold Atom Optical System for Space

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Miniaturize and integrate a laser and optical system for a rubidium 87 Bose-Einstein condensate into a portable, space qualified, and self-contained system.

DESCRIPTION: Atom interferometry with Bose-Einstein condensates (BEC) has the potential to revolutionize the field of inertial force sensing. This technology could make for very small, extremely precise sensors that consume very little power for many space-based applications including precise targeting, tracking, and pointing, all requirements for space-based C3ISR and space superiority (survivability, offensive and defensive counterspace, communications). Such a sensor could be made into a small, GPS-free, non-emanating, jam-proof inertial navigation system. Diode lasers have proven to be a low cost and versatile method to produce the stable frequency and narrow linewidth light needed for the BEC, but may not be the only solution. While the low power requirements, high efficiency, and robust nature of solid state diode lasers make them the perfect candidate for space-based sensors, these cold atom production systems (diode lasers, optics, acousto-optics, and electro-optics) are currently typically designed and built for the laboratory. Current commercial systems take up cubic feet of space and are highly sensitive to alignment, vibrations, temperature fluctuations and electrostatic shocks. To make the transition to space, miniature, robust, hardened, and integrated laser, optical, and electronic systems are needed. This effort will look to providing in a single compact unit, the appropriate lasers, optical components, and electronics to produce the necessary frequencies of light with fiber outputs needed to create a rubidium Bose-Einstein condensate. That is, the output of the system should be at least 3 different frequencies totaling 200 mW of 780 nm single-mode light at the rubidium 87 D2 line with a linewidth of less than 1 MHz. These frequencies need to be tunable with a range of 0-100 MHz detuning of the D2 line. The entire system should be contained in a volume smaller than 1/4 cubic feet. Accompanying the obvious challenges of miniaturization and hardening of the optics, electronics, shutters, and lasers, several additional challenges are envisioned. These include devising methods for autonomous locking to the correct frequency, frequency stability, power stability, and frequency tunability. Autonomous locking, hardening and miniaturization are currently large technical hurdles and are the essence of this research investment.
PAYOFF/WARFIGHTER IMPACT: Crucial step towards space deployable ultra-precise inertial force sensors for targeting, tracking, pointing, and GPS-free, jam-proof inertial navigation.

PHASE I: Design the unit including lasers, acousto-optic modulators, optics, frequency stabilization, and electronics.

PHASE II: Develop a prototype of the Phase I design of the self-contained unit with fiber outputs for the light of different frequencies.

DUAL USE COMMERCIALIZATION: This effort will produce a portable unit that can be used with any cold atom experiment, with minor modifications, and take the field of laser cooling and trapping from the lab to the field. This has applications in inertial force sensing, atomic clocks, magnetometers, spectroscopy, and quantum computers among others. Military applications include: GPS-free, jam-proof, navigation; remote sensing of other space objects via gravitational or magnetic sensing; tracking; targeting; and pointing with inertial sensors for feedback. Space-based commercial applications include satellite pointing for communications and miniature atomic clocks for time keeping.

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KEYWORDS: diode lasers, laser cooling and trapping, Bose-Einstein condensation, atom interferometry.

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AF06-270 TITLE: Autonomous Flight Termination & Satellite Based Telemetry System for Launch Vehicles

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop algorithms and hardware needed to implement a new tracking/telemetry paradigm that enables lower cost and more responsive launches of small satellites.

DESCRIPTION: Approaches and technologies are needed that enable small launch vehicles to be called up and launched in timelines ranging from an hour to a day. The same functions of telemetry, tracking, & notification that are performed today must still happen but at a much faster pace and at a cost consistent with small satellites. Systems are sought that can provide a means for telemetry, tracking, and flight termination in a low cost and responsive fashion. This requires that a launch vehicle be able to select a flight path and execute it within a matter of hours using algorithms that can be quickly modified. Development of integrated hardware to provide redundant position and velocity without deploying down range assets is needed. This requires an integrated, lightweight antenna for the launch vehicle to allow 10Mb telemetry over satellite links and possibly for tracking and termination command signals. Use of global positioning system (GPS)/inertial navigation system (INS) metric tracking is one possible means to speed up the time to configure and prepare the range assets as well as reduce launch costs. Autonomous Flight Termination will include on-board evaluation of instantaneous impact and approved flight corridors. It must sufficiently account for new trajectories, deal with wind and debris issues, and have the capability to fly in shadow mode for a number of test flights while working toward flight certification. System must meet the range safety requirements for fault tolerance and certification.

PHASE I: Conduct necessary conceptual and design studies for telemetry and autonomous flight termination systems to be developed and tested in Phase II.

PHASE II: Develop an operational telemetry and autonomous flight termination system that is lab tested and ready for testing for range certification.

DUAL USE COMMERCIALIZATION: Autonomous flight termination system may be applicable to unmanned aerial vehicles or cruise missiles, either as an improvement to current systems or as a backup system.

REFERENCES: 1. "Advanced Range Technologies Working Group," NASA Kennedy Space Center and Air Force Space Command, March 2004.

KEYWORDS: flight termination, launch vehicles, range safety, shadow mode flight, space based telemetry, GPS metric tracking

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AF06-271 TITLE: Lightweight Hybrid Radio Frequency (RF) and Optical Instrument

TECHNOLOGY AREAS: 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 and demonstrate a very lightweight hybrid radio frequency (RF) communication/optical imaging instrument.

DESCRIPTION: Future missions envisioned by the Air Force include the use of micro and nano-satellites for space situational awareness (SSA). A key enabler for such concepts is dramatic reduction in the mass, size, and cost of such satellites. For such missions, optical surveillance and RF communications subsystems play vital and unique roles. However, both subsystems are fairly expensive and massive, yet use very similar physics principles to collect the electromagnetic radiation. In this solicitation, the Air Force Research Laboratory (AFRL) seeks innovative concepts to combine these subsystems to achieve a significant mass reduction. Previous attempts at combining these systems into a single integrated unit have proven to be bulky and cumbersome, showing no mass or volume savings. Analysis shows that there is the potential to combine these systems using lightweight optical, wire mesh, and dichroic surfaces for antenna/optics elements, and to use adaptive electronics for the processing and modulation functions. Concepts are sought that achieve the goal of less than 1kg for the entire system to include the mechanical hybrid device and the necessary electronics operating package. Current systems have non-optimized masses on the order of 20 kg. The structural and electrical embodiments of such hybrid instruments must be efficiently designed to achieve this low-mass requirement. Additionally, the optical component may need to be capable of 6DOF alignment. Optical aperture diameter must be larger than 10cm. The larger RF system must be able to accommodate S, X, Ku frequency bands, to support 1Mb data rates from low earth orbit (LEO) to ground and S-band from geosynchronous earth orbit (GEO) to ground.

PHASE I: Formulate designs for a hybrid RF communication and optical imaging instrument meeting requirements outlined in the above description. Justify design claims through modeling, simulation and empirical methods.

PHASE II: Develop a prototype hybrid RF communication and optical imaging instrument meeting the stated requirements. Must be able to prove capability for space flight. Potential space flight demonstration may be available.

DUAL USE COMMERCIALIZATION: This SBIR topic has the potential for many dual-use applications, most notably the dual-use subsystem design, since the technologies could be integrated in any number of space situational awareness and/or communications satellites. Conceivably, these methods could be applied to terrestrial metrology applications, such as those pertaining to geological survey. Additionally, this technology has applications for terrestrial-based unmanned aerial vehicle utilizations.

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http://www.au.af.mil/au/2025/volume 3/chap 09/v3c9-1/htm#Introduction.

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http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/fal02/grenier.html.

KEYWORDS: hybrid communication instrument, lightweight, hybrid imaging instrument, dual use communications system

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AF06-272 TITLE: Satellite Design Automation (SDA) for Responsive Space

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Establish rapid-design toolchains for end-to-end generation of spacecraft designs from mission capture through integration / deployment, to accelerate responsive space mission implementations.

DESCRIPTION: The Air Force is actively pursuing the capability to assemble and launch a satellite within hours or days of mission call-up. This topic focuses on SDA approaches for responsive space. It is envisioned that SDA couples mission capture/modeling tools (requirement capture) to a sophisticated interactive synthesis engine that draws from a number of “wizards” and element libraries to form high-level satellite “strawman” rough designs, which can be overlaid against the original mission requirements (analogous to “back-annotation” in integrated circuit design) for conformal checking. The strawman designs are then coupled to detailed subsystem-level synthesis tools that generate component configuration and connective specifications, assuming plug-and-play library components. Rapid simulations are done in an iterative fashion until a constructible bill of materials is produced. Software applications, mission control scripts, test protocols, and even the console scripts necessary for ground operation could ultimately be produced automatically. Such an ambitious rapid design system, which ideally could accomplish an entire system design in less than one day, is believed essential to make responsive space a reality. We seek innovative concepts to address the rapid design of satellites. Offerors are encouraged to “pull the stops” on the ambitious undertaking of creating an open framework for an end-to-end SDA system, addressing as many of the following challenges as possible: rapid mission capture/planning, platform-level (bus and payload) “design advisor/wizard”, extremely rapid multi-level modeling and simulation/analysis, automatic software and test protocol generation, and subsystem / component synthesis methods that work in conjunction with elemental libraries of pre-fabricated but reconfigurable components. To accelerate the performance of these tools, offerors may propose innovative hardware acceleration and parallelization approaches, to include hybrid analog / neural net solver systems. In this manner, the ability to iterative solution cycles for the various tools in this framework is dramatically improved.

PHASE I: Phase I concepts will be based around an open framework, rapid design concept spanning mission capture to deployment. Design wizards, modeling/sim, automatic console and test script generation should be addressed, along with any acceleration concepts.

PHASE II: Phase II must demonstrate the tools proposed from Phase I in a practical setting, based on plausible assumptions regarding the mission classes and component libraries required to support a responsive space SDA system.

DUAL USE COMMERCIALIZATION: A successful Phase III project is highly desirable, with an emphasis on teaming with major systems primes. The offeror should secure agreements on co-investment inasmuch as possible with industry partners. The SDA approach will likely be applicable to a number of quick-turn terrestrial design concepts involving flexible vehicular platforms, such as search-and-rescue, geological survey, and robotic probes.

REFERENCES: 1. Lanza, D., J. Lyke, P. Zetocha, D. Fronterhouse, and D. Melanson, "Responsive Space Through Adaptive Avionics," presented at AIAA 2nd Responsive Space Conference, 2004.

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KEYWORDS: electronic design automation, responsive space, plug-and-play, rapid prototyping

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AF06-273 TITLE: Plug-and-Play Structures for Satellite Applications

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and demonstrate “plug-and-play” (PnP) structures for space vehicle applications

DESCRIPTION: The Air Force is actively pursuing the capability to assemble, checkout, and launch a satellite within days, or even hours of a battlefield commander's requirement. Such an operationally responsive space capability will provide our forces with an asymmetric edge in future conflicts as the commander will be able to expeditiously deploy tailored space assets to strategic orbits, in order to help our forces defeat the enemy. The Department of Defense does not currently possess this capability. In order to meet this goal, the Air Force Research Laboratory, Space Vehicles Directorate (AFRL/VS), in conjunction with the Joint Warfighter Space Program Office, is pursuing the development of low cost, plug-and-play (PnP) satellite structures to meet the needs of a range of payloads and space mission applications.

As a threshold, proposed PnP satellite structural concepts should enable a 2 day satellite integration and checkout period for a variety of space mission scenarios, with traceability to an objective goal of 12 hour integration and check-out. This is a nontrivial task and represents a revolutionary decrease in satellite assembly and integration time. Current systems typically take anywhere from 6 months to 2 years long. To enable maximum flexibility in the face of constantly changing mission requirements, PnP structural concepts should allow for rapid component swap-out, and truncated systems check-out to be completed within 6 hours; with traceability to an objective goal of 2 hours.

Because the intent is for the battlefield commander to be able to task these satellites, costs must remain extremely low. When the cost of the launch vehicle, launch operations, components, and primary payload are taken into account, this requirement implies that the complete bus for the satellite must remain on the order of $1M. The only way to meet this cost objective is to mass-produce the structural components and store them (analogous to an aircraft maintenance depot), so that we can assemble a satellite at the appropriate time. Thus, all PnP satellite structural concepts must demonstrate traceability to eventual mass-production.

Concepts under consideration will be modular, scalable, reconfigurable, and multi-functional. Structural panels should contain integral electrical, thermal management, and/or radiation-resistant capabilities. Other specific areas of interest include, but are not limited to: 1.) Structures with embedded health monitoring: A set of structural panels, each with embedded health monitoring capabilities that can be mechanically and electrically attached to each other in a variety of geometries. The panels must be able to communicate with each other such that the structure, as a whole, is able to detect, locate, and assess the severity of damage, regardless of the panel configuration. Additionally, the method of damage detection, location, and assessment must be amenable to connecting, and potentially swapping-out, a wide variety of components/payloads in multiple configurations. 2.) Structures with embedded thermal management: Analogous to health monitoring, with the exception that thermal energy is being managed between components and panels. Again, the key is that the panels must be capable of being arranged in multiple geometries and accommodate a wide variety of components/payload configurations; while keeping the components within their operating temperature ranges.

The specific technology challenges of this program that must be met are three-fold:
1.) Develop interfaces that allow for the efficient transfer of mechanical load, heat, and/or information between panels and components.
2.) Develop manufacturing methods for efficiently embedding additional functionality within the structural members.
3.) And most importantly, design a system that allows for the transmission of load, heat, and/or information between panels and components while allowing for geometric and configuration flexibility.
Achieving these challenges will allow for a wide range of missions to be conducted using a small set of pre-fabricated structures; providing orders of magnitude reductions in both schedule and cost.

PHASE I: Develop concept for PnP structures. Provide analysis of operating ranges, stiffness/strength. Develop analytical model. Model 3 panels, connected in 3 geometries. Simulate 2 components per panel, in 2 configurations, per panel geometry. Design standard interfaces leading to subscale demo. Prepare Ph. II plan.

PHASE II: Refine concept, develop prototype. Conduct prototype testing to validate models from Phase I, provide detailed evaluation report, recommendations. Key results: demo of mechanical & thermal/electrical properties, ease of assembly, reconfigurability, modularity, scalability. Provide AFRL/VS with prototype & draft users' guide.

DUAL USE COMMERCIALIZATION: Program offices will be able to procure plug-and-play structural “building blocks” for their particular application. A satellite design team can first determine their requirements, and then purchase the required amount of blocks to meet their needs. Such an approach will provide dramatic reductions in cost and schedule. Potential commercialization in private sector applications is also possible and encouraged. Potential commercial applications abound in the aircraft and automobile industry, as well as in high-speed data management. Another military application may be in the realm of rapidly deployed infrastructure. When US forces stand-up a forward located base, a spin-off technology can be used to set-up Command, Control, and Communications assets in a fraction of the time it currently takes.

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3. Smith, Joseph F., et. al., “Standardized Spacecraft Onboard Interfaces,” AIAA Paper 2003-6206, Space 2003 Conference, Long Beach, CA, September 2003.

4. Voss, David L., et al., “TEST: A Modular Scientific Nanosatellite,” AIAA Paper 2004-6121, Space 2004 Conference, San Diego, CA, September 2004.

5. Jilla, Cyrus D. and Dr. David W. Miller, “Satellite Design: Past, Present, and Future,” International Journal of Small Satellite Engineering, 12 Feb 1997.

KEYWORDS: plug-and-play, modular, multi-functional structures, thermal management, embedded electronics, standard interfaces

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AF06-274 TITLE: Next Generation Solar Cells Based on Nanostructures

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

OBJECTIVE: Develop very high efficiency next-generation solar cells based on utilization of nanostructures.

DESCRIPTION: Higher efficiency solar cells are needed to reduce solar array mass, stowed volume, and cost for Air Force (AF) space missions. Conventional crystalline multijunction solar cells are currently limited in efficiency by the complexity of adding more junctions to increase absorption of the solar spectrum, and the necessity to match lattice parameter and current for each junction. It is anticipated that solar cells using nanostructured materials can overcome these limitations with potential for efficiencies of >60%. Incorporation of these quantum structures can create intermediate states within the bandgap to harvest photons with energy less than the bandgap of the host material. Quantum structures can be introduced into polymeric materials to create extremely low cost, high specific power, flexible solar cells, and inorganic, radiation-hard versions of these devices are possible. Quantum structures in these devices can be optimized to absorb a large portion of the solar spectrum. The ideal new solar cell would be flexible and lightweight. However, efforts should be focused on significantly increased metrics (W/m2 and W/Kg) over state of the art (SOA) multijunction solar cells at lower costs. Current array level costs are ~$1000/watt. A threshold cost for early systems based on the new technology would be comparable or less than current systems, with costs dropping to <$250/watt with continued development. Current state-of-the-art crystalline multijunction solar cells are ~30 % efficient, >350 W/m2, and ~70 W/Kg at the array level. Thresholds for the new technology would be >40% efficiency, >450 W/m2, and >250 W/kg. Objectives would be >60% efficiency, >700 W/m2, and >500 W/kg. Technological hurdles are expected to include (but are not limited to): (1) synthesizing and ordering geometrically optimized nanostructures; (2) increasing the transport and separation of photogenerated carriers; and (3) increasing environmental stability (including ultraviolet (UV) radiation, electron and proton radiation, atomic oxygen). The potential for significantly increased air mass zero (AM0) conversion efficiency over SOA will enable high power platforms supporting higher bandwidth communications and high power radars for space based applications. In addition, higher power per area could enable body mounted solar cells for some spacecraft, significantly increasing space mobility and allowing spacecraft to be built and launched faster. The potential low costs and high manufacturability of nanostructured solar cells will further remove the solar array as a cost driver allowing for plug-and-play array solutions to be developed. System level array and integration issues should also be considered.

PHASE I: Demonstrate coupon sized nanostructured solar cell at AM0 efficiency >10%. Establish feasibility of concepts for a solar cell reaching efficiencies >40% with path to >60%. Develop models predicting theoretical efficiency. Address space environment concerns (UV radiation, electron and proton radiation, atomic oxygen)

PHASE II: Deliver a nanostructured solar cell with: (1) AM0 efficiency approaching 40% and potential to reach >60%; (2) capable of surviving the space environment (degradation must be comparable to or less than that of SOA space solar cells); (3)traceable to a cell level specific power greater than 500 W/kg; and (4)fabrication costs comparable to or less than SOA multijunction solar cells.

DUAL USE COMMERCIALIZATION: Dual use commercialization would occur through the development of high performance (high W/kg, high W/m^2, and low $/W) cells that could be used for terrestrial/space applications for both the military and commercial sectors. The potential for significantly increased air mass zero (AM0) conversion efficiency over SOA will enable high power platforms supporting higher bandwidth communications (of great interest for both commercial and military communications satellites) and high power radars for space based applications. In addition, higher power per area could enable body mounted solar cells for some spacecraft, significantly increasing space mobility and allowing spacecraft to be built and launched faster. The potential low costs and high manufacturability of nanostructured solar cells will further remove the solar array as a cost driver allowing for plug-and-play array solutions to be developed. In addition, low costs of manufacturing could allow these new solar cells to compete for terrestrial applications such as distributed power or grid power replacement/backup.

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KEYWORDS: nanostructured solar cell, quantum structure, quantum dot, intermediate band gap

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AF06-276 TITLE: Combining Remotely Located GPS Antennas

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop technologies for Controlled Reception Pattern Antenna (CRPA) formed by combining a number of fixed, remote distributed antennas on a platform.

DESCRIPTION: There are generally two kinds of GPS antennas (Fixed Reception Pattern Antennas-FRPA, and Controlled Reception Pattern Antennas-CRPA). FRPAs are inexpensive and small, and easy to integrate onto a platform. However, they do not provide any anti-jam capability inherent in a CRPA. Many platforms in the DoD do not currently have CRPAs, mainly attributable to the unit cost and size of CRPA, as well as the complexity of fitting the large array. This SBIR topic seeks to develop a hybrid approach in which a number of FRPAs on a platform can be combined into a network that provides the benefits of a CRPA, overcoming the cost, size and complexity issues of CRPA. Novel technologies can contribute to the benefits of such an approach, including micro-electro-mechanical systems (MEMS) approach, software-definable radio (SDR), and other algorithm/systems-level approaches.

PHASE I: Phase I offerors will propose approaches for combining remote FRPAs into a network CRPA, and they shall (using modeling, simulation, and simple sub-scale prototypes if possible) show the benefits of this hybrid scheme.

PHASE II: Phase II approaches shall develop a prototype system that combines a number of FRPAs on a platform into a network CRPA. The resultant system should be chamber tested to demonstrate the combined antenna performance.

DUAL USE COMMERCIALIZATION: Military application: A hybrid FRPA/CRPA scheme is expected to have tremendous latent applications in both military and commercial applications, since it allows one to combine potentially existing antennas into a network to achieve CRPA-like benefits. Such approaches might be useful in combining a number of fixed antenna (e.g., from applications such as cellular telephony) into novel distributed networks.

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KEYWORDS: User equipment, military and commercial signals, FRPAs, CRPAs

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AF06-277 TITLE: Reliable, Lightweight and Volume Efficient Electrical Harnessing

TECHNOLOGY AREAS: Electronics, Space Platforms

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Dramatically reduce integration, system checkout timelines, and cost for the Block 12 Space Tracking and Surveillance System (STSS) through the development of innovative power and data handling concepts.

DESCRIPTION: Conventional satellite power and data handling architectures require significant timelines to design, manufacture and integrate. Such configurations also drastically limit expeditious diagnostic capability and checkout. Contractors should submit proposals that develop revolutionary power and data handling concepts for space based applications to enable a threshold satellite assembly, integration, and checkout capability of 2-3 days, with an objective goal of 6 hours, without sacrificing reliability. Currently, integration and checkout timelines can exceed 4 months. Proposed concepts should have autonomous in-situ diagnostic checkout capabilities during satellite assembly/integration. Other innovations could involve the superposition of communication traces onto the power distribution grid itself for low data rate functions. In addition, existing power connections could be used for a low bandwidth health and status distributed network, thereby eliminating dozens to hundreds of wires. The challenge here will be to develop low-power, low-loss, robust, radiation hard, and EMI containing power and data-handling circuitry and modules. For enhanced operational reliability, circuit reconfigurability could be explored as an option to mitigate circuit failure. Integral radiation resistance is highly desirable. Proposed concepts could be a modular family of components that can be easily rearranged to facilitate routing in close quarters and last minute satellite component repositioning. The power grid itself could be designed to be modular and distributed within the satellite bus.

Embedded and trace-tailorable EMI shielding, especially at interconnects, is an option to consider and would eliminate the need for metallic housings. All concepts will be tested in a relevant launch and space environment to ensure survivability. Concepts should facilitate mass production and thereby decrease fabrication cost relative to conventional canon plug circuit configurations by at least 20%, with an objective goal of 60%. Proposals can focus on one or more of the innovations listed above, but are certainly not limited to these ideas. This solicitation will consider other ideas from industry that meet the overall objective. Proposals must identify key technical challenges for their power and data handling concept and subsequently establish a developmental strategy to mitigate technical risk.

PHASE I: Design and develop an Engineering Design Unit (EDU) of their proposed power and data handling concept. The Engineering Development Unit (EDU) will be tested to characterize performance and to assist in developing a Phase II development strategy.

PHASE II: Design and fabricate prototype concepts and functionally validate them in accordance with STSS requirements. Work closely with the STSS bus contractor to transition the circuit concept.

DUAL USE COMMERCIALIZATION: Innovations in flexible circuitry are easily transferred to the commercial sector. Industry is always pushing for better-performing electronics for space, home, or the office. The technologies developed under the proposed topic would assist the commercial industry to achieve these goals.

REFERENCES: 1. “Multifunctional Structures”, presented at the AIAA Space 2001 Conference in Albuquerque, NM, 28-30 August 2001.

2. Yamar Electronic Ltd. website, www.yamar.com, 2005, Tel Aviv, Israel.

3. “Design & Testing of Multifunctional Structure Concept”, presented at the 41st Annual Structural Design and Materials AIAA and ASME Conference, 4 April 2000, Atlanta, GA.

4. “Multifunctional Structures Technology Demonstration on NMO Deep Space 1”, presented at the Deep Space 1 Technology Validation Symposium, 9 February 00, Pasadena, California.

5. “Overview of Multifunctional Structure Efforts at the Air Force Research Laboratory”, presented at the Space 2000 & Robotics 2000 Conference, Albuquerque, NM 28 February 1999.

KEYWORDS: Smart circuitry, satellite avionics, reconfigurable circuits, space electronics

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AF06-283 TITLE: Threat Detection, Validation, and Mitigation Tool for Counterspace and SSA Operations

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms

OBJECTIVE: Develop technologies which will assist in the detection of satellite threats through data mining and fusion techniques, recommend threat mitigation strategies, and assist with solution validation.

DESCRIPTION: Many of today's Air Force satellites are susceptible to attack with no standardized procedures or technologies in place to detect these attacks and discriminate them from other non-related anomalous conditions. In addition, procedures to react to potential attacks are ad-hoc at best. In recent years there have been several Air Force efforts put in place which had a focus on threat detection. This topic seeks to take the next step in the counterspace spectrum and focus on the assessment of threats after they have been detected. Many organizations are beginning to address various components in the counterspace domain, however, what is still lacking is a framework for how all of these components tie together in order to achieve a complete picture of this problem area. What is also lacking are tools and techniques to assist in the validation of proposed solutions. This topic contains two focus areas: Developing data fusion and threat assessment technologies for space situational awareness (SSA), and validating the outcomes of the threat detection and mitigation outcomes through performance metrics. The toolset must be robust enough to allow exercising multiple what-if scenarios as well as allowing for the integration of both hardware and software components. As an example, the framework should cover the full spectrum and at a minimum should, at a high level, contain the following: entity tracking; characterization; detection of threat; assessment of the situation; notification; coordination with all relevant parties; determination of appropriate responses; active response; and final assessment and reporting. One of the keys to this process is data fusion and space situational assessment. There are countless data fusion methodologies in existence each with it's own advantages and disadvantages. One of the outcomes of this topic is to help quantify the benefits of the various approaches and develop an architecture which will generate performance metrics. The Joint Directors of Laboratories (JDL) model for data fusion should be considered with any proposed solution.

PHASE I: Develop and demonstrate a high level architecture for a toolset which will enable detection of threats and the validation of results for defensive counterspace and space situational awareness.

PHASE II: Build on the architecture developed in Phase I and incorporate higher fidelity components at all levels. This phase will also develop multiple data fusion technologies which can be used for space situational awareness. Phase II will culminate in a detailed prototype demonstration of the architecture and provide performance metrics which would have broad applicability beyond the space domain.

DUAL USE COMMERCIALIZATION: The underlying technology to be developed focuses on applying intelligent systems technologies to the problem of detecting anomalous situations on-board Air Force satellites from heterogeneous information sources. This technology would also have equal applicability to commercial spacecraft. The environmental factors affecting commercial spacecraft are identical to those encountered by military spacecraft. In addition core spacecraft bus systems are very similar between military and commercial spacecraft.

REFERENCES: 1. Zielinski, Lt Col Robert, Lt Col Robert Worley, Maj Doug Black, Maj Scott Henderson and Maj David Johnson, "Star Tek-Exploiting the Final Frontier: Counterspace Operations in 2025, "A Research Paper Presented To Air Force 2025," August 1996,
http://www.au.af.mil/au/2025/volume 3/chap 09/v3c9-1/htm#Introduction.

2. Grenier, Maj John, "A New Construct for Air Force Counterspace Doctrine," Air and Space Power Journal, Fall 2002,
http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/fal02/grenier.html.

KEYWORDS: data fusion, intelligent reasoning, counterspace, space situational assessment

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AF06-284 TITLE: Miniature Frequency Agile RF Beacon Receivers for Ionospheric Effects Monitoring

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop and demonstrate a small, low cost hardware and software system to characterize the effect of the ionosphere on radio wave propagation by receiving and analyzing signals from various ground and space based Radio Frequency beacons.

DESCRIPTION: Radio waves from VLF through UHF are often strongly effected by the ionosphere. When these signals propagate through the ionosphere, they are modified in frequency, amplitude, phase, polarization, time of flight and propagation path as a direct result of the ionosphere plasma and its structures. These modifications both represent a potential system impact as well as afford a method of ionospheric monitoring. Governments and private organizations operate a large number of beacon transmitters both in space and on the ground. These include GPS, VHF/UHF beacons, communication satellite transponders, VLF, MF, HF and VHF ground based beacons and broadcasting, ionosondes, and many more. The size, expense and logistics of transmitters precludes their use at spacing much less than 1000 km, and ionospheric structures of 10km to 1000 km are known to exist, but the spatial nature of the propagation impacts on these scale sizes is poorly known due to the lack of adequate sensor density. A frequency agile beacon receiver system could revolutionize the concept of beacon monitoring. Current receivers and antenna systems are too large, expensive and inflexible to be purchased, deployed and used in sufficient numbers to place at ~100 km. Present analysis software is insufficient to extract ionosphere effects and system impacts from a wide variety of potential beacon sources. Innovative research breakthroughs are needed in small, frequency agile antennas and digital receivers to obtain high density data, and especially needed are sophisticated signal processing algorithms to obtain and extract useful scientific data from these beacon signals, which are typically modulated for some other purpose. Properly fielded, these receiver networks can provide data for assimilation into contemporary ionosphere specification and forecast models to provide increased model resolution and fidelity.

PHASE I: Design and build a small, low cost, flexible RF beacon monitor. Demonstrate the ability to extract ionosphere information from various space and ground based beacons.

PHASE II: Demonstrate and validate the ability of multiple sensors to provide high resolution ionosphere data from various beacons and perform mapping of messo-scale ionospheric phenomena.

PHASE III DUAL USE APPLICATIONS: Instruments based on successful developments in Phase II are expected to greatly increase the utility, range, resolution and operational effectiveness of existing ground-based space weather observation networks operated by the DoD and other US Government agencies. Military applications of this technology include multi-band, frequency agile, intelligent and propagation-aware communication systems optimized for robust message delivery. A successful low-cost miniaturized multi-frequency receiver can be expected to find immediate, widespread, and profitable commercial application in a wide range of navigation, timing, monitoring, and related applications, in addition to research and weather observation programs such as the National Science Foundation Distributed Arrays of Small Instruments (DASI) initiative.

REFERENCES: 1. Basu, S., K. M. Groves, Su. Basu and P. J. Sultan, “Specification and Forecasting of Scintillations in Communication/Navigation Links: Current Status and Future Plans,” Journal of Atmospheric and Solar-Terrestrial Physics, v. 64, No. 16, Nov 2002, pp. 1745-1754.

2. Zabotin, N. A. and J. W. Wright, "Ionospheric Irregularity Diagnostics from the Phase Structure Functions of MF/HF Radio Echoes," Radio Science, v. 36, No. 4, 2001, pp. 757-772.

3 Calais, E., J. S. Haase and J. B. Minster, “Detection of Ionospheric Perturbations Using a Dense GPS Array in Southern California,” Geophysical Research Letters, v. 30, No. 12, 2003, p. 1628.

KEYWORDS: ionosphere impacts, radio beacon receiver, ionospheric propagation, frequency agile, GPS, TEC, scintillation, HF, ionosonde

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AF06-292 TITLE: Intumescent Material Passive Fire Protection Technique for Aircraft Engine Nacelle

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a lightweight, quick-expansion, and high-activation-temperature intumescent material for passive fire protection in engine nacelles on manned/unmanned platforms.

DESCRIPTION: Fire is either the primary cause, or a contributing factor, in most aircraft kills (both in peacetime and wartime). In many instances, injuries to personnel and loss of mission capability accompany a fire event. Methods and technologies to mitigate them are imperative. A previous program has proven the feasibility of using intumescent material to create an “instant firewall” in an aircraft engine nacelle as a fire protection solution. The intumescent material responded sufficiently to create a firewall, which ultimately extinguished the nacelle fire within 10 seconds. The intumescent material’s shortfall was that its activation temperature was too low for an engine nacelle’s environment. The current intumescent material begins expanding at temperatures less than 200ºF. There is an industry-wide need for a passive lightweight fire protection technique for current and future aerospace systems. A modified intumescent material is needed that is lightweight, quick-expanding, has a char strength sufficient to withstand airflow, and does not initiate expansion/activation until reaching 700ºF or higher. This new enhanced high temperature expanding intumescence will significantly advance the state-of-the-art in intumescent materials capability to suppress fires rapidly and effectively in manned and unmanned aerospace systems.

PHASE I: Develop thin, lightweight intumescent coating,that begins expanding above 700ºF, fully expands & extinguishes within 10 seconds of fire initiation,withstands -50ºF to 160ºF without performance degradation,and char withstands 5 lbms/sec airflow. Demonstrate coating’s performance in a lab environment.

PHASE II: Demonstrate the new intumescent material’s performance capability which meets/exceeds the criteria identified in Phase I in a full-scale engine nacelle test facility. The intumescent material must comply with all performance criteria identified in Phase I, including engine nacelle fire extinguishment within 10 seconds of fire initiation.

DUAL USE COMMERCIALIZATION: The new intumescent coating developed for the Department of Defense for manned and unmanned aerospace systems is equally applicable for use throughout industry as a fire retardant/suppressant on commercial aircraft, in buildings, and in construction of new facilities.

REFERENCES: AFRL-WS-WP-TR-2004-9001 (JASPO-03-V-003). Intumescent “Instant Firewalls” for Low-Cost Fire Protection. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, October 2004.

KEYWORDS: Intumescent Material, Fire Protection, Intumescent Coating, Instant Firewalls, Survivability, Vulnerability, Firewalls, Intumescents, Engine Nacelle.

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AF06-293 TITLE: Electronic Virtual Thermal Mapping Device

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a low-cost, high-speed, virtual electronic Thermal Mapping Device (TMD) capable of identifying fire ignition source in large and small areas.

DESCRIPTION: Throughout the Department of Defense, identification of a fire source is paramount to timely fire suppression and ensuring the survivability of aerospace platforms. A TMD is needed that can instantly identify the location of fire sources and assist in precise direction of onboard fire suppressant to the correct area. This device will be used to significantly enhance the survivability of current and future aerospace systems. This technology will advance the capabilities of fire suppressant systems to suppress fires rapidly and effectively in manned and unmanned systems. This device will also assist the modeling and simulation community with precise data for use in model validation.

PHASE I: Develop and demonstrate a low-cost, high-speed (less than 500 msec) wireless electronic TMD that will identify fire ignition source in large and small areas. Ideally, the device will be small, expendable, heat-resistant, and capable of software mapping and electronic pattern recognition.

PHASE II: Demonstrate the electronic TMD in a generic platform where a fire is initiated and the device identifies the location of the fire's source and produces an electronic thermal map of the area. Demonstrate device's capability of software mapping and pattern recognition (used as model input) to detect temporary blockages between fire suppressant discharge head and the fire source.

DUAL USE COMMERCIALIZATION: The new virtual electronic TMD developed for the Department of Defense for manned and unmanned aerospace systems is equally applicable for use throughout industry to identify fire sources in buildings, commercial aircraft, and high-value computer systems requiring immediate and accurate dispersion of fire suppressants.

REFERENCES: JTN-COS-96-083, TR-97-61. Complex Magnitude and Phase Measurements of EM Fields from Transmitting Antennas Using Innovative Infrared Imaging Techniques. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, August 1997.

KEYWORDS: Thermal mapping, electronic device, virtual, high speed, fire ignition source

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AF06-294 TITLE: Mutil-mode Sensor Characterization

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a prototype device for presenting truth data to a multimode sensor that allows testing and evaluation of advanced sensor applications in a dynamic simulation environment.

DESCRIPTION: The next generation of weapon systems uses multimode sensors for target detection and tracking. One mode of these sensors is a Ka band Synthetic Aperture Radar (SAR). Testing this mode requires an innovative prototype device capable of radiating in free space the correct radio frequency (RF) waveform that allows the sensor to image multiple moving targets in a validated SAR scene. General requirements include the following: The sensor must a.) produce a linear frequency modulated waveform with a minimum bandwidth of 700 MHz in 23usec, b.) be phase coherent, and c.) present the necessary RF data for the sensor to create a SAR image with a 4 inch resolution.

Generation of realistic Complex Target Returns for sensors utilizing compressed waveforms has been difficult in the past due to the inability to synthesize individual points of an extended target using current real-time processing capabilities. Although traditional synthesizer, Digital Signal Processing, or Digital Radio Frequency Memeory based approaches used to generate targets provide adequate results against simple single-point targets, the nature of the return from a complex, multipoint reflector for compressed waveform makes the generation of the spatial convolution a more difficult task. There are two dimensions to the problem: The first is the ability to produce the appropriate number of overlapping returns to represent the simulated target with sufficient range resolution, and the second is the need to model the changing geometry to provide the desired fidelity for the simulation. Overall the processing load to calculate, in near real time, the changing coefficients to perform the spatial convolution necessary to represent the overlapping and the summing of the returns from the various points of reflection to the system under test is a difficult processing task.

The intent of this research is to investigate system architectures and algorithms consistent with real-world implementations utilizing state-of-the-art technology to provide spatially summed point reflections to represent arbitrarily complex multipoint reflectors simulating returns from a complex target. Due to the larger bandwidth and frequency agility of many of the current sensors when using compressed waveforms, special consideration needs to be given to real-time implementation and wide bandwidth capabilities. This capability is of great importance in a test environment where it is desirable to identify limitations in the capabilities in the equipment under test. All suitable algorithms shall be analyzed, since these are important tools in the verification of the theoretical solutions. The results of these investigations will include all suitable algorithms required for an assessment of the performance against a range of different compression waveforms including chirps, phase coded, and others. Hardware requirements to implement these algorithms will be identified.

PHASE I: Investigate innovative architectural design concepts to determine the feasibility of generating a Complex waveform to a radar system utilizing compressed waveforms in real time. Identify cost/benefit relationships between the various options.

PHASE II: Using results from Phase I, develop and demonstrate a prototype device to be used in providing Complex Target Returns (range extended targets) capability in hardware-in–the-loop simulation for sensors utilizing compressed waveforms.

DUAL USE COMMERCIALIZATION: This device allows the developers of products using SAR to avoid expensive flight testing. This research will ultimately find utilization within the general transportation segment of the economy. It will be suitable for land, sea, and air applications. The development of extended target returns will also benefit the testing and validation of advanced weather radar.

REFERENCES: 1. Perry, R. P.; R. C. DiPietro; and R. L. Fante. SAR Imaging of moving Targets. IEEE Transactions on Aerospace and Electronic Systems AES-35 (1999): 188-200.

2. He, Ch., and J. Moura. Target Detection in Unfocused SAWISAR Image. Proceeding of the IEEE-National Radar Conference, Syracuse, New York, 1997.

KEYWORDS: Synthetic,aperture,radar,moving,targets

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AF06-297 TITLE: Develop Flow-Field Seeding for Large Tunnels

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a flow-field seeding capability for large production wind tunnels.

DESCRIPTION: Wind tunnel optical instrumentation complements standard intrusive techniques. Flow visualization and measurement techniques such as Laser Vapor Screen (LVS), Particle Imaging Velocimetry (PIV), and Doppler Global Velocimetry (DGV) require the seeding of the flow with light scattering particles. Water, theatrical fog fluid, and mineral oil (to name a few) have been used in various applications. In a production wind tunnel environment, the flow-seeding technique must not significantly degrade productivity or flow quality. This means that the seeding system must be easy to install/remove, requires minimal or no cleanup of seed material, is not hazardous to humans, the hardware is robust, the hardware does not introduce flow disturbances or otherwise alter test conditions, and it is easy to control the amount of seeding and the location where the seed is introduced into the flow. To be viable for PIV the seeding generator must fill the measurement region with 1-5 micron particles and maintain a number density of 4000 particles/ cm3 during data acquisition. For DGV the particles can be an order of magnitude smaller and the particle number density can be several orders of magnitude higher. Rather than filling the entire tunnel with particles, stream-tube seeding is preferred, with a steering capability to adjust stream-tube location. Stream-tube cross-sections ranging from 150 cm2 to 1 m2 are required and the solution may require more than one set of seeding hardware. Additionally, investigators are encouraged to consider innovative flow tagging techniques that permit spatially resolved flow visualization and velocity measurements. The analysis should include an assessment of potential seeding system impact on flow quality and tunnel productivity.

PHASE I: Demonstrate feasibility of a flow seeding system.

PHASE II: Develop and demonstrate a prototype in a large scale wind tunnel.

DUAL USE COMMERCIALIZATION: Potential military applications include support the test and evaluation of DoD air platforms at DoD test centers. PRIVATE SECTOR COMMERCIAL POTENTIAL: Potential commercial applications include small scale educational and research facilities such as universities with aeronautical programs (i.e. Princeton University, Georgia Tech, etc.), automobile wind tunnel testing or power plant development and could be marketed as an optional capability by vendors providing Doppler Global Velocimetry (DGV), Planar Imaging Velocimetry (PIV) and Laser Vapor Screen (LVS) diagnostic techniques. For example, use these technologies for measuring the flow velocity around automobiles or commercial aircraft for improved performance and fuel economy.

REFERENCES: 1. Beresh, S. J., et al., “Stereoscopic PIV for Jet/Fin Interaction Measurements on a Full-Scale Flight Vehicle Configuration,” AIAA-2005-0442.

2. Elliott, G. S., et al, “Evaluation and Optimization of a Multi-Component Planar Doppler Velocimetry System,” AIAA-2005-0035.

3. Byun, Gwibo, Olcmen, Semih M. and Simpson, Roger L., "A Miniature Laser-Doppler Velocimeter for Simultaneous Three-Velocity-Component Measurements," Measurement Science and Technology, Vol. 15 No10, October 2004.

KEYWORDS: flow seeding, wind tunnels, flow visualization, flow measurement

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AF06-298 TITLE: Non-Invasive Model Attitude and Deformation Measurement

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a system capability to determine model position and displacement in aerodynamic test facilities.

DESCRIPTION: Subscale versions of airfoils and other models are tested in large scale wind tunnels to simulate aerodynamic loads and other flight parameters. Accurate knowledge of the position of an aerodynamic test model as to roll, pitch and yaw is fundamental during these tests. Further, deformation due to aerodynamic loads is experienced as the models are not perfectly rigid. Deformations up to 0.25 inches at the wing tips must be measured with accuracies of < 25 microns (0.001 inch) with model attitude changes of < 175 microradians (0.01 deg). The accuracy in determining wing twist and bending has become of major importance in wind tunnel testing. Small deformations and model attitude changes can cause significant errors in the apparent model attitude and hence lift, drag and roll force coefficients. Several techniques have been examined and applied to measure and correct for these effects. Moire' interferometry, wing pressure evaluation technique, stereo pattern tracking, image correlation (similar to PIV particle Imaging Velocimetry) and encoded projection have been demonstrated. Measurement rates of 40Hz are required at standoff distances of 3 meters. Each has shortfalls that should be critically assessed and an innovative approach developed for an operational prototype measurement system.

PHASE I: Demonstrate feasibility to measure the model position and displacement due to aerodynamic loads.

PHASE II: Develop a prototype and demonstrate in a large-scale wind tunnel.

DUAL USE COMMERCIALIZATION: Potential military applications include integration of robust reliable systems into wind tunnels for test support. Commercially, a measurement system of this nature could be used in a hundred or so active wind tunnels in the commercial sector. Applications also include design validation of fabricated precision parts such as using profilometry (milling machines) to monitor material removal with accuracies of 0.001".

REFERENCES: 1. Germain, Eric, and Quest, Jugen, "The Development and Application of Optical Measurement Techniques for High Reynolds Number Testing in Cryogenic Environment," AIAA -2005-458.

2. Pallek, D., Butterisch, K. A., Quest, J. and Strudthoff, W., "Model Deformation Measurement in ETW using Moire' Technique," International Congress on Instrumentation in Aerospace Simulation Facilities ICIASF 2003 Record, Gottingen, Germany, August 25-29, 2003.

3. GroB, N., "ETWA Analytical Approach to Assess the Wing Twist of Pressure Plotted Wind Tunnel Models," AIAA Paper #2002-0310.

KEYWORDS: optical metrology, model deformation, measurement

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AF06-299 TITLE: Aeropropulsion Test Facility Diagnostics

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop smart diagnostic capabilities for high enthalpy airflows.

DESCRIPTION: Arc heated and propulsion test facility users and facility operators require an understanding of the influence of facility modifications or adjustments and resultant flow-field conditions. For example, changes to the power supply may decrease the amplitude of arc current oscillations and decrease the flow-field turbulence in an arc heater. Non-deterministic analytical techniques such as Monte Carlo analysis or genetic algorithms may be used in conjunction with innovative flow measurement techniques to tailor facility input so that flow-field conditions (i.e. turbulence or pressure or temperature fluctuations) are minimized. Non-intrusive methods for measuring fluctuations are preferred. Innovative approaches are sought to characterize the flows in high enthalpy test facilities. Identify a set of flow-field measurement techniques and other technologies that may be used in conjunction with non-deterministic techniques to develop "smart" diagnostics for high temperature flow fields generated by arc facilities or propulsion test facilities.

PHASE I: Demonstrate the feasibility of diagnostic and analytical techniques to optimize flow field understanding of high enthalpy flows.

PHASE II: Develop a prototype flow-field measurement capability.

DUAL USE COMMERCIALIZATION: Potential military applications include incorporation of the prototype diagnostic system into high enthalpy facilities such as arc heaters and hypersonic wind tunnels, and combustion generated flow fields of scramjets, rockets and etc. Commercially, smart diagnostics for measuring air flows can be applied for evaluation of system component integration. Also, this technology can be adapted to commercial turbine engines for online-flight health monitoring and engine process control.

REFERENCES: 1.Beale, David K., Cramer, Kevin B., and King, Peter S., "Development of Improved Methods for Simulating Aircraft Inlet Distortion," AIAA PAPER 2002-3045.

2.Beale, D. K., "Improving Information Productivity and Quality in Turbine Engine Ground Testing," AIAA PAPER 2001-0163.

3.Bruce, W.E. III and Horn, D.D., "AEDC Arc Column Diagnostics Measurements," Proceedings of the 38th International Instrumentation Symposium, pg. 509 (Paper #92-0190) Las Vegas, NV, April 26-30, 1992.

4.Hiers III, Robert, and Hiers Jr., Robert, "Development of Exit-Plane Probes for Turbine Engine Condition Monitoring," AIAA Paper 2002-4304. 2002.

KEYWORDS: Turbulence, Distortion, Flow-Field Diagnostics

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AF06-300 TITLE: Hypervelocity Projectile Position, Angle of Attack, and Velocity Detection System

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a system that will track an 8000m/s projectile giving its pitch, yaw, velocity and radial position as it passes along a 10 ft diameter chamber several hundred feet in length.

DESCRIPTION: An innovative approach to track projectiles launched at speeds up to 8000 m/s is required. The projectile location is to be tracked while passing through an altitude simulation chamber 10 feet in diameter for several hundred feet. It is desirable to know the pitch, yaw, velocity and radial position of the projectile as it progresses down the chamber. This process is currently monitored by calibrated x-ray systems located at intervals along the chamber. The current system require a detection system, an x-ray system, film cassettes holders, multiple tank viewing ports and an extensive calibration process. This process is very labor intensive and requires a lot of chamber access time, and space. The data reduction is prone to human error and requires frequent repeats. A modular digital based detector system is desired that can be mounted at multiple locations along the chamber and can provide the projectile orientation parameters. Detectors have to be insensitive to light generated by glowing projectiles or impact flashes that occur when the projectile impacts a nearby target. The current reconstruction process requires at least an image in 2 orthogonal planes with the pitch, yaw velocity and radial position listed with the image. The system should be rugged, self contained and easily portable for moving from one location to another. It should be accurate to within 0.030 inches in reading displacements from centerline and 0.025 degrees when reading angles. It is desirable to locate the units external to the chamber and view the projectile through access ports but internal access is possible with low cost disposable components. Projectile dimensions can vary with diameters ranging from 2 inches to 8 inches and lengths ranging from 3 inches to 35 inches. The projectile flies down the centerline of the chamber and it is desirable to have a minimum of 48-inch view field.

PHASE I: Develop a prototype system with the Projectile Position, Angle of Attack, and Velocity capability and a detection field of 24 inches.

PHASE II: Develop and demonstrate a complete prototype system with a minimum of 48 inches detection field that can be integrated together to give a complete flight history of a projectile.

DUAL USE COMMERCIALIZATION: The system can find several DoD applications including ballistic testing of artillery shells especially post fire guidance systems for smart munitions. In-flight assessment is important to determine the effectiveness of cross range control systems. High speed imaging and analysis of industrial processes, e.g., high speed part manufacturing and part placement, is important to determine production line problems and to affect solutions in a timely manner.

REFERENCES: 1.Abbott, Fred; Burhardt, K.K., Waltz, F.M, "Inferential Physical Measurements Using Detectors and Detector Arrays," AD# ADD309376.

2.Roe, Ryong-Joon, Chang, J. C., Fishkis, M., Curro, J.J., "Adaptation of a Kratky Camera to use with a One-dimensional Position Sensitive Detector," AD# ADA087523.

3.Anderson, Chris, "Development of an All Electronic, Behind the Armor Debris Witness Panel," AD# ADA396721.

4.Denton, M.B., Bilhorn, R.B., Epperson, P.M. and Sweedler, J.V., "Recent Advances in Optical Spectroscopy Using High Performance Array Detectors," AD# ADA194219.

KEYWORDS: Position, Velocity, Pitch and Yaw, Angle of Attack, Hypervelocity Detection

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AF06-301 TITLE: Gas Turbine Particle Matter Emission Characterization

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a capability to measure gas turbine particle emission indices.

DESCRIPTION: The goal is to develop a fast, accurate capability for measurements of particle number density, size distribution and mass-based emission factors (indices) as an alternate to EPA Method 5 currently used by DoD for reporting turbine particulate matter (PM) emission rates. The DoD-JSF Environmental office, EPA, FAA and NASA have expressed this need to the SAE E31 Committee. Air bases, many in non-attainment areas, remain non-exempt from local air quality PM Regulations as upheld in courts, March 2002 [1]. Method 5 does not provide PM size (critical for health effect issues) and is costly requiring long engine run times. Aircraft-generated PM is composed of nonvolatile particles (soot) and volatile particles, including volatile condensed onto nonvolatile. PM techniques used in research for determining particle size, number, and mass require fundamental research before EPA and FAA will accept the viability of these PM techniques and associated sampling methodologies for regulatory compliance. Current instruments do not provide real-time data [2]. Differential mobility analyzers and CNCs are used to measure number densities and size distributions [3]. Assumptions for particle shape factors and mass density, used to convert these measurements to mass-based emission indices, add a large uncertainty to the mass based emission indices thus determined. Fundamental research is required to experimentally determine these shape factors and particle mass densities as a function of combustion aerosol size for aircraft engine emissions to thus define and possibly eliminate these uncertainties. Measurements in the laboratory and on a variety of engines are required to establish correlations for shape factor and mass density to engine type and engine operating conditions. Ultimately, a fast technique (~1 Hz per 10-1000 nm dia. scan) is required for measuring accurate number densities, size distributions and mass based emission factors as a function of engine type and operating condition for engines in a variety of test environments to provide a sound, accurate basis for DOD to report PM emission rates to the regulatory authorities.

PHASE I: Demonstrate the feasibility of resolving measurement system particle density and particle shape factor effects.

PHASE II: Develop a prototype measurement system for particle emission indices in a turbine engine exhaust.

DUAL USE COMMERCIALIZATION: Military and commercial applications include applying these techniques to a range of engine types to demonstrate the viability as a regulatory technique.
Commercially, these particle measurements in combustion systems or smoke stacks are required by military and civil aircraft, land-based power turbines, trucks, locomotives, automobiles and gas-fired power plants for regulation and development of control technologies that mitigate or inhibit particle formation.

REFERENCES: 1.Office of Air Quality Planning & Standards, “Draft Staff Paper for Particulate Matter Fact Sheet,” Environmental Protection Agency, Washington DC, August 2003. http://www.epa.gov/ttn/oarpg/t1/fact_sheets/pmfdsp_fs.pdf

2.SAE E31 Committee, “Nonvolatile Exhaust Particle Measurement Techniques,” SAE E31 AIR5892 Committee Aerospace Information Report.

3.Schmid, Otmar, Hagen, Donald, Whitefield, Philip, Trueblood, Max, Rutter, Andrew, and Lilenfeld, H., “Methodology for Particle Characterization in the Exhaust Flows of Gas Turbine Engines,” Aerosol Science & Technology Volume 38, Number 11 / November 2004, pages 1108 – 1122.

KEYWORDS: Gas Turbine, Particle Number, Size, Mass, Volatile, Nonvolatile

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AF06-302 TITLE: Volatile Particle Condensing Chamber for Turbine Engine Emissions

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a controlled environment reaction chamber for the formation of volatile particles.

DESCRIPTION: The goal is to develop an environmental reaction chamber and validate parametric influences of sampling geometry, temperature, pressure, humidity and air mixing on volatile particle generation and properties. The DoD is not exempt from local air standards and must report aircraft particulate matter (PM) emission rates. Health and environmental impacts of volatile particle emissions depend on size, number, mass and species. Aircraft-generated PM is composed of nonvolatile particles (soot) that exist at engine exit plane conditions and volatile particles that form downstream from the condensable gases (also volatile condensed onto nonvolatile) as the exhaust mixes and cools. The current EPA Method 5 used by DoD for reporting PM emission factors is applied far downstream of the engine exit plane and does not measure the PM size and number. For a viable regulatory compliance method, direct measurement of volatile PM must be independent of ambient environment conditions. This can only be achieved through a controlled simulated standard day environment that requires development of an emissions sampling system capable of delivering volatile particles to measurement instrumentation from a hot exhaust sample. A turbine engine exhaust exit plane sampling system with a controlled environment reaction chamber must be designed that would allow the condensable species to transition to the condensed phase in a manner that could be related to what happens when the exhaust is emitted into the atmosphere. The investigator must be evaluate and validate parametric influences of sampling geometry, temperature, pressure, humidity and air mixing on volatile particle generation and properties, and define or propose a "standard-day" condition.

PHASE I: Determine the feasibility of a controlled environment reaction chamber for volatile particle formation and particle characterization.

PHASE II: Development and validate a prototype system in a relevant turbine exhaust environment.

DUAL USE COMMERCIALIZATION: Military and commercial applications include applying the controlled environment chamber sampling system to a variety of engine types and work with the SAE E31 committee to develop an accepted recommended practice (ARP) for volatile particle indices measurements. Commercially, measurements of particles emitted from gas turbine combustion systems and/or smoke stacks are required for military and civil aircraft, and have potential for land-based power turbines, trucks, locomotives, automobiles and gas-fired power plants for regulation and development of control technologies that mitigate or inhibit particle formation.

REFERENCES: 1.Office of Air Quality Planning & Standards, "Draft Staff Paper for Particulate Matter Fact Sheet," Environmental Protection Agency, Washington DC, August 2003. http://www.epa.gov/ttn/oarpg/t1/fact_sheets/pmfdsp_fs.pdf

2.SAE E31 Committee, "Nonvolatile Exhaust Particle Measurement Techniques," SAE E31 AIR5892 Committee Aerospace Information Report.

3.Schmid, Otmar, Hagen, Donald, Whitefield, Philip, Trueblood, Max, Rutter, Andrew, and Lilenfeld, H., "Methodology for Particle Characterization in the Exhaust Flows of Gas Turbine Engines," Aerosol Science & Technology Volume 38, Number 11 / November 2004, pages 1108 - 1122.

4. Andersen, W.C., "Research Needs Related to Improving Air Emissions from Diesel Engines, Gas Turbines and Ordnance," American Academy of Environmental Engineers, Annapolis MD, 1999, http://www.aaee.net/newlook/air_quality_issues.htm.

KEYWORDS: Volatile Particles, Gas Turbine Exhaust, Particle Matter, Combustor

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AF06-303 TITLE: <u>Telemetry for Testing Applications</u>

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop wireless capabilities that will enable testing and engine health monitoring.

DESCRIPTION: Solutions are sought for the multi-channel turbine engine telemetry and wind tunnel applications. The requirements and specifications for wireless transmission (i.e. telemetry) sensor information for a turbine engine or components testing for sea level, simulated altitude flight conditions have been identified by the Propulsion Instrumentation Working Group (PIWG). The ultimate turbine engine goal is to provide enough channels for up to 100 dynamic strain and 100 temperature channels simultaneously with constraints on size of an 1/8 cubic inch volume and weight of less than 15 grams for any multi-channel module. Current technologies can not operate uncooled in the environment where temperatures range from -55°F to +400°F minimum (+500°F desired) and G-loads of up to 100,000 Gs. The high temperature requirement may exceed the current silicon based technologies for analog and digital IC's which are generally limited to less than 350°F. Wind tunnel testing requires the monitoring of similarly large numbers of channels of temperature, pressure, strain, and heat flux in similar adverse environments, but generally at lower g-levels. High total temperature wind tunnels, generally below the 300 °F limit, require the measurement of many steady state parameters simultaneously. Digital, PCM/FM telemetry electronics has been the methodology of choice for turbine engine testing, but other approaches will be considered such as passive, RF powered transponders. Transponders could play a useful role in both development testing for turbine engines and wind tunnel models. Individual module programmability is required with minimum functions to include calibration, excitation and module on-off. Remote control of functions such as gain and carrier frequency is desired, if applicable. An operating life of > 1000 hours (90% survivability) at simultaneous maximum temperature and G-loads is desired.

PHASE I: Develop at least one module and demonstrate the feasibility to transmit and receive sensor data in high speed rotating machinery in near-real time.

PHASE II: Develop and demonstrate a prototype in a testing environment with successful long term operation at simultaneous maximum G load and maximum temperature conditions.

DUAL USE COMMERCIALIZATION: Military applications include packaging and applying prototype telemetry systems to long-term turbine engine or similar test programs in cooperation with asset owner organizations.
Commercially, the telemetry technology would be useful to process control and health monitoring for rotating machinery in power plants. For commercial jet engine, telemetry sensors will make engine health management and feed-back control system more practical.

REFERENCES: 1.Propulsion Instrumentation Working Group, February 1, 2005, http://www.piwg.org/PDF/Telemetry.pdf

2.Lisa Fakhry, ED Online ID #3627, May 26, 2003, http://www.elecdesign.com/Articles/ArticleID/3627/3627.html

3.Anderson, Robert, Atkinson, William , and Bonsett, Tom, "To Speak with One Voice:The Propulsion Instrumentation Working Group," Sensors Online, June 1997,http://www.sensorsmag.com/articles/0697/jet_eng/main.shtml

KEYWORDS: engine health monitoring, wireless communication

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AF06-306 TITLE: Optical /Technology for Cryo-Vacuum Mirrors

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a technology for high quality cryo-vacuum optical mirrors.

DESCRIPTION: Research and develop cryo-vacuum reflective optics materials for optical components such as mirrors, both convex and flat. . The distortion caused by thermal mismatches must be kept to a minimum so that the scene projected to the sensor under test simulates a real target complex. The materials used in cryo-vacuum optical testing of space surveillance and seeker systems must hold their surface figure (0.071of a wave @ 632.8 nanometers) even when mounted to an aluminum optical bench. One might consider innovative mounting methods to compensate for material thermal mismatch of the mirror and aluminum bench. The coating must be durable and have a high reflectivity throughout the infrared (2-20 microns). A 30" diameter mirror and mount is required with a performance equal or better than aluminum at cryogenic (~20 Kelvin) conditions with a reflectivity greater than 90% in the MWIR and LWIR. There are limitations (cost, surface roughness, coatings, etc) in the fabrication of the typically used aluminum mirrors that could be overcome with alternate materials if their performance can be proven at cryogenic conditions. Development of such materials and associated mounting concepts is the object of this topic.

PHASE I: Development and demonstrate a proof of concept for cryo-vacuum mirror material.

PHASE II: Develop and demonstrate a prototype mirror at cryo-vacuum conditions.

DUAL USE COMMERCIALIZATION: Potential military applications include applying the technology to space facility components.
PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercially, advanced systems such as space telescopes and satellites require cryo-rated mirrors for earth imaging in agricultural, environmental and other commercial applications.

REFERENCES: 1.TREX Enterprises, "CVC SiC for Advanced Optical Systems," March 8, 2005, http://optics.nasa.gov/tech_days/tech_days_2003/docs/39TrexCVCSiC.pdf .

2.McCandliss, Stephan R., France, Kevin, Feldman, Paul and Pelton, Russ, "Long-slit Imaging Dual Order Spectrograph – LIDOS", Johns Hopkins University, www.pha.jhu.edu/~stephan/ SPIEpapers/SPIE2002-4854-09/haw2002.pdf

3.Marx, Bridget, "Porous Silicon Layers Form Broadband Mirrors," Laser Focus World, July 2004.

KEYWORDS: wavefront error, space simulation, cryogenic optics materials, thermal expansion

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AF06-311 TITLE: Directed Energy Targets with Un-hardened Electronics

TECHNOLOGY AREAS: Air Platform

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop communication and telemetry capability, so that functionality endures high levels of directed energy.

DESCRIPTION: Directed energy weapon testing requires instrumented targets with continuous radio link between the target and ground stations. This may be simple monitoring of the weapon and target via real time telemetry, which allows safety monitoring, collection of test point data, and forensic operations in case of catastrophe. With mobile targets, the radio link may also operate in the reverse direction to command various operations, including commanding flight termination in the interest of safety.

The lethality mechanisms of directed energy weapons differ from kinetic energy weapons in that the effects are progressive and can vary from temporarily disabling to catastrophic failure of systems without airframe damage. During testing of lasers and radio frequency emitters, incident radiation can cause disruption of the telemetry radio signal or hardware function, manifested as momentary dropouts of telemetry to permanent loss of vehicle command and control. The Air Force Flight Test Center needs techniques to mitigate these disruptions, to provide full testing capabilities and to provide acceptable safety margins.

The contractor must apply expertise to understand physical phenomena and investigate different techniques to control adverse affects of incident high energy during testing. This work will focus on ways to retrieve data lost during an event and ensuring post-event data following the irradiation by high-powered radiation. The proposal should assume telemetry interrupt during the actual event regardless of damage sustained by the host vehicle.

The challenge is to understand any communication implications of material damage such as antenna pattern and radiation efficiency changes due to material property changes, which may include charring of composite materials. The myopic idea of "hardening" by shielding of the electronics and materials will only postpone the problem, because the intent of weapons developers is to overcome these efforts used by an enemy. In a test environment, we need to assume that the weapon can appropriately attack the system under test. Given that denial, degradation, damage, or destruction will occur and adversely affect the engineered communication systems, mitigating communication protocols, protections, or procedures.

Cooperative techniques that work in a controlled test environment are needed to ensure safety and collection of test data and to provide telemetry of a minimal set of test parameters for a few seconds (e.g., 30 seconds up to the remaining flight duration) during and following a test event.

PHASE I: Research communication, telemetry, and flight termination systems for immunity to DEL and HPM irradiation. Determine the source of the immunity and how to integrate it on existing test profiles and platforms. Report beneficial qualities of each design and describe a system combining them.

PHASE II: Develop a prototype system and apply it to a target vehicle. Demonstrate proper operation in test representative scenarios. The design must provide a minimal data set during and after a flight vehicle is exposed to radiation (or surrogate radiation) that affects vehicle systems. Demonstrate the option of terminating or not terminating the flight depending on a flight vehicle's behavior.

DUAL USE COMMERCIALIZATION: Produce a hardware, software, and techniques package that can be integrated into Air Force and DOD test facilities as well as government and contractor laboratories. Manufacturers and researchers of commercial relay blimps, UAVs, and missiles will need this capability when designing vehicles that will be exposed to hostile conditions.

REFERENCES: 1. "Flight demonstration of flight termination system and solid rocket motor ignition using semiconductor laser initiated ordnance", N. Schulze& B. Maxfield, AIAA Paper 95-2980, AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 31st, San Diego, CA, July 10-12, 1995.

2. SecDEF CTEIP Directed Energy Test & Evaluation Capabilities (DETEC) study, shortfalls 1.10.5, 1.14B, 1.14C. Mr. Brad King, Technical Project Manager, 505.678.7545, kingb@wsmr.army.mil. Associated CTEIP DETEC shortfall solicitations, Spring 2005.

KEYWORDS: Directed Energy, Flight Test Safety, High Power Microwave, High Energy Laser

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AF06-312 TITLE: Threshold-capable Multi-wavelength High Energy laser Protection

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop a design to provide clustered area protection from high energy lasers.

DESCRIPTION: People, test targets, and analytical test equipment need to be protected from direct exposure to high energy laser irradiation.

Technology exists to protect from fast on-set broadband flash damage, as demonstrated by polarized lanthanum titanium zirconium (PLTZ) goggles for nuclear detonations. The Air Force Flight Test Center needs a protection capability that will react to dangerous laser intensity and provide area protection such as inside a cockpit, or instrumentation cluster on a test range.

Technical challenges will be responding to multiple narrow-band energy sources and threshold the protection such that low levels of radiation are not affected, but when beyond programmable limits, shielding capable of absorbing incident radiation is enacted.

Equipment needs to selectively eliminate the damaging wavelength(s), while leaving other spectral information and intensity minimally affected. Designs suitable for stationary implementation and airborne platforms are needed.

PHASE I: Investigate methods to provide the capability of blocking laser intensity. Report on expected response times, threshold capability, and energy absorption.

PHASE II: Show the capability to block high levels of laser light while not affecting human-safe instrumentation-intensity transmissions. Develop a prototype system and apply it to a flight platform in a test representative scenario.

DUAL USE COMMERCIALIZATION: In addition to Air Force needs, the other military services will benefit; such as the Army in the battlefield. In the private sector, commercial airlines will be interested in the protection afforded to their pilots while civilian peace officers will be interested in this capability as hand-held lasers become a threat to their efforts.

REFERENCES: 1. “Laser Event Recording Complete Initial Outdoor Testing,” Jerri Ann Tribble, Craig Schwarze, Norm Barsalou, Rich Folga, James Sheehy; SUSNAP Science & Technology, Society of Naval Aerospace Physiologists, Vol IV, Issue 2, October 2003.
http:/www.susnap.org

2. “Laser injures Delta Pilot’s Eyes,” Bill Gertz, Washington Times Nation/Politics, 29 Sept 2004.

3. Nuclear Lash PLTZ Goggles. http:/www.fb-111a.net/goggles.html.

4. Airborne target board typical of the types needing protection.
http:/www.de.afrl.af.mil/News/2004/04-20.html

KEYWORDS: Directed Energy, Flight Test Safety, High Power Microwave, High Energy Laser

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AF06-313 TITLE: Optimization of Parameter Identification for Flutter and Flying Qualities

TECHNOLOGY AREAS: Air Platform

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Improve the speed, reliability, and accuracy of parameter identification algorithms used for flutter and flying qualities flight testing.

DESCRIPTION: A significant portion of the flight testing that must be accomplished in order to certify a new aircraft is dedicated to flutter testing and flying qualities testing. The objective of flutter testing is to assure that the aircraft is aeroelastically stable within the operational envelope of the aircraft. The purpose of flying qualities testing is to assure that the aircraft is controllable within the operational envelope of the aircraft.

Flutter testing and flying qualities testing differ significantly in terms of frequencies of interest, open versus closed loop stability, and frequency-damping versus phase-magnitude. However, both disciplines are fundamentally trying to identify the transfer functions that best describe the aeroelastic stability and flying qualities of the aircraft at various flight conditions.

Currently it takes several minutes worth of flight test data to identify one of these transfer functions for one flight condition. With the right combination of pre-processing, modern parameter identification algorithms, and flight test techniques the time should be reduced to 5 seconds or less, which would dramatically reduce the time and cost required to clear the aircraft envelope, and subsequently certify the aircraft.

In order to realize this potential gain in efficiency, fundamental development of the pre-processing techniques and parameter identification algorithms must be addressed. Specifically, the algorithms must be made robust enough to tolerate the low signal to noise ratio inherent in flight test data and adequate data resolution given the limited bandwidth available for telemetry of flight test data.

Although this advanced research will build on existing parameter identification technology, preparing them to be utilized in an open air flight test environment will require a significant development. Ultimately, the results of this research will not only benefit the military and commercial aviation, but also other fields that rely on parameter identification, like the automotive, music, voice recognition, and rotating machinery industries.

PHASE I: Identify time and frequency domain parameter identification algorithms that tolerate low signal to noise ratio and identify parameters with very limited data sets. Identify developmental pathways that lead to a robust parameter identification tool for flutter and flying qualities flight testing.

PHASE II: Using the results from Phase I, develop a robust parameter identification tool and displays prototype to be utilized for flutter and flying qualities flight testing.

DUAL USE COMMERCIALIZATION: Commercial and military aviation will benefit from this research since both segments of the aircraft industry are equally affected by instabilities that effect the elastic structure and the rigid body motion of the aircraft. In addition there are many industries that rely on parameter identification that could also benefit from this research. For example, the automotive, music, voice recognition, and rotating machinery industries could benefit.

REFERENCES: 1. Edward N Bachelder, Peter M. Thompson, Chuck Harris, “System Identification Methods for Improving Flutter Flight Test Techniques.” AIAA Atmospheric Mechanics Conference, 16-19 August 2004, Providence, RI

2. Rick Lind, Marty Brenner, Flight Test Evaluation of Flutter Prediction Methods, American Institute of Aeronautics and Astronautics, 2002, AIAA-2002-1649

KEYWORDS: Parameter Identification, System Identification, Data Analysis

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AF06-314 TITLE: Aeroservoelastic Predictive Analysis Capability

TECHNOLOGY AREAS: Air Platform

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Improve the reliability and accuracy of aircraft simulations where fluid, structure, and control system interactions are of prime concern.

DESCRIPTION: High gain control systems are often utilized to make modern military aircraft more responsive. The downside to utilizing high gains is they can easily interact adversely with structural modes to create instabilities. In addition, nonlinearities in the aerodynamics, actuators, and the structure can interact with the control system in unintended ways resulting in instabilities or unacceptable flying qualities.

Currently test and evaluation of these systems rely heavily on wind tunnel tests, instrumented ground tests, and open air flight tests to discover and resolve these kinds of aeroservoelastic issues. This approach is neither efficient nor safe. Computational and predictive tools do not exist to adequately simulate the subtle interactions that exist between a flexible aircraft, flow fields, and modern flight control systems.

Coupled field technology already exists that is capable of accurately representing the aerodynamics (using Computational Fluid Dynamics (CFD)) and the elastic structure (using non-linear Finite Elements). The missing capability that needs to be implemented is the control system including the flight controller, control actuators, control surface motion, sensors, and their interaction with the aerodynamic flow field and elastic structure.

Although many of these technologies exist individually, incorporating them into a coupled field framework that is capable of producing predictive aeroservoelastic analysis will require advanced development of the requisite algorithms in order to assure that the order of accuracy for the overall simulation is not lost during message passing between the fluid dynamics, the structural dynamics, and the control dynamics that must take place in order to capture the interaction between these three disciplines. Ultimately this predictive analysis capability can be exploited to predict aeroelastic instabilities, aerodynamic characteristics, performance and flying qualities and help establish the safety boundary prior to open air flight tests. It should also significantly reduce the flight test time required to certify new military and commercial aircraft.

PHASE I: Identify a means for modeling control systems, sensors, and actuators and for implementing them in a fluid structure interaction coupled field analysis software code. To reduce the risks with emulating a flight control computer in software, explore including a hardware in the loop simulation.

PHASE II: Modeling technologies addressed in Phase I will be incorporated into an coupled field analysis code. 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 early supersonic flight regimes, and is capable of handling moving control surfaces.

DUAL USE COMMERCIALIZATION: Commercial and military aviation will benefit form this research since both segments of the aircraft industry rely on fly-by-wire control systems, and are affected by interactions between the aerodynamics, structural dynamics, and control system dynamics. In addition there is a great potential for use in any field where unsteady active control systems are used in an aerodynamic system. One example of this is wind turbine dynamics.

REFERENCES: 1. Mark Balas, “Modal Control of Certain Flexible Dynamic Systems”, SIAM J. Control Optim., 16 (1978).

2. B. Koobus and C. Farhat, “Time-Accurate Schemes for Computing Two and Three-Dimensional Viscous Fluxes on Unstructured Dynamic Meshes” AIAA Paper 96-2384, 14th AIAA Applied Aerodynamics Conference, New Orleans, Louisiana, June 18-20 (1996).

KEYWORDS: Coupled Field Analysis, Fluid Structure Interaction, Aeroelasticity, Aeroservoelasticity, Flight Control System.

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AF06-316 TITLE: Noncoherent Telemetry Demodulator

TECHNOLOGY AREAS: 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a noncoherent telemetry demodulator for Advanced Range Telemetry Tier I and Tier II waveforms.

DESCRIPTION: Telemetry of data from an air vehicle to ground stations is required in many test and training missions. The test and training communities have seen a 20 fold increase in the telemetry data rates over the past 10 years. At the same time, a reduction in available spectrum has been caused by the auctioning of government only telemetry spectrum. This combination has impacted test and training cost and schedule of major weapons system programs. Capabilities are needed to increase the efficiency and quality of aeronautical telemetry systems.

One approach to increasing spectrum usage efficiency is to decrease the amount of spectrum test missions require. The Advanced Range Telemetry (ARTM) program's main focus was just that, find more spectrally efficient modulations schemes to carry the information from test assets to receive station. This lead to the development, testing, and fielding of two modulation schemes referred to as ARTM Tier I and Tier II. Both of these schemes carry the information in the phase of the carrier. Currently, the only demodulators available on the open market for purchase are coherent demodulators.

Though these demodulators function well, it is thought certain gains can be achieved if a noncoherent demodulator can be realized. One aspect that may be improved upon is resynchronization time. Depending upon the usage, one potential drawback to the ARTM Tier II waveform is the resynchronization time of the demodulator. Since initial carrier phase does not need to be known, the demodulator can resynchronize in a shorter amount of time. It is recognized that this resynchronization scheme does not come without a price. The optimal noncoherent detector can not operate equally with the coherent detector in terms of bit energy to noise density ratio (Eb/No).

To be endorsed and useful to the telemetry community, the hardware demodulator resynchronization time should be cut in half with no greater than a 2dB degradation in Eb/No performance for both Tiers of waveforms when compared to existing Tier I and Tier II demodulators. Performance should be judged in terms of Eb/No performance and resynchronization after a flat fade.

PHASE I: Perform a literature search and propose several demodulator schemes for both the ARTM Tier I and Tier II waveform. Simulate the performance of each proposed demodulator with a software tool such as MatLab. Based upon the simulated results, propose a design for both waveforms.

PHASE II: Improve and finalize the demodulator design. Build a prototype demodulator for both waveforms with a target size of 1 rack unit (1U). Test the demodulator to validate simulated results. Testing of the new demodulator will occur at both the manufacturers test facility and the ARTM Telemetry Lab located at Edwards AFB with support coming from the Telemetry Lab at Pt. Mugu.

DUAL USE COMMERCIALIZATION: Commercial aircraft and both racing and commercial automotive industries could potentially use this technology. Similarly this could be used for other fields that are starting to use telemetry for testing or ongoing monitoring.

REFERENCES: 1. Telemetry Group, Range Commanders Council, IRIG Standard 106-04, Telemetry Standards, Secretariat, Range Commanders Council, U.S. Army White Sands Missile Range, NM, (2003).

KEYWORDS: Demodulator, ARTM, Tier I, Tier II, Telemetry

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AF06-317 TITLE: Automated Analysis of Datalink Transmissions (AADT)

TECHNOLOGY AREAS: Information 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Investigate the feasibility of developing a PC-based automated datalink analysis tool to evaluate military radio transmissions during developmental testing.

DESCRIPTION: Datalink transmissions are currently verified by manually comparing input signals with output signals. This is time consuming and limits the amount of analysis which can be done on any given test, and allows for human error to be a factor in datalink transmission analysis. Future tests which include the Wideband Network Waveform (WNW), which is expected to be much more complex than any currently fielded waveforms, and legacy waveform tests which coordinate multiple simultaneous signal sources, will significantly tax our manual datalink analysis capabilities. Networks with large numbers of nodes will become a common feature of future "network-centric" battlefields; the technology does not exist now to fully examine these networks.

Research into automated analysis of datalink transmissions has been primarily directed towards practical TCP/IP networking technology and point-to-point (p2p) data transfer. There is no current tool for detailed analysis of the data that passes through data links and networks as it pertains to military and advanced commercial software-defined radio (SDR) transmissions.

With a properly designed automated tool, the data collected from a test can be analyzed and evaluated far more quickly and accurately than if the data must be manually analyzed. An automated system for data validation would reduce man-hours required per test point; tests will become possible which include more test points than currently feasible to evaluate.

PHASE I: Develop a PC software tool to automate analysis of arbitrary waveform transmissions across tactical datalinks and networks. Investigate methods for examining multiple simultaneous transmissions. Propose a network structure visualization interface and means to track degraded network performance.

PHASE II: Develop and demonstrate a prototype solution demonstrating the system design and potential user interfaces proposed in Phase I. The system should be usable for an arbitrary waveform and for multiple simultaneous transmissions, and should be able to be integrated with existing range equipment. Develop and implement a dual application commercialization plan for military and civilian use.

DUAL USE COMMERCIALIZATION: The technology developed by this effort will be usable in commercial network development and loads testing as well as DOD defense system testing. Potential customers include broadband internet providers, cellular phone companies, and other organizations for whom quality of information transfer is important.

REFERENCES: 1. Joint Tactical Radio System Impact.doc, JTRS ORD JROC Approved (11Mar03).doc,

2. JTRS Program Schedule, Migration Plan v6.0, Waveform Schedule,

3. WNW FDD, 2003-06-17_ASD_NII_Spectrum, (all of these documents are available at http://jtrs.army.mil)

KEYWORDS: Joint Tactical Radio System (JTRS), Wideband Network Waveform (WNW), Test Tools, Automated Datalink Analysis

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AF06-318 TITLE: Identification and Tracking of Juvenile Desert Tortoises

TECHNOLOGY AREAS: Battlespace

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop identification and tracking technology to gather field data on the migratory paths of juvenile desert tortoises in solid rocket motor plume outwash areas.

DESCRIPTION: The Precision Impact Range Area (PIRA) at Edwards Air Force Base accounts for 60,800 acres of designated critical habitat of the desert tortoise of the total 93,000 acres that is used to support testing of new and existing aircraft and weapons delivery systems. Based on the federal listing of the desert tortoise and designation of critical habitat, protection measures are required for most of Edwards AFB operations and routine activities. Test facilities located here are valued in the tens of billions of dollars and cannot be operated if the desert tortoises are present.

Little information is available on desert tortoise movements during the transition from juvenile to adult due to the inability to track their movements as they mature. There is no means available to effectively locate, track, and identify individual juvenile desert tortoises in the field in their natural habitat. This effort will address the identification and tracking of individual juvenile desert tortoises in their natural habitat to ensure no tortoises are in an active test area such as the PIRA.

The proposed technology may be passive (such as a harmonic transponder) or battery operated. However, size and battery life are limiting factors. The units must be small and not constrain the growth or behavior of the study animals. The units must individualize each study animal, or there must be a complimentary technology that will allow each animal to be individualized. The units must allow location of the animals in the field and, if feasible, record movements in an electronic format that will allow analysis of patterns between and among animals for a prolonged period of time. The system cannot rely on grid transmitters or receivers and must be appropriate for use in federally designated critical habitat.

PHASE I: Develop a conceptual design of the key component technologies and provide a detailed analysis of the predicted performance to include simulation of a prototype device. Determine the technical feasibility of the prototype device and provide a plan for practical field deployment.

PHASE II: Based on the Phase I results, a working, scaled-up prototype system will be designed, built and tested in the laboratory utilizing mock-up juvenile desert tortoises. At no time will actual juvenile desert tortoises be utilized during this Phase II effort. Field trials may be performed on Edwards AFB to exhibit sensitivity and tracking capabilities of the system.

DUAL USE COMMERCIALIZATION POTENTIAL: From the development of a working prototype in Phase II, key information will be derived about the performance of the system and how to modify it to achieve the most cost efficient means to identify and track juvenile desert tortoises in their natural habitat. This will provide not only Edwards AFB, but other DOD installations the tools to better understand the life history of juvenile desert tortoises to lessen the controls and restrictions due to its listing and critical habitat designation. This technology will also have applications in tracking other endangered or threatened animals, such as the Arroyo Toad and Mohave Ground Squirrel, with minimal interference. The technology could be adapted for tracking of soldiers in battle scenarios.

REFERENCES:

1. Boarman, William I.; Goodlett, Tracey; Goodlett, Glenn; Hamilton, Paul. Review of Radio Transmitter Attachment Techniques for Turtle Research and Recommendations for Improvement. 1998, Herpetological Review 29(1).

2. Boarman, William I. Threats to Desert Tortoise Populations: A Critical Review of the Literature. 2 Aug. 2002, U.S. Geological Survey, Western Ecological Research Center. Paper prepared for West Mojave Planning Team Bureau of Land Management.

3. Gutierrez, Eddie; et al. Final Report: Identifying Desert Tortoise Burrows with Ground Penetrating Radar. June 1995, Defense Evaluations Support Activity Kirtland Air Force Base, New Mexico.

KEYWORDS: Desert Tortoise, Critical Habitat, Federally Threatened Species

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AF06-320 TITLE: Ground Loads Predictive Analysis

TECHNOLOGY AREAS: Air Platform

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Expedite ground loads testing by developing reliable and accurate predictive ground loads analysis tools.

DESCRIPTION: To certify military aircraft it is necessary to test the landing gear to ensure that it will not collapse under normal operational conditions. Currently, predicted loads for these tests are accurate only at low speed taxi conditions; at higher speed taxi conditions, as aerodynamic effects become dominant, the predicted loads become undependable.

Dominating factors in high speed taxi tests include; landing gear dynamics, runway conditions, wind direction and strength, aircraft structural dynamics, and aerodynamics. A comprehensive analysis requires not only consideration of the aeroelastic effects but also must include the gear dynamics, ground effects, runway condition, wind strength and direction, and the forced displacement that drives the landing gear. Developing an analysis capability that includes all of these effects and that produces reliable results will require a significant research effort.

There are several coupled field analysis codes available that use computational Fluid Dynamics (CFD) to solve the aerodynamics and Finite Element Method (FEM) to solve the structural dynamics. Some of these codes do an excellent job of predicting aeroelastic phenomenon. This research should build on that existing technology and develop and incorporate new technology needed to represent the non-linear gear dynamics, runway conditions, wind direction and strength, and the ground effects.

A serious development effort is required to develop these technologies and incorporate them without compromising the order of accuracy of the underlying aeroelastic analysis code.

PHASE I: Define the optimal representation for nonlinear landing gear dynamics with time dependent forced displacements. Identify pathways for implementing this technology with an aeroelastic analysis code that include ground effects. Demonstrate the benefits and technical implementation approach.

PHASE II: Using the results of Phase I, the modeling technologies developed in Phase I will be integrated into an aeroelastic analysis code. Development should focus on an available CFD-based aeroelastic code that has been validated for a complete aircraft configuration.

PHASE III DUAL USE APPLICATIONS: Commercial and military aviation will benefit from this technology since both are equally influenced by loads induced through ground operations. In addition to commercial and military aviation the automotive and racing industries will benefit, and other industries like turbo machinery could benefit.

REFERENCES:

1. E.Mirra, L.De Francesco Alenia, "Description and Validation of Dynamic Model for Loads Analysis", G-TNOT-120/000-0300-0001-AL Issue 1, 15/09/2000.

2. FAR Part 25 "Airworthiness Standards: Transport Category Airplanes"

KEYWORDS: Coupled Field Analysis, Fluid Structure Interaction, ground loads, ground effects, landing gear dynamics

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AF06-325 TITLE: Automation of Analysis of Digital X-Ray Images

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop automation of the analysis of digital X-ray images to reduce labor and interpretation errors in the evaluation of aircraft wear patterns, cracks, corrosion trending and growth, and other system/material damages affecting safety of flight.

DESCRIPTION: Aircraft are cycled through depot-level repairs at planned intervals of years, typically five or greater. This repetitive inspect/repair activity gives the opportunity to perform "as required" repair, monitor trends, and better apply available repair dollars to higher priority needs. Improved capability to analysis and rapidly, accurately, and inexpensively compare information is needed to enable the evolution of these processes in the aerospace industry.

The objective of this topic is to perform research in the development of a technology that can be applied to automate the quantitative analysis of digital x-rays to determine damage area, extent of damage and change characteristics of the damage state. Develop an automated method and computer algorithms for analysis and visual display with dimensionally accurate position that can determine dynamic changes to decision-making characteristics of the digital images. This includes but is not limited to gray scale, size, location, shading, edge definition or other defined points on stored images. Proposed capability of system shall be specified and include methods for upgrading as digital x-ray thresholds of detection improve over time.

The automated system shall significantly reduce the time for comparison of digital x-rays images of same specific aircraft locations from different time periods. Techniques for risk to safety of flight and to cost of ownership shall be developed as part of the analysis capability. Computer aid of repair decision planning, such as repair now, delay and monitor, or delay and reevaluate at next depot cycle, is an important objective of the system capability.

PHASE I: Provide a demonstration of an innovation concept to automate visual inspection of processed images to determine corrosion or other NDI damage criteria. Provide report of parameters required for going to Phase II for prototype development and benefits that could be realized.

PHASE II: Develop a prototype of system documented in Phase I and test the results in a depot shop that has a vast data base of images to process. Document results and report on findings.

DUAL USE COMMERCIALIZATION: Military application: Multiple applications in government and industry for analysis of NDI images exist to determine corrosion or other damages to critical parts.

REFERENCES: 1. http://nvo.gsfc.nasa.gov/nvo_datamining.html.

KEYWORDS: Data Mining, Image Processing, Digital Images

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AF06-326 TITLE: Environmentally Friendly Cleaning for Titanium Welds and Brazing

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an environmentally friendly cleaning for titanium welds and brazing of engine components that will eliminate chemicals or dry methods.

DESCRIPTION: Prior to the depot level repair and overhaul of Gas Turbine Engine components, a critical first step in welding or brazing operations is thorough cleaning to remove contaminants and products of oxidation and/or carbide build up from substrates such as titanium, Aluminum Alloy 6061, and stainless steel. A non-solvent, non-abrasive cleaning method is needed that will effectively clean components prior to welding or brazing without using or generating hazardous substances. Current methods include chemical (wet) processes using acid baths and mechanical (dry) processes using bead blast, grinding, or brushing. The acid baths use hydrofluoric acid and various pickling processes subject to EPA permits and OSHA protective gear and air handling requirements. The process generates a waste stream of spent acid and sludge requiring disposal. The dry method of surface cleaning also requires special protective handling gear and disposal of accumulated grinding material. Dry methods remove parent material in the process which leads to eventual part condemnation. Neither current process can thoroughly clean in a crack or between sandwiched layers of sheet metal, while both methods provide the possibility of contamination during cleaning.

A new technology that uses less or eliminates chemicals, produces less material disposal such as blast/abrasive materials, grinding wheels, and chemical tank sludge and used chemicals, reduces EPA compliance of permits, certificates, inspections, rework, air handling, and protective gear; improves the cleaning power of removing impurities even inside of cracks and between sheet metal layers, and hand-held operated by a worker while increasing the throughput is in line with the strategies of the various Depot Modernization Planning Documents.Clearly document approach and identify all technical parameters and how your approach addresses them. In the final report, document concept, metrics and benefits. A small demonstration of actual application would be suggested.

PHASE I: Research and develop an innovative approach in the development of a proof of concept of environmentally friendly cleaning process for titanium welds and other materials stated above.

PHASE II: Design and develop a prototype capability for applying a prototype production capability within a depot shop. Final report will document validated measured metrics and benefits.

DUAL USE COMMERCIALIZATION: Military application: Commercial applications would be applied to all OEM's with aging aircraft support, air industry with similar materials cleaning requirements and contract repair facilities.

REFERENCES: 1. http://www.pw.utc.com/serv_sms_rem.asp.

2. www.ml.afrl.af.mil/stories/MLS/asc_03_2762.html

3. www.afrlhorizons.com/Briefs/Feb05/ML0331.html

KEYWORDS: Non Chemical Cleaning, Titanium weld cleaning, Thermionic Cleaning

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AF06-327 TITLE: <u>Dielectric Measuring Tool for Radome Checkout</u>

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Use of dielectric measuring tools to assess the intrinsic electromagnetic properties of radome structures during depot repair and maintenance.

DESCRIPTION: Electromagnetic properties are determined by the molecular structure of the radome dielectric material. Measuring the properties can improve repair capabilities and provide insight into all stages of radome lifecycle. Electromagnetic radiation patterns and transmission efficiencies cannot be detected visually. Dielectric measuring tools can be used to assess the effects of chemical and structural breakdown in radome material. Metal intrusions, resin rich and starved areas, delaminations between fabric plies, disbonds between core and fabric plies, thick coatings and contamination from fluids such as water, oil, and fuel can affect radome transmission efficiency and cause potential beam shifts and pattern distortions.

This research effort will investigate the use of dielectric measuring tools to verify separation in dielectric layers, test for breakdown through multi-layer laminate fabric plies and foam sandwich walls, identify good versus bad areas after a radome has been repaired and pinpoint areas that failed to meet electrical test requirements. Dielectric measuring capabilities must be compatible with current electrical test parameters and requirements and measure frequency specific dielectric constants, reflection, phase, and transmission efficiency.

PHASE I: Develop a concept demonstration of a dielectric measuring tool and perform preliminary investigations to determine defect identification capabilities. Identify dielectric specifications for the radome checkout application, design a test system that measures these parameters.

PHASE II: Implement a prototype production system for use in the depot composite repair shop. Final report will include benefits, production system requirements and test results.

DUAL USE COMMERCIALIZATION: Military application: This technology can be applied to military and commercial aircraft as well as radome manufacturing for both military and commercial industry.

REFERENCES:
1. //www.admc.aeat.co.uk/Background/Manufacturing/Manufacturing%20Issues%20MF/NDT_issues.shtml

KEYWORDS: Dielectric constants, transmission efficiency, repair area defects

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AF06-328 TITLE: Coating Application using Liquefied Powder

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a material and a process where powder can be liquefied and atomized as it comes out of a spray device, then dried instantly on contact with a substrate.

DESCRIPTION: In the current powder coating process, a positively charged powder is sprayed on a negatively charged substrate and is then subsequently cured in an oven at about 300 to 400 deg F. This process has limitations due to both oven size and potential impact to the mechanical properties of aircraft metallic substrates. Since surface heating will not be required for cure, the mechanical properties of a metallic substrate will not be impacted. Application to a non-metallic substrate would be desirable, but is not required.

Research the development of required material, process and spray gun design for selected metals where powder can be liquefied and atomized as it comes out of the spray device and can dry instantly on contact with a substrate. This technology would be used to coat an entire large airplane.

PHASE I: Research and identify one or more coating technology(s) that could be used for application to aircraft outer skin. Describe the material composition and details of the application process. Provide description and or demonstration of technology.

PHASE II: Develop a powder coating material to be used for this process and develop a spray device that will liquefy the powder as it comes out of the nozzle. Develop a testing protocol to test the integrity of this process using applicable standards. Perform two tests: a small size test application, and an actual test application of larger size, both under the observation of government representatives.

DUAL USE COMMERCIALIZATION: Military application: This technology when developed will be useful in commercial and military aviation worldwide and will be applicable to most aviation weapon systems currently in use.

REFERENCES: 1. //p2library.nfesc.navy.mil/P2_Opportunity_Handbook/4_5.html>

KEYWORDS: Cold spray powder coating, coating application, mechanical properties

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AF06-329 TITLE: Next Generation Supply Chain Management Practices, Processes and Systems

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Define and develop technologies for the next generation supply chain technologies which will enable the supply chain to support lean Maintenance, Repair and Overhaul operations.

DESCRIPTION: Traditional material resource planning (MRP) tools or enterprise resource planning (ERP) tools, including advance planning systems, are focused on manufacturing production systems. From a material resource (supply chain) planning perspective, aircraft maintenance, repair and overhaul (MRO) operations differ dramatically from traditional manufacturing operations. There is, in effect, no fixed bill of material and accompanying resource requirements which form the basis traditional MRP systems operations. This unique characteristic is generated from the fact that 20-60% of the repair and maintenance effort is discovered during the actual work after the initial inspection process (Boydstun et al., 2002). The result of applying traditional techniques is large with awaiting parts inventory levels, unrealistic production schedules, inflated time and cost estimates, inconsistent flow day performance, and low availability rates. These problems will continue to grow in the face a changing global readiness, requirements, extended use of today's weapon systems and the large number of lean transformations, focused on operations, in process throughout the Air Force MRO facilities.

Material forecasting and acquisition will rapidly become the most visible bottleneck to improving flow times and readiness. Forecasting systems must address seldom or infrequently occurring events. These enhanced forecasting processes will need to drive the material and capacity planning systems supporting a more effective material acquisition process. Innovative arrangements with suppliers enhancing responsiveness are required.

This effort should identify scalable processes which will link the elements of supply chain planning to form an effective tool set supporting rapid material acquisition in the face of work-in-process material requirements changes.

PHASE I: Define elements of the supply chain planning and acquisition process which are unique to an MRO environment. Define interrelationships and develop approaches to address the unique MRO requirements. Provide a concept description/demonstration of an integrated tool set for MRO acquisition process.

PHASE II: Develop an integrated tool set for use in managing the unique aspects of the acquisition process in an MRO environment and the associated scheduling systems. Prove the viability to the management of the supply chain planning using metrics set in Phase I. Prepare a detailed final report on the lessons learned and implementation procedures.

DUAL USE COMMERCIALIZATION: Military application: The integrated tool set would be useful in MRO operations for any large and complex systems requiring significant maintenance (Trains, Tanks, Ships, telecommunications). In the commercial segment, commercial aircraft, ships/boats and trains would present a similar opportunity for the application of this technology.

REFERENCES: 1. Boydstun, F., Graul M., Benjamin P., Painter M., New Perspectives Toward Modeling Depot MRO, Winter Simulation Conference, Dec 2002; http://www.informs-cs.org/wsc02papers/prog02.htm

KEYWORDS: Supply Chain, lean, advance planning, enterprise resource planning

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AF06-330 TITLE: Advanced MRO Multi-Echelon Planning and Scheduling

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Identification and integration of multi-echelon constraints in Manufacturing Repair Overhaul (MRO) process planning.

DESCRIPTION: In the case of an MRO environment that is highly constrained with respect to its operations and desired outcomes, constraints with respect to work, resources, deadlines, physical limitations exist at multiple echelons. These dimensions introduce yet another level of complexity with regards to constraint representation, capture, satisfaction, relaxation with respect to planning, re-planning, simulation and process design / analysis that the core MRO processes and support technology is focused on. The constraint representation, capture satisfaction, and constraint relaxation must account for the inherent multi-echelon nature of an MRO environment. In its essence the problem faced is that while repair actions are performed locally – process and resource awareness (in terms of availability and capability) across echelons requires technology that is global in its scope.

Multi-echelon based problems and solutions have traditionally been employed in the logistics domain, from the early 1980's work performed by Rand resulted in the development of several MRO level systems that were used to manage the echelons within the depot. These efforts were predicated upon the belief that depot MRO was similar to manufacturing environments to the extend that system concepts for planning and scheduling, in addition to top down management paradigms, were interchangeable.

The inherent multi-echelon nature of MRO organization and processes presents the constraint representation, capture, conflict detection and resolution with a new dimension. These constraint-centered technological developments must take into account the multi-echelon nature of MRO in order to be successful in correctly solving the MRO process improvement, planning and scheduling problems. As such, the multi-echelon paradigm used in the logistics and supply-chain domains to address the multi-echelon planning, analysis, scheduling, and dispatching issues at OC/ALC and other MRO organizations needs to be employed.

Previous efforts have addressed techniques for lean and efficient control of critical part procurement across multiple MRO shops. However, the uses of multi-echelon constraints in process planning have not been fully addressed.

Any approach to the MRO Multi-Echelon necessitates the need for appropriate constraint representation, capture satisfaction, constraint relaxation and the need to modify existing planning/scheduling/dispatching algorithms to support these techniques. The resulting technologies must be demonstrated within the context of the MRO environment in order to follow strategic (analytical) operational (estimating and planning) and tactical (dispatching) framework of world views.

PHASE I: Identify multi-echelon constrains at an AF depot aircraft MRO shop environment for resource planning and research the best process planning for that depot. Based on the results of the research performed, develop a concept demonstration and define metrics for assessing the program for Phase II.

PHASE II: Develop and demonstrate in a realistic shop environment. Conduct testing to prove feasibility of a full operational capability. Prove the viability to the management of the depot using the metrics set in Phase I. Prepare a detailed final report on the lessons learned and implementation procedures.

DUAL USE COMMERCIALIZATION: Military application: With minor modifications, the implemented solution could be utilized in any industry that involves diagnostic based systems architected within multiple echelons. The tool could be applied for any process improvement or re-engineering business process i.e. hospitals, diagnostic repair systems, city, state, national emergency response systems.

REFERENCES: 1. Sherbrooke, Craig "Optimal Inventory Modeling of Systems: Multi-Echelon Techniques," Kluwer Academic Publishers, May 2004.

2. Raymond Pyles, “The Dyna-METRIC Readiness Assessment Model,” a RAND corp. report for the U.S. Air Force, July 1984.

3. Beck, J C and Fox M S, "Mediated Conflict Recovery by Constraint Relaxation", Working Notes of AAAI Workshop on Conflict Management, Seattle, 1994.

KEYWORDS: Multi-echelon, planning, constraint representation, constraint relaxation, scheduling, MRO

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AF06-331 TITLE: Filtration of Used Non-destructive Testing Fluids

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop hazardous fluids filters for equipment utilized in nondestructive testing of aircraft parts and support equipment.

DESCRIPTION: During penetrant testing inspection of aircraft parts and support equipment, liquid penetrants are rinsed from the tested surfaces; waste is created that contains the dye residues and often, cleaners, testing components, and any other contaminants. Penetrant wastes are then either dispose off-site or treated locally to remove the dyes and oils. Either way, this process is expensive. A parallel problem is encountered when processing x-ray films used in nondestructive radiographic, and magnetic particle inspections.

Filters for each NDI process should be developed. Local nondestructive testing labs do not have the capability to filter these waste. The developed filters units should satisfy the identified requirements of the Air Force and as well as commercial industry.

PHASE I: Develop hazardous waste filters for use in penetrant, magnetic particle, and x-ray chemical film processing. Provide a concept demonstration of proposed device.

PHASE II: Develop prototype device for production ready use in an AF depot shop. Perform extended field or depot testing, and collect data and information on acceptance and expanding capability requirements.

DUAL USE COMMERCIALIZATION: Military application: With minor modifications, the proposed filters units could be utilized in any commercial airline industry that involved hazardous waste filters. Multiple applications of proven hazardous waste filters will apply to Air Force, other DoD branches and commercial airline use.

REFERENCES: 1. Nondestructive Testing Handbook 3rd Edition, Vol. 2, Liquid Penetrant Tests American Society for Nondestructive Testing.

2. Principles of Penetrants, Betz Carl E., Magnaflux Corp., Chicago, IL.

KEYWORDS: Non-Destructive Testing, Penetrant Testing, Radiographic Testing, Magnetic Particle, Filtration, Hazardous Waste

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AF06-332 TITLE: Use of Environmental Forensics for Trichloroethylene (TCE) Plume Delineation

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop and utilize a methodology for using Environmental Forensics to completely delineate a site.

DESCRIPTION: Major problems associated with remediating contaminated sites is the ability to determine where the plume is sourced, how many sources (multiple or single), age of plume, how is the TCE from one sample different from TCE in another sample, how far from the source has the contaminant plume has traveled, etc? The ability to determine these variables will enable successful and optimal remediation of TCE contaminant plumes resulting from unknown releases that occurred decades ago as is typical of most DoD Facilities. This includes tasks such as determining the time of contaminant release(s), determination of a single source or multiple source locations, direction of travel from the source(s), etc.Gather groundwater samples at a site contaminated with TCE and determine key indicators of variations in age of plume components, indicators of travel distance and migration path from the source, and distance traveled from source. Evaluate the indicators and specify how many sources, time of contaminant release(s) and the source locations.

PHASE I: Generate 3-dimensional contaminant plume maps for key constituents showing the contamination and its migration path from the source. Each contaminant plume map should consist of a map showing both vertical and horizontal migration paths.

PHASE II: Confirm results of 3-dimensional map to demonstrate proof of concept. This should include drilling and gathering groundwater samples at various locations horizontally and vertically. Generate a protocol for sampling parameters and procedures, and test this protocol at multiple TCE contaminated sites.

DUAL USE COMMERCIALIZATION: Military application: The protocol generated from this project can be used at any contaminated site where contaminant sources and pathways are unknown.

REFERENCES: 1. Schug, Ertel, T., et al, Localization and Identification of Contaminant Sources, Contract No. EVK1-CT-1999-00017, May 2003.

2. Stephens, Daniel B., Application of Groundwater Contaminant Transport Modeling in Environmental Forensic Investigations: Tucson Airport Superfund Site, ISEF Stresa Italy Workshop, May 19-20, 2003.

3. Sueker, Julie, K., Isotope Applications in Environmental Investigations: Theory and Use in Chlorinated Solvent and Petroleum Hydrocarbon Studies, Remediation Journal, Volume 12, Issue 1, pages 5-24, December 2001.

KEYWORDS: Environmental Forensics, Plume Delineation, Trichloroethylene

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AF06-338 TITLE: Noninvasive Pressure Measurement of Aircraft Pressurized Lines

TECHNOLOGY AREAS: Sensors, Electronics

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop MEMS sensors and associated algorithms to automatically isolate blockage and internal leakage faults in hydraulic, fuel, or pneumatic systems.

DESCRIPTION: During fault isolation of pressurized lines, it is very difficult to monitor the pressure at various locations in a system without installing numerous gages. On most aircraft, installing gages is impractical due to cost, weight, power, communications, and access issues. Fault isolation of hydraulic, fuel, and pneumatic systems often require manual troubleshooting due to hydraulic/fuel lines becoming blocked, faulty components, or actuators leaking internally. Currently, there is no simple method to determine where a line is blocked, or which component is faulty. Often, the manual troubleshooting process involves a systematic removal and replacement of components until the faulty one is found. This process results in a tremendous amount of unnecessary work and its associated costs. Research existing or new external pressure-sensing devices which meet the following requirements: (i) Sensing device must be small enough to fit into tight aircraft spaces, (ii) measure fluid line parameters with sufficient accuracy to perform automated fault isolation during system operation, and (iii) be cost competitive with traditional sensors.

PHASE I: 1. Perform a feasibility study on whether such a MEMS sensor can be developed.
2. Document prototype sensor design and algorithms for automated isolation of blockage and internal leakage faults.
3. Develop a strategy for collecting information from sensors during system operation.

PHASE II: 1. Build prototype MEMS sensor.
2. Code prototype algorithms.
3. Demonstrate that prototype sensor and algorithms can automatically isolate blockage and internal leakage faults of fluid and pneumatic lines in a laboratory environment.

DUAL USE COMMERCIALIZATION: Pressurized fluid and pneumatic lines are very common in present-day military and commercial aircraft, vehicles, and ships. A successful program will develop technology that will be a strong candidate for transition to these types of platforms.

REFERENCES: N/A

KEYWORDS: Health Monitoring, automated isolation, MEMS sensors

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AF06-339 TITLE: Advanced Frangible Composite Structure

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Provide a low cost, frangible composite structure.

DESCRIPTION: FAA regulation requires any structure located within 250 feet of runway centerline has to be frangible, which means the structure needs to break away when hit by an aircraft to minimize damages to the aircraft and its pilot. Many structures located at our nation airports (including Hill AFB) do not meet this frangible requirement.

The use of composites in the construction of towers, lends the possibility of frangibility to towers. Due to their composition, composites not only do not corrode in highly humid environments, they can break away when struck by an aircraft without extensive damage to the aircraft. Due to the close proximity these towers have to an air field, they can not be guyed, but should be sufficiently stiff without the use of guy wires. The development of an economically viable composite tower with a special emphasis on frangibility is desired. A lower cost alternative consists of composite pultruded I-beams and tubes designed for use in a limited number of structural applications.

This project seeks a low cost composite solution achieved through an improvement in material properties. A primary objective will be a 100% frangible tower that will create little to no damage when struck by an airplane. A second objective will be to investigate a low cost manufacturing process. The final goal will be to validate the structural strength and economic viability with an economic cost equivalent to steel.

PHASE I: Design a frangible composite tower with the following target capabilities: (i) When struck with a small plane the tower will break away with minimal damage to the plane, (ii) Tower will not require guy wires for stability.

PHASE II: Develop a commercially viable process for manufacturing the towers. Based on Phase 1 design, build a frangible composite tower proposed for a tall tower or platform. Test the specimens for deflection, strength, fatigue and frangibility in accordance with ASTM standards. In addition, test specimens for degradation associated with moisture absorption and UV resistance.

DUAL USE COMMERCIALIZATION: The proposed product will have numerous benefits to the military and civil infrastructure communities such as civilian airports. The material will be valuable for use as roadside reflector stands, road signs, and electric and light poles that now are responsible for the damage, injuries, and deaths from autos impacting these structures.

REFERENCES: 1. ASTM Standard D2990-01, Standard Test Method for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics. Web site www.astm.org

2. ASTM Standard D790, Standard Test Method for Flexural Properties of Unreinforced and reinforced Plastics. Web site www.astm.org

3. Composite Tower System Requirement Document, AF Tactical Shelter & Radome Program Office, Dec 2002.

4. FAA E-2702, Low Impact Resistant Support Structures (LIRS).

5. AFMAN 32-1076, Run Way Lighting Structure Requirements.

KEYWORDS: Composite, frangible, deflection, stiffness, tall structures, tower, platform, low cost

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AF06-340 TITLE: Tiled Ultra High-Resolution Light Engine

TECHNOLOGY AREAS: Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a compact light engine for head mounted displays and/or projectors. Particularly interested in current-technology integrated into a seamless, tiled configuration that’s cheap and deployable.

DESCRIPTION: One of the significant technologies needed for training systems is an ultra high-resolution light engine with a minimum 6Kx3K pixel array and 60 Hertz update rate, which can be fielded in a compact head mounted and/or off-the-head display to support training at remote locations. This compact system will need to meet requirements for seamless tiling, a single output projection lens, transportability, and sustainability. The Air Force is seeking innovative solutions that provide sufficient brightness, contrast, and resolution to support fast-jet visual simulation. Relatively low production cost, high reliability, and large commercial potential are critical requirements for this technology. High input data requirements may be met through the use of multiple image generator channels

PHASE I: Present a complete and documented design for a multiple-chip, tiled light engine configuration including display optics. The design should have an illumination system capable of providing output luminance and temporal response necessary to support fast jet simulator training.

PHASE II: Phase II will involve complete engineering, and fabrication, as well as perceptual test and evaluation of a functional compact, full-color, ultra high-resolution light engine for head mounted display and/or projector applications prototype suitable for commercial production.

DUAL USE COMMERCIALIZATION: This work, combined with ongoing Air Force efforts to decrease size, increase display resolution and reduce overall system cost, will have immediate benefit to the expanding world of virtual reality for industrial, medical, special effects and electronic media applications, as well as the motion picture and CAD/CAM industry.

REFERENCES: 1. VESA (2001). Flat-Panel Display Measurement Standard

2. Best, L., Wight, D., Peppler, P., (1999). M2DART Visual Display, A Real Image Simulator Display System, Aerosense Conference., Orlando, Fla.

3. Geri, G.A. , Morgan, W.D. (2004). A comparison of the temporal characteristics of LCD, LcoS, laser, and CRT projectors. Warfighter-Contract Technical Memorandum, 24-02.

4. Surber B.L., Peppler P.. (2003). Image Generator Requirements for Driving the 5120 x 4096 Pixel Ultra High Resolution Laser Projector, AFRL Science & Technology Reports-Tech Memo: Special Report.

5. Surber B.L., Guckenberger, D., (2001). Ultra-High Resolution DMT Visual Display Via PC-IG Array Technologies, Inter-service/Industry Training Simulation and Education Conference (I/ITSEC).

KEYWORDS: COMPACT, LCOS, OLED, GRAPHICS, DEPLOYABLE, FAST JET, HIGH-RESOLUTION, IMAGE GENERATOR, LIGHT ENGINE, LOW-COST PROJECTOR, SEAMLESS, SIMULATOR, TILED, ULTRA VISUAL SIMULATION, VISUALIZATION

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AF06-341 TITLE: Advanced Rigid Composite Tower

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Provide a low cost, rigid composite tower.

DESCRIPTION: There are many DOD radar systems that required the use of very rigid supporting structures. There are available steel structures that can meet that rigidity requirement, but they are prone to corrosion problems, require frequent expensive maintenance, and thus are not desirable.

In order to avoid the corrosion problems associated with steel, it is proposed that composite tower structures be developed to replace steel tower structures. Composite materials have been shown to be corrosion free in extremely harsh, high humidity environment which is also desirable. However, the use of composite materials in the design of rigid, tall, narrow, civil infrastructures, have been practically nonexistent due to technical difficulties and high costs. The tower must be sufficiently rigid without the use of guy wires. A lower cost alternative consists of composite pultruded I-beams and tubes designed for use in a limited number of structural applications.

PHASE I: Design a rigid composite tower with the following target capabilities: (i) Stiffness that is equal or better than 5 Hz (vibration measurement) in accordance with ISO standard, (ii) Develop a joining system and determine the best resin/composite combination for the proposed environment.

PHASE II: Develop a commercially viable process for manufacturing the towers. Based on Phase 1 design, build a rigid composite structure proposed for a tall tower or platform. Test the specimens for deflection, strength, and fatigue in according to ASTM & ISO standards. In addition, test specimens for degradation associated with moisture absorption and UV resistance.

DUAL USE COMMERCIALIZATION: The proposed product will have numerous benefits to the military and civil infrastructure communities as well as the environments.

REFERENCES: 1. ASTM Standard D2990-01, Standard Test Method for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics. Web site www.astm.org

2. ASTM Standard D790, Standard Test Method for Flexural Properties of Unreinforced and reinforced Plastics. Web site www.astm.org

3. Composite Tower System Requirement Document, AF Tactical Shelter & Radome Program Office, Dec 2002.

4. ASTM Standard A-871, Standard Specification for High-Strength Low-Alloy Structural Steel Plate with Atmospheric Corrosion Resistance. Web site www.astm.org

5. ISO Standard Handbook – Mechanical Vibration and Shock, Vol.1, 1995. Web site www.iso.org

KEYWORDS: Composite, stiffness, rigidity, tall structures, tower, platform, low cost

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AF06-342 TITLE: Thermoplastic Large, Ground-Based Radomes

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a process and engineer a design to utilize thermoplastic composites in the manufacturing of durable and functional large, ground-based radomes.

DESCRIPTION: The current inventory of Department of Defense (DOD) large, ground-based radomes heavily relies on thermoset plastics and thermoset manufacturing processes. Thermoset plastics and thermoset manufacturing processes have many drawbacks that thermoplastics and thermoplastic manufacturing processes bypass.

The main issues of concern for using thermoset plastic in radomes is that such plastics are extremely susceptible to impact damage and weather related deterioration that can result in delamination and water intrusion in radomes and radome panels, making extensive field and depot level repairs critical. Also, the preservation techniques that have been developed and used to extend the service life and prevent operational failures of thermoset radomes (e.g. the use of primers, topcoats, and abrasive cleaners) are highly toxic and require significant resources for repeated applications and disposal. Additionally, thermoset resins require a chemical reaction during manufacturing which releases hazardous solvents, i.e. volatile organic compounds (VOCs), in the process, and the chemical process to fabricate thermosets is irreversible, i.e. a cured thermoset structure cannot be reprocessed or reformed for use in other structures.

Thermoplastics can bypass many of the issues that arise from using thermosets in large, ground-based radomes. For instance, thermoplastics are much more damage tolerant when it comes to impact resistance than thermoset plastics due to the non-brittle nature of thermoplastics. Also in contrast to thermosets, the processes to mold thermoplastics emit zero VOCs during manufacturing, and thermoplastics will melt repeatedly when heated to processing temperatures and will harden when cooled. This enables thermoplastics to be recycled for repair or to build a new structure. Also, thermoplastics can be manufactured in a monolayer fashion that would eliminate delamination. However, such a design for large, ground-based radome panels is not currently available due to the need for additional structural, engineering, and manufacturing engineering and optimization of the material.

The following issues arise in using thermoplastics for large, ground-base radome applications: i) Glass is often added to thermoplastics to give the plastic added structural stability; the more glass that is added, the more brittle the structure and thereby the more susceptible to impact damage. ii) The non-rigid nature of thermoplastics implies more movement of the radome as compared to a radome made with thermoset plastic. iii) Weather related deterioration in the form of UV and wind damage is a concern with thermoplastics as it is with thermosets. iv) Thermoplastic has a lower melting point that thermoset plastic and therefore will soften in extremely high temperature environments before thermoset plastics. The effects of such softening on radar performance have been minimally explored. v) Thermoplastics have not been adequately optimized for structural, electrical, and manufacturing concerns for use in large, ground-based radomes. However, if each of the above issues can be satisfied through engineering and design principles, a significant reduction in life-cycle costs of radomes can be achieved by substituting thermoplastics for thermosets in large, ground-based radomes.

PHASE I: Design/research thermoplastic materials and processes to mfg large, ground-based Radomes, eliminating delamination, painting, hazardous waste, and increase life cycles, and reduce maintenance costs. All electrical and structural requirements will be maintained. A feasibility study is required.

PHASE II: Develop and test a cost-effective material and manufacturing process to construct commercially viable thermoplastic large, ground-based radomes. Also, conduct structural analyses by computerized simulation and construct a prototype to ensure the structure will meet or exceed air force requirements.

DUAL USE COMMERCIALIZATION: The proposed process and resulting radomes/radome panels will be applicable in multiple radar systems, used both by the commercial airlines and by the government. Large, ground-based radomes are also being used in applications that range from ensuring accurate gathering of weather data to serving as warning systems for national defense purposes.

REFERENCES: 1. ASTM D2990-01, Standard Test Method for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics. Web site WWW.ASTM.ORG

2. ASTM D790, Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics. Web site WWW.ASTM.ORG

3. ASTM D4762-04, Standard Guide for Testing Polymer Matrix Composite Materials. Web site WWW.ASTM.ORG

KEYWORDS: Large Ground-Based Radomes, Radomes, Thermoplastic, Thermoset, Composite, Delamination, Low Cost, Long Life-Cycle, Structural, electrical, Manufacturing Engineering

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AF06-344 TITLE: Multi-spectral Physics-based Projector

TECHNOLOGY AREAS: Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Development of multi-spectral projector with multiple laser frequencies, which displays visible and infrared correlated imagery for daylight and night vision goggle training stimulation.

DESCRIPTION: Of particular interest to this solicitation will be novel concepts to integrate multiple frequencies of lasers into a single projector, which provides a broad range of correlated coverage for the visible and infrared (IR) light spectrums. Current techniques for presentation of imagery within the visible and IR spectrums include use of separate projectors and IR display devices for each portion of the light spectrum. Traditionally, a standard red, green, blue (RGB) video projector or monitor is used to display the visible light spectrum. Conventional display of the IR spectrum involves use of a separate device for stimulation of existing IR sensors or simulation methods that exhibit IR-like images on standard RGB displays. The device used for stimulation of the IR sensor and/or light amplifier is frequently a standard RGB projector that has been specifically modified to control (i.e. - limit) the visible portion of its light spectrum, while providing the imagery necessary to appropriately stimulate the sensors. Since standard RGB projectors are not designed to operate in the IR spectrum, this approach can be a daunting task with conflicting results when attempting to simultaneously display both the visible and IR light spectrums. The focus of this solicitation is to identify and define an innovative approach for a multi-spectral, laser-based projector, used in concert with a physics-based material encoded database, to realistically portray both the visible and infrared light spectrum within a single integrated projector. This projector should have a correlated response for the visible and IR bands; with appropriate display characteristics for both spectrums. There should be minimal adverse interaction between the visible and IR spectrums. The imagery should include realistic dimming of the visible spectrum during low illumination scenes with appropriate black levels, which do not negatively impact the IR spectrum. The video format for a proof of concept can be 1280 pixels x 1024 (non-interlaced) lines with a 60 Hertz update rate.

PHASE I: Provide a technical report determining the feasibility of the concept and provide a feasibility demonstration. The report will include an industry survey to determine the availability and affordability of lasers and other necessary hardware.

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

DUAL USE COMMERCIALIZATION: This work, combined with ongoing Air Force efforts to improve display system technology, would have immediate benefit to military flight simulation, law enforcement training systems, commercial multi-spectral displays, medical applications, metrological displays, agricultural hyper-spectral image sampling, and machine vision applications, as well as other scientific assessments requiring an IR-to-visible spectrum translation.

REFERENCES: 1. Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Readiness Research Division, 6030 Kent Street -- Mesa Arizona 85212 (602) 988-9773. http://www.mesa.afmc.af.mil/ (Mr. Phil Peppler x273 or Dr. Byron Pierce x219)

2. Hill, B. (2002). The History of Multi-spectral Imaging at Aachen University of Technology, Rheinisch Westfaelische Technische Hochschule (RWTH) Aachen University of Technology. Aachen, Germany.

3. Knoig, F, Ohsawa K, Hill, B. et al. (2002). A Multiprimary Display: Optimized Control Values for Displaying Tristimulus Values, IS&T PICs Conference, An International Technical Conference on Digital Image Capture and Associated System, Reproduction and Image Quality Technologies. Portland, Oregon; April 2002; p. 215-220; ISBN / ISSN: 0-89208-238-0

4. Toet, A, Walraven J,. (1996). New False Colour Mapping for Image Fusion, Optical Engineering. 35(3) 650-658 (March 1996), TNO Human Factors Institute, Kampweg 5 3769-DE Soesterberg, The Netherlands

5. Wight, D., Best, L., Peppler, P., (1999). M2DART Visual Display, A Real Image Simulator Display System, Aerosense Conf., Orlando, Fla.

KEYWORDS: MULTI-SPECTRAL, PHYSIC-BASED, LASER, SIMULATION, STIMULATION,IR SPECTRUM, GRAPHICS, PROJECTOR, VISUALIZATION, NVG, INFRARED, COLLIMATED, MATERIAL ENCODED DATABASE

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AF06-345 TITLE: Blast-Resistant Composite Panels for Composite Tactical Shelters

TECHNOLOGY AREAS: Materials/Processes, Human Systems

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Provide reasonably-priced and blast-resistant composite panels that can be incorporated into a variety of tactical shelters.

DESCRIPTION: Existing tactical shelters are used in support of field hospitals, sleeping quarters, command centers, personnel transport, and provide support for nearly every important strategic and tactical weapon system (e.g., communications systems, electronics, and vital support equipment). The proposed objectives of this technology are: (i) protect the lives of personnel; (ii) protect strategic and high cost assets within a high risk environment; (iii) deflect energy associated with electro-magnetic radiation (from inside and outside the shelter).

PHASE I: Develop blast-resistance within composite tactical shelter panels that does not substantially increase weight or reduce performance and retains the panel's thickness of 1"-3", that absorbs or deflects secondary fragmentation energy, stopping or reducing subsequent damage, at a reasonable cost.

PHASE II: Develop blast resistant composite panel mfg process, produce prototype that reduces personnel injury and equipment damage from secondary fragmentation. An engineering analysis is required to ensure design meets/exceeds ASTM Std E1925 and other Air Force specifications. Use successful prototype panel on at least one tactical shelter configuration and further test to ensure end product viability.

DUAL USE COMMERCIALIZATION: The resulting technology and impacted systems will provide for the protection/safety of military personnel and strategic equipment. Industrial applications will include low cost and light weight blast resistant walls that can be easily set up and removed; protection of high risk government and industrial facilities; protection of high cost or strategic equipment during shipment, protection in high risk and/or volatile industrial applications; increased security; and support to homeland defense.

REFERENCES: 1. ASTM E1925, Specification for Engineering and Design Criteria For Rigid Wall Relocatable Structures.

2. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000

3. Advanced Composite Structures: Fabrication and Damage Repair, Abaris Training, May 1998.

4. MIL-STD-1472D, Notice 3, Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

5. ISO 668-1995 Series 1 Freight Containers-Classification, Dimensions and Ratings

KEYWORDS: Blast-Resistant, Secondary Fragmentation, Tactical Shelter, ASTM E1925, Personnel Safety, Increased Security

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AF06-346 TITLE: Delamination and Water Intrusion Detection

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop a reliable process/instrument and engineer a design to detect delamination and water intrusion in advanced composite structures.

DESCRIPTION: Advanced composite structures, as well as other aged structures, demand that damage diagnostic methods be implemented in order to ensure structural health. Two common damage states of advanced composites include delamination and water intrusion. Detection of each is critical for Department of Defense (DOD) structures such as radomes/radome panels, composite shelters, and composite towers. The current method implemented during field maintenance of DOD advanced composites involves tap testing. More sophisticated methods for detection have been proposed in the past for damage diagnosis of DOD composite structures, each of which has been unsatisfactory in accuracy and consistency. Tap testing, though primitive in this age of technology, continues to be the preferred method of damage detection in DOD advanced composite structures due to the unreliability of advanced methods utilized by the DOD thus far. It is proposed, however, that current detection methods can be improved to be more reliable and accurate for use in advanced composites, or that a completely new process can be developed for damage detection. An automatic process that requires minimal analysis would be preferable, especially since such a process would be lower cost than one that demands scrutiny by testers and since such a process could eliminate much human error.

Note: In detecting delamination and water intrusion in advanced composites, the obvious goal is to accurately detect the extent of each while maintaining structural integrity of the test subject. However, in the case of radomes, there is also the issue of electrical integrity to be considered: the suggestion of sensors placed in the panels as a means of detecting delamination and/or water intrusion should be considered in light of the purpose of a radome, i.e. to protect an antenna from harmful environmental effects while not affecting the electrical performance of the antenna.

PHASE I: Design or research existing methods for accurate delamination detection and water intrusion in composite structures, especially composite sandwich panels, that is easy to use and handle by Radome climbers in the field. A feasibility study will be required to prove the concept of Phase I completion.

PHASE II: Develop and test a cost-effective and reliable process to accurately detect delamination and water intrusion in advanced composite structures, especially composite sandwich panels.

DUAL USE COMMERCIALIZATION: The proposed process will be applicable to both the commercial sector and the government/military sector because of both groups' use of advanced composite structures and composite sandwich panels. For example, composite towers, shelters, and radomes are prevalent in the military and commercial sectors. This project will also build the foundation to develop methods to detect delamination and aircraft fluid intrusion in aircraft composite material.

REFERENCES: 1. Wavelet-based Active Sensing for Delamination Detection in Composite Structures, February 2004, Charles R. Farrar. Web site www.iop.org/EJ/abstract/0964-1726/13/1/017/

2 Electrochemical Based Moisture Sensor for Detecting Moisture in Composites and Bonded Structures, 2004, G.D. Davis. Web site http://www.daccosci.com/Tri-Service%2099%20paper.htm

3 Piezoelectric Active Sensing for Delamination Detection in Composite Structures, Sohn Hoon, Los Alamos National Laboratory. Web site http://atlas-conferences.com/c/a/n/b/21.htm

KEYWORDS: Delamination, Water Intrusion, Sandwich Panels, Advanced Composites, Damage Detection, Damage Diagnosis, Engineering, Structural Health

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AF06-347 TITLE: Low Cost Wear Resistant Surfaces for Composite Shelter

TECHNOLOGY AREAS: Materials/Processes

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop materials for improving the wear characteristics of composite shelter and shipping container floors.

DESCRIPTION: The operational need for a new family of portable shelters to replace metal shelters has been recognized for more than a decade. Composite Rigid Wall Relocatable Structures (RWRS) will require less airlift resources to transport and will be highly corrosion resistant. RWRS have the potential for better operational characteristics than do similar all-metal structures. Many tactical shelters are designed to house personnel and equipment and thus require floors with good wear resistance. Metallic flooring provides adequate wear properties. Metals like aluminum however are relatively dense and require frequent maintenance to preserve their structural integrity. Fiber-reinforced composites exhibit different wear characteristics depending on fiber type, fiber volume, matrix resin type, and construction. Application of a highly wear resistant surface layer to pultruded composite panels would provide flooring components that performed like the metallic structures used in current shelters.

PHASE I: Develop a composite floor system for military tactical shelters that According to Specifications for Engineering and Design Criteria For Rigid Wall Relocatable Structures (ASTM E 1925).

PHASE II: Further develop, fabricate and test prototype composite floor panels for mechanical strength, wear resistance, fire resistance and impact properties in accordance with ASTM E 1925. Design and build prototype shelter flooring component to allow pilot plant manufacturing of composite shelters.

DUAL USE COMMERCIALIZATION: The benefits of a pultrusion-processable composite system for floors include: economical manufacturing methods, high wear resistance, good fatigue strength, and structure weight savings. Potential commercial applications lie in the manufacture and repair of advanced composite components for aerospace, marine, and civil engineering markets as well as for easy-to-repair truck trailer and railcar flooring components.

REFERENCES: 1. Merkle, D. H., New Family of Portable Shelters, Vol.2, Air Force Research Laboratory Report No. WL-TR-97-3032, May, 1998

2. ASTM E 1925, Standard for Engineering and Design Criteria for Rigid Wall Relocatable Structures. Web site www.astm.org

3. ASTM D2990-01, Standard Test Method for Tensile, Compressive, Flexural Creep and Creep-Rupture of Plastics. Web site www.astm.org

KEYWORDS: Composite, Shelter, wear, floor, friction, hardness, pultrusion, sandwich

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AF06-350 TITLE: Medium Caliber Gun Barrel Bore Coatings

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Investigate, develop and demonstrate a coating process to protect medium caliber gun barrels from in-service wear and corrosion.

DESCRIPTION: Over the years, evolving mission requirements have dictated a continual need to increase the performance of gun systems resulting in hotter, more erosive propellants. The electroplating of chromium onto the bore surface has been the state of the art means to combat the effect of these erosive gas flows for years and the increase in ammunition performance has driven some previously unplated barrels to be replaced with chrome-plated variants. The chromic acid used in the deposition process is problematic when it comes to pollution prevention and worker safety. Micro-cracks and porosity in electrodeposited chromium allow hot propellant gases to reach and degrade the steel substrate resulting in severe reduction of barrel life and overall performance. There are a few alternatives to electroplating that have already demonstrated a potential of bonding erosion resistant materials to the bore surface of gun barrels. The Army is developing a process known as Cylindrical Magnetron Sputtering. They have made a lot of advances in the application of coatings to internal surfaces of cylindrical substrates but, due to fundamental limitations in bore diameters smaller than 55mm, these advances have proven better suited for larger bore diameters. Explosive cladding of tantalum has shown successes in the M242 Bushmaster but still has issues related to the high cost of consumable materials and the softness of the unalloyed coating. There is a strong drive to develop a technique to bond quality coatings to gun tubes with dimensions below 55mm (all medium calibers). Proposed deposition process would demonstrate its ability to produce uniform, well-adhered dry coatings on bore surfaces of medium caliber gun tubes (20mm caliber) to comply with existing performance requirements. The technique should have the prospective to develop a multitude of coatings in a thickness compatible with the thickness of electroplated chrome currently applied to gun bores.

PHASE I: Demonstrate the feasibility of producing performance-effective coating material and a process for erosion protection of medium caliber gun tube samples under simulated exposure conditions. Common coating characteristics (i.e., uniformity, density, adhesion, etc.) should exceed current capabilities.

PHASE II: Further develop, optimize and implement the approach developed in Phase I and demonstrate performance improvements by applying the developed coating technology to a full-scale hardware.

DUAL USE COMMERCIALIZATION: Phase III would produce a coating unit to deposit the successful coating on gun tubes for military purchases from its vendors. It is anticipated a successful coating would be applied to medium caliber gun tubes by the OEMs with further implementation of the technology in a small caliber production environment.

REFERENCES: 1. “Analysis of magnetron-sputtered tantalum coatings versus electrochemically deposited tantalum from molten salt”, Surface and Coatings Technology 120-121 (1999), 44-52.

2. Tri-Service “Green” Gun Barrel, www.serdp.org/research/PP/PP-1074.pdf.

3. "Analysis of magnetron-sputtered tantalum coatings versus electrochemically deposited tantalum from molten salt", Lee, Cipollo, Windover, Rickard; Surface and Coating Technology 120-121 (1999) 44-52.

4. Ceramic Gun Barrel Liners, Retrospect and Prospect: Dr. R. Nathan Katz, Worchester Polytechnic Institute, see: http://users.wpi.edu/~katz/coverpg.html

5. Gradiated Gun Barrel Fabrication Process, see: http://www.zyn.com/sbir/sbres/sbir/dod/navy/navysb03-1-065g.htm

KEYWORDS: erosion, coatings, chrome replacement, adhesion, gun tubes, steel

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AF06-351 TITLE: Eliminating Legacy Performance Barriers Imposed on New Systems

TECHNOLOGY AREAS: Information 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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research the affects that produce communication failure, race conditions, deadlocks and other deficiencies in integrated systems composed of subsystems that perform independently. Use research to produce new paradigms in systems and system integration that hold promise in providing increased throughput and performance enhancement.

DESCRIPTION: The AF and all services are seeking performance gains in new, existing and replacement systems. One area of interest for the AF is Automatic Test Systems modernization. Although modern ATS developers and integrators are taking advantage of advancements, such as new standards, size reduction, capability enhancements, synthetic instrumentation, and software layering, they are largely incorporating these into their designs using existing architectures, concepts, and frameworks. Research is needed into the issues resulting from coupling and combining subcomponents into systems of subsystems that impact performance, system utilization and throughput. Although this topic is directed at ATS for this program, the research should be applicable to all systems of subsystems. Many systems of subsystems including ATS have significantly more inherent capability than they can render because of the constraints and restrictions imposed by the traditional system integration paradigms utilized. This research will attempt to obviate these limitations and provide a direction to overcome them.

PHASE I: A successful phase I effort would provide the basis for a new system integration paradigm that addresses restrictions imposed by conventional philosophies. The research would define a vision for applying the innovation to ATS, project technical merit, and establish a favorable commercialization strategy.

PHASE II: The effort would realize an implementation of the innovation discovered. A prototype capable of exposing performance gains and system utilization enhancements enabled should be developed. A plan will be produced that specifically defines and specifies the data collection facilities that the prototype will engage to assemble the information needed to objectively and effectively evaluate the concept merit.

DUAL USE COMMERCIALIZATION: the innovation should show potential application in DOD and Commercial systems including ATS, Avionics, Satellites, communications, transportation control systems and others.

REFERENCES:
1. Model-Integrated System Development: Models, Architecture and Process
http://www.isis.vanderbilt.edu/publications/archive/Karsai_G_8_0_1997_Model_Inte.pdf

2. Humans and Computing, writings on projects language and design, http://www.humansandcomputing.org/ (starting April 22, 2004).

3. How To Get Unbelievable Load Test Results, Dr. Neil Gunther, http://www.teamquest.com/resources/gunther/load-test.shtml (April 19th 2004).

4. Flexible Test Architectures Lower Cost-Of-Test for Mixed-Signal-Devices. Larry Debattista, http://www.credence.com/e_news/articles/flex_test_arch.pdf.

KEYWORDS: test, automated, systems, throughput, footprint, architecture, software

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AF06-353 TITLE: High Efficiency Flexible Photovoltaic Modules

TECHNOLOGY AREAS: Ground/Sea Vehicles, 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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Identify new technologies with the potential for low cost production of high efficiency flexible photovoltaic modules.

DESCRIPTION: The Air Force is currently evaluating the use of amorphous silicon photovoltaic (PV) modules. The PV cells, being flexible and light weight, are mounted to the exterior of tents as deployed in battleground areas and are supplying power for environmental control. The efficiency of the current modules is 13%. Encouraged by the preliminary results, the Air Force recognizes the potential of photovoltaic systems to lower the fossil energy demand in the BEAR application. Wishing to further the utilization of PV, the Air Force is seeking new ideas for the construction and manufacture which promise to lower the cost and raise the efficiency of flexible PVs suitable for incorporation into tent construction.

It is desired to raise the efficiency of the flexible cells from the current 13% to 20%, with promise of low cost continuous manufacturing process. Such a breakthrough would result in rapid acceptance of the PV system in civilian applications.

PHASE I: Identify alternate PV constructions with the requisite efficiency and stability. Demonstrate feasibility and efficiency in laboratory testing.

PHASE II: Develop a production scalable process to implement the manufacture of the technology.

DUAL USE COMMERCIALIZATION: High efficiency low cost PV modules will find many applications in the civilian sector, for example, off the grid housing and temporary emergency shelters. Teaming with an established high technology manufacturing firm will insure the needed resources and capital.

REFERENCES: 1. “Amorphous Silicon Alloy Photovoltaic Research-Present and Future”,
S. Guha, J. Yang and A. Banerjee, United Solar Systems Corp. Prog. Photovolt. Res. Appl. 8, pages 141-150 (2000)

2. http://www.uni-solar.com/

3. http://www.wired.com/news/technology/0,1282,64021,00.html

4. http://www.iowathinfilm.com/

5. http://www.icpsolar.com/ssfamille.php3?id_rubrique=11

KEYWORDS: photovoltaic, amorphous, thin film, distributed power

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AF06-354 TITLE: Noise Suppressor (Hush House) Fire Suppression

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.

STATEMENT OF INTENT: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Research and develop a “common” fire suppression system for use in Air Force Jet Engine Noise Suppressors (hush houses) that meets current mission requirements.

DESCRIPTION: The United States Air Force utilizes hush houses to reduce noise levels during jet engine tests. One major hazard associated with hush houses is catastrophic fire fueled by high hydrocarbon fuel rates and rapid air flow. To reduce fire damage, each hush house is equipped with a fire suppression system. The A/F32T-9, A/F37T-

10, A/F37T-11 and A/F37T-12 hush houses have configurations that utilize Halon 1301 to suppress fires. An alternate configuration for the A/F32T-9 uses a water deluge system, and an alternate configuration of the A/F37T-10 and A/F37T-11 uses a high expansion foam system. However, there are problems with each of these systems. There are 152 Hush Houses located worldwide. Halon 1301 is classified as a Class I Ozone Depleting Substance (ODS) and is banned from manufacture by the Montreal Protocol. An executive order will ban commercial purchase of any Class I ODS effective 31 December 2010. While the water deluge system and high expansion foam system are more environmentally "friendly," there is concern they do not meet the requirements set forth in the Operational Requirements Document (ORD). As such, the Air Force is actively seeking a fire suppression prototype that will not interfere with normal hush house operation, does not utilize any substance that may be banned from use in the next 20 years and meets all requirements of the ORD and current aircraft requirements. The prototype must work to limit the damage to both traditional and new composite type aircraft materials typically found in modern military aircraft design; limit harm to personnel and damage to other ground support equipment; and incorporate into the existing hush house facilities with minimal modifications.

PHASE I: Conduct applied technology research to exceed the current operational requirements to include those anticipated over the next two decades. The research must consider all safety, cost and environmental issues. That option with minimal risk will move to Phase II.

PHASE II: Develop and manufacture a prototype to demonstrate design performance and reliability. This will be accomplished at a facility that represents and requirements and restrictions of the Hush House operational environment.

DUAL USE COMMERCIALIZATION: Civilian uses for fire suppression systems are widespread. Any facility where fire poses danger to persons or property, such as chemical processing plants or commercially owned aircraft engine test facilities, could consider this a viable safety feature.

REFERENCES: WR-ALC/LEEE publication: Point Paper on Hush House Fire Suppression System, 5 Nov 2003

KEYWORDS: fire suppression, hush house, noise suppression, chemicals

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AF06-355 TITLE: Damage Detection and Identification in Composites

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an accurate, rapid, inexpensive method for easy, repeatable detection of composite internal damage/health at different levels of depth.

DESCRIPTION: Composite materials such as boron, Kevlar, graphite and carbon materials are widely used in many advanced aerospace structural systems. Reliable damage assessment for these structures, which are subject to wear and tear and sometimes extreme operational conditions, is one of the most serious and costly problems faced in field of depot maintenance. This problem is compounded by the fact that damage can occur in many different forms, such as delamination, disbond, and fiber breakage in composites.

Damage in composites can be detected in numerous ways, but detection methods are frequently limited to certain kinds of materials and structural geometries and usually are weak at quantifying the damage. Moreover, they often require the structure to be at least partially disassembled and a skilled technician to interpret the observations, increasing labor costs and adding to the time needed to complete the inspection. This proposal should also address defect signature analysis with a view to implementing an automated defect identification, extraction and classification (e.g. disbond, delamination, water penetration) methodology which will ensure minimum operator intervention.

PHASE I: Develop and demonstrate 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 test articles by determining the location and extent of damage in composite panels.

PHASE II: Develop and deliver a portable system for on-site use. Demonstrate the damage-detection system on actual composite aircraft structures with known flaws, similar to those found in practice, placed in the structures, and demonstrate that developed software enables identifying the character of the defect. Evaluate the efficacy of the damage-detection system by comparing the with conventional results.

DUAL USE COMMERCIALIZATION: Potential applications include inspection of composites structures including commercial aircraft. Potential customers include aerospace, Federal Aviation Administration, and Department of Defense.

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.

3. Proceedings of the 2cd International Workshop on Structural Health Monitoring , Stanford University, Stanford, CA, September 8-10, 1999, Edited by F. K Chang, Techonomic Publishing Co. Lancaster r Pennsylvania

KEYWORDS: Vibration-based damage detection, surface evaluation, cracks, delamination, composite and metallic structures

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AF06-356 TITLE: <u>Damage Detection and Identification of Adhesive Bonding in Metal Components</u>

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: This topic holds the greatest potential for meeting the technical needs of our warfighters supported by PEOs and Centers.

OBJECTIVE: Develop an accurate, field and depot method of detecting a disbond in tongue and groove adhesively bonded aluminum components of aircraft. The objective is to easily identify and detect disbond.

DESCRIPTION: The method of assembling the components is a tongue and grove methodology. The area of concern is where the different parts are adhesively attached. The tongue's width is between 0.060 and 0.100 inches. The disbond in these components cannot be accurately detected until the part fails. Reliable assessment for these structures is one of the more serious issues faced in maintenance. This solicitation therefore seeks to address the inability of existing technology to reliably characterize the extent of defects.

PHASE I: Develop and demonstrate a technique capable of assessing damage to the disbond in aircraft components. Demonstrate the proof-of-concept on test articles by determining if there is a disbond.

PHASE II: Develop and deliver a portable and cost effective system for on-site use. Demonstrate the damage-detection system on actual aircraft structures with known flaws, and demonstrate that developed software enables identifying the character of the defect. Evaluate the efficacy of the damage-detection system by comparing the results with those from conventional techniques.

DUAL USE COMMERCIALIZATION: Potential applications would include similar construction techniques on other military aircraft and also commercial aircraft. Potential customers include aerospace, Federal Aviation Administration, and Department of Defense.

REFERENCES: 1. http://www.flightdailynews.com/farnborough2004/07_20/hall/grid.shtm

2. http://www.aerostructures.goodrich.com/html/rd_gridlock.asp

KEYWORDS: tongue and grrove

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