AIR FORCE
SBIR 05.1 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 14 Dec 04), 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 (15 Dec 04 through 14 Jan 05), 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 reviewed 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, 14 January 2005 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

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.

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)
AF05-001 thru AF05-012	Directed Energy Directorate AFRL / DE 3600 Hamilton Ave. SE Kirtland AFB NM 87117-5776	Ardeth Walker (505) 846-4418	Dave Tuttle (505) 846-8133
AF05-014 thru AF05-044	Space Vehicles Directorate AFRL / VS 3600 Hamilton Ave. SE Kirtland AFB NM 87117-5776	Ardeth Walker (505) 846-4418	Francisco Tapia (505) 846-5021
AF05-049 thru AF05-080	Human Effectiveness Directorate AFRL / HE 2610 Seventh St. Bldg. 441 Rm 216 Wright-Patterson AFB, OH 45433-7901	Sabrina Davis (937) 255-2423 Ex. 226	Jeannette Snyder (937) 255-2527
AF05-084 thru AF05-115	Information Directorate AFRL / IF 26 Electronic Parkway Rome, NY 13441-4514	Janis Norelli (315) 330-3311	Lori Smith (315) 330-1955
AF05-117 thru AF05-143	Materials & Mfg. Directorate AFRL / ML 2977 P St. Suite 13 Bldg. 653 Wright-Patterson AFB, OH 45433-7746	Marvin Gale (937) 255-4839	Terry Rogers (937) 656-9001
AF05-145 thru AF05-174	Munitions Directorate AFRL / MN 101 West Eglin Blvd. Suite 140 Eglin AFB, FL 32542-6810	Dick Bixby (850) 882-8591 x 1281	Judie Jacobson (850) 882-4294 Ex. 3399
AF05-178 thru AF05-198	Propulsion Directorate AFRL / PR 1950 Fifth St. Bldg. 18 Wright-Patterson AFB, OH 45433-7251	Laurie Regazzi (937) 255-1465	Susan Day (937) 255-5499

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF05-200 thru AF05-204	AFRL / PRO 5 Pollux Drive Edwards AFB, CA 93524-7033	Debbie Spotts (661) 275-5617	Patricia Roberts (661) 277-3344
AF05-207 thru AF05-233	Sensors Directorate AFRL / SN 2241 Avionics Circle, Rm N2S24 Bldg. 620 Wright-Patterson AFB, OH 45433-7320	Marleen Fannin (9370 255-5285 Ex. 4117	Sharon Hall (937) 656-9828
AF05-238 thru AF05-250	Air Vehicles Directorate AFRL / VA 2130 Eighth St. Bldg. 45 Wright-Patterson AFB, OH 45433-7542	Madie Tillman (937) 255-5066	Capt Kenric Phillips 937-656-9749
AF05-255 thru AF05-267	Oklahoma City Air Logistic Center 3001 Staff Drive, Suite 2AG70A Tinker AFB, OK 73145-3040	Oscar Diaz-Valle (405) 736-2158	Joe Starzenski (405) 739-5510
AF05-268 thru AF05-278	Ogden Air Logistic Center 5851 F Avenue Bldg. 849, Rm A-15 Hill AFB, UT 84056-5713	Craig Shaw (801) 586-4692	Paulette Crowell (801) 775-2365
AF05-282 thru AF05-285	Warner Robins Air Logistic Center 420 Richard Ray Blvd., Suite 100 Robins AFB, GA 31098-1640	Jamie McClain (478) 926-6617	Nita Steinmetz (478) 926-3695
AF05-289 thru AF05-295	Air Armament Center 46 TW / XPP 101 West D Ave. Suite 222 Bldg. 1 Eglin AFB, FL 32542-5492	Pablo Dejesus (850) 882-6766	Vicki Keider 850-882-0170

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF05-296 thru AF05-307	Arnold Engineering Dev. Center AEDC / DOT 1099 Avenue C Arnold AFB, TN 37389-9011	Ron Bishel (931) 454-7734	Kathy Swanson (931) 454-4409
AF05-309 thru AF05-320	Air Force Flight Test Center AFFTC / XPDT 307 East Popson Avenue Bldg.1400 Rm 107A Edwards AFB, CA 93524-6843	Abraham Atachbarian (661) 277-5946	Octavia Hicks (661) 277-5967

AirForce 05.1 Topic Index

AF05-001	Cold Cathode for Traveling Wave Tubes
AF05-002	Target Discrimination Based on Rigorous Models of Laser Scattering from Complex Media
AF05-003	High-Resolution Wide-Dynamic-Range MEMS-Based Closed-Loop Adaptive Optics System
AF05-004	Laser Vibrometry System for Space Situational Awareness
AF05-005	Refractory Coatings on Mechanically Resilient Insulators
AF05-006	Tuneable Low Frequency Microwave Source
AF05-007	Solid State Ultra-Wideband Microwave Source
AF05-008	High-Power, Optical Fiber Coupling
AF05-009	Simulation of Extended Scene Imaging through Turbulence
AF05-010	Aero-Optics Research & Development
AF05-011	Algorithms for Stereo Image Creation from a Sequence of Two Dimensional Images
AF05-012	Compact Ultra-Wideband Target Identification System
AF05-014	Advanced Algorithms for Exploitation of Space-Based Imagery
AF05-015	Electronically Scanned Array (ESA) Antenna Transmit/Receive Module
AF05-017	Field Programmable Gate Array Based Channelizer
AF05-018	Radiation-Hardened By Design Techniques for Total Dose and Single Event Upset
AF05-019	Combined Analog-to-Digital Converter and Demodulator
AF05-020	Chalcogenide Based Field Programmable Gate Array
AF05-021	MicroElectro Mechanical Systems MEMS Based, Electronically Steerable, Phased Array Antenna
AF05-022	Radiation-Resistant Solar Cell Coverglass
AF05-023	Next-Generation 30-45% Efficient Multi-Junction Solar Cell
AF05-024	Design-Hardened Analog/Mixed-Signal Electronics
AF05-025	Adaptive Tasking of Radar and Optical Sensors
AF05-026	Electro-Optical (EO) Signal Processing for Detection and Classification of Cruise Missiles
AF05-027	Small Launch Vehicles (SLV) Technologies
AF05-028	Practical Ionospheric Enhancement Technology
AF05-029	New Sensing Capabilities for Space Situational Awareness
AF05-031	Innovative Data/Electrical Interfaces for Modular Spacecraft
AF05-032	Low Cost, Tailor able Avionics for Rapid Response Satellites
AF05-033	Innovative, Low Cost, Flexible Satellite Inertial Measurement System
AF05-034	Reconfigurable Electronics for Responsive Space Systems
AF05-035	The Self-Aware Satellite
AF05-036	Enhanced Scattering of Trapped Energetic Electrons in the Inner Magnetosphere
AF05-037	Nowcasting/Forecasting the Battlespace Environment
AF05-038	Space Qualified Nonvolatile Memory
AF05-039	Synthetic Aperture Radar (SAR) Improved Through Waveform Diversity
AF05-040	Low-Power Phased Array Control Technologies
AF05-041	Electronic Protection for Space-borne Phased Array Antennas (EP-SPAA)
AF05-043	Ultra-High Performance Opto-Electronics Synthesizer
AF05-044	Advanced Metrology Technologies for Next-Generation Space-Based Radar
AF05-049	Air Traffic Control (ATC) Tactical Briefcase
AF05-051	Novel Methods for Delivery of Lifesaving Fluids and Medications
AF05-052	Helicopter Aircrew Restraint
AF05-053	Carbon Monoxide Detector Kit
AF05-054	True 3-D Display
AF05-055	Portal Workstation Development: Multi-Sensor Network-Centric, Open Systems Portal
AF05-056	Network-Centric Communications: Distributed Real-Time UAV Access
AF05-057	Advanced Subminiature Loudspeaker/Earphone Driver
AF05-059	MEMs Co-located Integrated Microphone/Earphone for Active Noise Reduction
AF05-060	Helmet Mounted Image Source/Display for Tactical Air Combat Operations

AF05-061	Hands Free Data Collection for Aircraft Maintainers
AF05-064	Aircrew Flash Blindness Goggle
AF05-065	Network Health Monitoring and Diagnosis for Distributed Mission Operations (DMO) Training
AF05-066	Role Based Real-Time Virtual Collaborative Toolkit for TST
AF05-069	The impact of cultural factors on human performance modeling and simulation
AF05-070	Decision Support Technologies for Logistics Readiness Center
AF05-071	Embedding Cognitive Systems into Systems Engineering Practice
AF05-073	Developing Bioinformatics Tools for Proteomics Research
AF05-074	Laser Eye Protection Contact Lens
AF05-075	Visualization of Propellant Residues From Shoulder-Fired Rockets Upon Skin and Clothing
AF05-076	Immunotoxicity Monitoring Method for Unknown Noxious Exposures (IMMUNE)
AF05-077	Training Simulations for Decision Effectiveness in Computer Network Defensive Operations
AF05-078	Force Cueing Technology Integration and Feedback Metrics to Improve DMO Simulator Effectiveness
AF05-080	Innovative Pharmaceutical Delivery Device for Use in Military Operations
AF05-084	Fusion of Entity Information from Textual Data Sources (e.g. HUMINT)
AF05-085	Multi-Level Security for Dynamic COP
AF05-086	Neuro-Networking Techniques for N/UWSS
AF05-087	Priority/Preemptive Capability within IP
AF05-088	Integrated Cognitive Architectures for Synthetic Environments
AF05-089	Asymmetric Adversary Tactics and Strategy Generation
AF05-090	Enabling Visualization of Event Information from Unstructured Text
AF05-091	Modeling and Executing System and Operational Architectures with Representational Languages
AF05-092	Hardened or Deeply-Buried Target (HDBT) Optimization Techniques for Detecting Obscure Geomorphic States (HOTDOGS)
AF05-093	Secure TCP/IP Broadcast/Multicast
AF05-095	Predictive Analysis Tools for PBA/IPB
AF05-097	Dynamic Enterprise Workflow Management
AF05-098	Automated Assistance with Metadata Generation (A2MG) Tools for PBA/IPB
AF05-099	Automated Tools to Assist FDO Duties
AF05-100	Web-Enabled Information Sharing and Data Distribution
AF05-101	Integration of Composable Simulations with Real-time Applications and Databases
AF05-102	Dynamic Resource Reservation on satellite Communication Links
AF05-103	Information Exploitation
AF05-104	Innovative Approaches to Behavioral Modeling, Threat Modeling and Threat Prediction
AF05-105	Information Mangement
AF05-106	Cyber Operations
AF05-107	Command and Control
AF05-108	Connectivity Technologies for the Warfighter Network
AF05-109	Computer Architectures for Understanding
AF05-110	Situation Awareness within a Network Centric Operations Construct
AF05-115	Tactical Air Controller Wargame
AF05-117	Chemical/Biological (CB) Protected Mobile Maintenance Shelters
AF05-118	Lightweight Durable Intumescent Paint
AF05-119	Fuel Processor Hardware Components For Deployable Fuel Cell Power Generation
AF05-120	Advanced Shelter Technology
AF05-121	Lightweight Environmental Control Unit (ECU)
AF05-122	Efficient Superalloy Ingot Breakdown
AF05-123	Decision Making Tool for Lean Aircraft Assembly Modernization
AF05-124	In situ Repair of Ti-6-2-4-2S Structures
AF05-125	Composite-Bonded Joint Strength Evaluation
AF05-126	Quality Assurance of Composite Bonding Processes

AF05-127	Machining of Complex Integral Airframe Structures
AF05-128	High-Performance Hybrid Electronic Enclosure
AF05-129	Fretting Wear Elimination in Gear Box Housings
AF05-130	Numerical Modeling Tools for Cold-Hearth Melting Processes
AF05-131	Robust Solid Lubricant Coating for Gears of Cryogenic Fuel Turbopumps
AF05-132	Thermal Response Modeling of Trajectory Shaping Vehicles (TSVs)
AF05-133	Multifunctional Aircraft Protective Coating
AF05-134	Microelectronical Devices for the Health Monitoring of Nonstructural Materials
AF05-135	Polymeric Nanophotonics: High-Index Polymeric Photonic Crystals for Optics
AF05-136	Technologies for In Situ Interrogation of Damage States in Structural Materials
AF05-137	Development of Durable, Fiber-Reinforced Refractory Composites for Thermal Protection Systems (TPSs)
AF05-138	High-Temperature Integral Tank Sealant
AF05-139	High-Refractive-Index Polymer Fibers for Imaging Systems
AF05-140	Replicated Hybrid/Composite Mirror Technologies
AF05-141	Improved Manufacturing Technologies for Aircraft Engines
AF05-142	Compact Water Recovery Unit for Fuel Cell Applications
AF05-143	Innovative Thermal Protection Systems (TPSs) for Trajectory Shaping Vehicles (TSVs)
AF05-145	Insensitive Munitions Booster Explosives
AF05-146	Target Tagging By-products for Bomb Damage Information (BDI)
AF05-147	Multiaperture Optical Systems
AF05-148	Advanced NanoEnergetics and Electrical Conversion Processes
AF05-149	Field Programmable Gate Array (FPGA) Defragmentation for Performance Sustainment Technology
AF05-151	Development of Multi-Hit Nonlinear Progressive Collapse Models for Fixed Targets
AF05-152	Development of HFPB Structural Response Models for Brick Masonry Construction
AF05-153	Methods to Direct and Focus Blast
AF05-154	Passive and Active Camouflage Techniques for Micro Vehicles
AF05-155	Statistical Modeling of Obscured Targets with Environmental Returns (SMOTER)
AF05-156	Transport, Compartmentalization, and Effects of Nanoparticles in the Environment
AF05-157	Shock Hardening of Fuzing Optoelectronics/Communication Devices
AF05-159	Guidance Research
AF05-160	Ordnance Research
AF05-161	IR Algorithms for Video-Aided Navigation
AF05-162	Real-time Video Stabilization for Micro-air Vehicles
AF05-164	Micro Air Deployed Munition for Cluttered Urban Environment
AF05-165	Mid Air Refueling of Powered Weapons
AF05-166	Jerk Reduction Technology (JRT)
AF05-167	Development of HFPB Structural Response Models for Steel Column/Girder Construction
AF05-168	Novel 3D Shape Representations
AF05-169	High Resolution Urban & Natural Background Scene Generation For Small Cooperative Weapons
AF05-170	Material Bonding For Lethal Air-to-Air Warheads
AF05-173	Cryogenic Temperature Material Processing for Warhead Effectiveness
AF05-174	Creative Mobile Terrain Sensing Multi-Valued Behavior Robots
AF05-178	Development of Acoustic Models for High-Performance Combustors
AF05-179	Thermal Barrier Coating Life Determination
AF05-180	Advanced Redundancy Management Strategies for Engine/Aircraft Control
AF05-181	Coatings and Surface Treatment for Bearing Wear and Corrosion Prevention in Advanced Gas Turbine Engines
AF05-182	Innovative Combustor Concepts for Advanced High-Performance Military Gas Turbine Engines
AF05-183	Field Mistuning Inspection Tool
AF05-184	Passive Thermal Management System for High-Temperature Military Aircraft Actuation System

AF05-185	Integration of Engine Failure and Trending Data to Support Reliability Centered Maintenance
AF05-186	Maintenance Cost Model for Advanced Propulsion Technologies
AF05-187	Gear Material and Lubrication for Advanced Gas Turbine Engines
AF05-188	Methodology for the Real-Time Management of Aero Gas Turbine Engine Usage Data
AF05-189	Bayesian Engine Reliability Development Tool
AF05-190	High-Temperature Wiring for Engine Bays
AF05-191	Lithium Batteries for Strategic Missile Flight Testing
AF05-192	Aeropropulsion and Power Technology
AF05-193	Performance-Based Inspection Techniques for Turbine Engine Blades and Rotors
AF05-194	Improved Modeling Tools for High Speed Reacting Flows
AF05-195	Innovative Heat Management Schemes for Hypersonic Aircraft
AF05-196	Device Technologies for Photonic Electrical Power Systems
AF05-197	Power Manager for Special Operations Portable Power Applications
AF05-198	Plasma Switches for High-Repetition, High-Power Applications
AF05-200	Mitigating Electric Propulsion Impact on Laser Communications for Transformational Communications
AF05-201	Advanced Rocket Propulsion Technologies
AF05-202	Liquid Rocket Engine Heat Transfer Tools
AF05-203	Noise and Artifact Reduction in Computed Tomography (CT) Images
AF05-204	High Power Hall Thruster Technology Development
AF05-207	Algorithms for Hyperspectral Sensor Fusion
AF05-208	High Fidelity Simulation Concepts/Technologies For Rapidly Evolving/Transitioning EW Countermeasure Techniques
AF05-209	High Fidelity RF Emitter Parameter Generation Capability
AF05-210	Collaborative Virtual Combat Simulation Technology For System of Systems Research
AF05-211	Database Expansion Issues
AF05-212	Air to Ground Signature Database Development Technologies for Combat Identification
AF05-213	Trajectory Shaping Vehicles Accuracy Assessments
AF05-214	Low Cost High Efficiency Millimeter Wave Electronically Scanned Antenna
AF05-215	Multi-band Electronically Configurable Feed for Ground Antennas
AF05-216	Passive Ground Moving Target Indication for Gunship Aircraft Using Unmanned Airborne Vehicles (UAV-PGMTI)
AF05-217	Radio Communication Through The Hypersonic Plasma Sheath
AF05-218	Compact, Multi-Spectral Measurement System
AF05-219	Sensor Exploitation by Adaptive/Learning Systems (SEALS)
AF05-220	Efficient Interaction Methodologies for Simulating the Scattering from Electrically Large Objects and Scenes
AF05-221	Next Generation Laser Detectors
AF05-222	Low Cost Adaptive Optics for Tactical LADAR
AF05-223	High Speed Readout for Photodiode Focal Plane Arrays
AF05-224	Broad Bandwidth Components for Advanced Microwave Sensors
AF05-225	Performance Improvement of a Receiver on a Chip (ROC)
~~AF05-226~~	TOPIC DELETED
AF05-228	Waveforms for Simultaneous Air and Ground Surveillance Operations
AF05-230	Tunable, Low Mass, Low Loss, Millimeter Wave, MEMS RF Filters
AF05-232	High Speed Double Balanced Photodetectors for Lasercom
AF05-233	Space-Based Light Weight Radiation-hardened Integrated Monolithic Tunable Laser
AF05-238	High-Strength and High-Durability Radio Frequency (RF) Transparent Structures
AF05-239	Macrostructure Integration via Friction Stir Welding (FSW)
AF05-241	Coupling of Computational Fluid Dynamics (CFD), Reentry Vehicle Surface Ablations, and In-Depth Conductions
AF05-242	Diagnostic Techniques for High Speed Flows
AF05-243	Integration of Flight Control and Flow Control
AF05-244	Technologies for Control of Morphing Aircraft
AF05-245	Mechanical Attachments for Advanced Thermal Protection Systems (TPS)

AF05-246	Innovative Transformational Aircraft Configuration Technology
AF05-247	Advanced Heat Pipe Concepts for Leading Edges
AF05-248	Innovative, Weight Efficient, Composite/Metallic Structural Joining Concepts
AF05-249	Influence Boundaries in Computational Fluid Dynamics (CFD)
AF05-250	Novel Computational Approaches for Solving Optimization Problems
AF05-255	Non-Destructive Grain Orientation Verification in Directionally Solidified Nickel Super alloy Turbine Blades
AF05-257	Aircraft Battle Damage Assessment Tool, (Aircraft Battle Damage Repair (ABDR))
AF05-258	Methodology for Determining Optimal Injection Techniques for Remediation of Contaminated Groundwater
AF05-259	Fixture Design Tool with Enhanced Input/Output Interface Capability and Internal Graphical Correlation/Reconciliation Of Engineering Data
AF05-260	Advanced Technology for Improving Composite Material Ply Utilization in Aircraft Construction and Maintenance
AF05-261	Non-Destructive Residual Stress Measurement in Superalloy Turbine Blades
AF05-262	Dimensional and Positional Locations for Manual Aircraft repair Processes
AF05-263	Pattern Recognition for Aircraft Maintainer Troubleshooting
AF05-264	Correlation and Reconciliation of Engineering Data - Master Gage - Actual Parts in Aging Aircraft
AF05-265	Next Generation Aircraft Depot Maintenance Management Technologies
AF05-267	Technology for Aircraft Maintenance Part Inspection and Production
AF05-268	Non-Intrusive Method and System for Inspection of Aging Electronic Systems
AF05-269	Non-Destructive Inspection of Parent Material Around Encapsulated Bushing
AF05-270	Low-Cost Electro Magnetic Interference (EMI) Composite Shelter
AF05-271	Flight Line Intermittent Fault Detector
AF05-272	Alternative Energy Sources Augmenting and/or Replacing Existing Generators
AF05-273	Automated Delivery of Pigmentation for Camouflaging Patterns for Composite Shelters
AF05-275	Complementary Methods for Non-Invasive Printed Circuit Board (PCB) Component Performance Evaluation
AF05-276	Automatic Development of Test Program Sets (TPS) Without a Board Model
AF05-277	Low-Cost Composite Ball and Roller Bearings
AF05-278	Inorganic Materials for Production of Fire-Resistant Composite Structures
AF05-282	Natural Gas and JP-8 Multi-fuel Reformer
AF05-283	Compact Integrated Hub Traction Motor and Inverter
AF05-285	Advanced Lithium Ion Battery Manufacturing
AF05-289	Accurately Validated High-Speed Wear Prediction Code
AF05-291	Enhanced Focal Plane Array Technology
AF05-293	High Speed Target Acquisition and Tracking System
AF05-294	Data Mining and Knowledge Discovery Tools for Store Separation Engineering
AF05-295	Laser Hardening of Test Targets
AF05-296	Dynamic Pressure Calibrator for Wind Tunnel Models
AF05-297	Reduction of Effects of Support System Dynamics on Wind Tunnel Test Data
AF05-298	Throat and Wall Materials for Hypersonic Wind Tunnel
AF05-299	Variable Electrochromic Devices (VEDs) for Space Simulation Testing
AF05-301	Chemical Quick Quench Probe for Engine Emissions Measurements
AF05-304	Imaging Acoustic Signature Analyses for Plant Turbo-machinery
AF05-307	High Temperature Endoscopic Particle Imaging Velocimetry (PIV) System
AF05-309	Automated Learning Video Analysis (ALVA)
AF05-310	Multi-Spectral Projection Using Reflective Microelectromechanical Systems (MEMS)
AF05-311	Independently Controlled Extended Infrared Source Array
AF05-312	Joint Tactical Radio System (JTRS) Wideband Network Waveform (WNW) Host Simulator
AF05-313	Open-Air Range Scattered Laser Light Detectors
AF05-314	Instrumentation Hardware Abstraction Support Tools
AF05-316	Health and Environmental Simulation
AF05-318	Buffet and Dynamic Loads Analysis

AF05-319	Control Systems for Data Relay Stations
AF05-320	Personal Issue Flight Test Data Recorder with Display

AirForce 05.1 Topic Descriptions

AF05-001 TITLE: Cold Cathode for Traveling Wave Tubes

TECHNOLOGY AREAS:

OBJECTIVE: Develop a semiconductor-junction based cold cathode for traveling wave tube (TWT) applications that provides uniform emission, high current density, and long lifetime.

DESCRIPTION: Traveling wave tubes [1] are essential components for generating the high frequencies and high power needed for radar, electronic warfare, communications, and many space applications. A key element of these tubes is a source of electrons, which is generally supplied by a thermionic emitter. Since these emitters operate at high temperature, their operating lifetime is limited, especially at the higher current densities (>1A/cm2) required for TWTs. Therefore, new cathode technologies that operate at lower temperature are highly desirable for space, where long-term reliability is critical. One approach for a cold cathode is based on a dense array of field emitters [2,3]; however, these arrays have proven difficult to fabricate with uniformly high emission and they also present long-term reliability problems.

One attractive approach, among others[4,5], for a cold cathode is to utilize a semiconductor device. For example, electrons could be injected into a p-type surface layer with negative electron affinity (NEA), using a p-n junction. The device must be designed so that the electrons are accelerated toward the surface to achieve high efficiency. A means must also be developed to create a NEA surface that will be maintained in the TWT environment. The anticipated result would be a cathode that provides uniform electron emission at high current density from a planar surface with little additional thermal energy. Ideally, emission modulation at frequencies in excess of 1GHz would also be possible using this innovative cold cathode.

Since this innovative cold cathode would be easy to fabricate using conventional semiconductor materials and processing methods, it would support a new class of TWTs that could be produced by a large number of electronic manufacturers.

PHASE I: Develop and demonstrate the concept of the innovative cold cathode. The goal for the emitted current density will be in the 1 to 10 A/cm2 range. An analysis will be performed to predict the characteristics (e.g. current density) of a cold cathode designed to be incorporated in a traveling wave tube (TWT) device.

PHASE II: Fabricate and demonstrate a prototype TWT that utilizes the innovative cold cathode. This tube will be designed to meet a set of specification objectives. The primary objective of this TWT will be to demonstrate the unique advantages of the new cold cathode, including the more uniform current density, smaller device envelope, and reduced heater power dissipation. The deliverable package will include specifications, test data, and any operation/maintenance manuals needed to operate and evaluate the prototype tube.

DUAL USE COMMERCIALIZATION: Military applications for the TWT include radar, electronic warfare, and communication systems. Commercial applications for the TWTs include fusion research and thermal processing of materials. The cold cathodes also have a wide variety of commercial application possibilities independently of being incorporated in a TWT, including flat panel displays (FPDs), photolithographic equipment, plasma etchers, and so on.

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KEYWORDS: Microwave, Traveling wave tube, Cold cathode, RF power, Negative electron affinity surface, Semiconductor

AF05-002 TITLE: Target Discrimination Based on Rigorous Models of Laser Scattering from Complex Media

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Develop and verify experimentally target discrimination measurements and algorithms that utilize laser scattering from complex target media.

DESCRIPTION: Directed-energy laser weapons, such as the Advanced Tactical Laser (ATL), are being developed for high-precision strike missions from mobile platforms. In this context the ability to positively identify a target will maximize the efficiency and minimize the collateral damage associated with laser weaponry. Directed-energy systems employ coherent, typically polarized illuminators and collocated detectors in the backscattering or monostatic geometry, and the basic physics of laser-target interactions in directed-energy systems is therefore significantly different from that encountered in passive systems, which utilize solar or thermal emission sources. As a result, effects that are not observed under passive illumination, including laser speckle and coherent backscattering, arise in directed-energy systems, the description of which generally demands more rigorous and diverse models than are necessary in the passive case. Robust laser-based target discrimination will require more comprehensive scattering models than are currently available. The objectives of this project are to develop and test scattering models that enable optimal utilization of basic properties of laser light at non-destructive power levels for the detection of differences or changes in target orientation, composition, and microstructure; derive from these models optimal measurements and algorithms for the identification and discrimination of targets of interest; and demonstrate optimal discrimination schemes in laboratory and field settings.

PHASE I: Develop candidate-targeting algorithms based on a rigorous understanding of laser scattering phenomenology. Develop phenomenology required to test and demonstrate targeting algorithms. Identify properties of scattered laser light, such as polarization or statistics that enhance target identification. Identify targeting algorithms for laboratory demonstration in Phase II.

PHASE II: Build laboratory testbed to demonstrate targeting algorithms. Perform experiments that identify key performance parameters of algorithms relevant to transition to a realistic field environment. Optimize performance of algorithms in the presence of system noise.

Demonstrate measurements and algorithms for laser-based discrimination of targets of interest in typical military environments. Specify existing hardware, including laser sources and detectors, required for optimal discrimination schemes. Demonstrate, using specified laser sources and detectors, optimal discrimination schemes in field environments that include noise sources anticipated in military environments.

DUAL USE COMMERCIALIZATION: Rigorous models of laser scattering from complex media have numerous commercial applications including computer-graphics design, machine vision, laser biopsy and tissue diagnosis, industrial process evaluation and control, and many others. Military applications include targeting, identification, range control, and damage assessment for advanced laser weaponry.

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KEYWORDS: Sensors,Electronics,Materials,Polarimetry,Laser,Active Remote Sensing

AF05-003 TITLE: High-Resolution Wide-Dynamic-Range MEMS-Based Closed-Loop Adaptive Optics System

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop closed-loop adaptive optics system for wide-dynamic range aberration control with high-resolution Micromachined Electro-Mechanical Systems (MEMS) mirrors.

DESCRIPTION: An emerging generation of deformable mirror (DM) technologies based on Micromachined Electro-Mechanical Systems (MEMS) manufacturing techniques resulting in DM components with capabilities exceeding those of conventional DMs while, at the same time, reducing cost, weight, and electrical power requirements. Large throw, high-pixel-number MEMS DMs are an enabling technology that may facilitate the development of optical systems with inherently large time-dependent aberrations or high-spatial-frequency aberrations. These include systems based on large lightweight primary mirrors, (1) systems involving propagation of laser light through extended atmospheric turbulence, (2)systems that operate with large dynamic aberrations associated with varying field angles or object distances, (3)opthalmic instrumentation, (4) and multi-conjugate adaptive optics, (5).

These advances in DM components will challenge the capabilities of closed-loop adaptive optics techniques developed to operate with conventional deformable mirror systems. While conventional DM devices operate with a few microns of stroke, up to 1,000 control channels, and frame rates up to 1 kHz, novel MEMS-based high-resolution DMs could be capable of up to 40 microns of stroke, up to 1,000,000 control channels, and frame rates up to 100 kHz (Generally, a given MEMS DM does display simultaneously all of these capabilities). Consequently, full utilization of the MEMS DM capabilities poses new challenges for wave front sensing and control systems.

Implementation of DMs into optical systems requires some method for measuring the system optical performance and the generation of control signals to optimize the DM surface. The increased resolution, speed and stroke of emerging MEMS-based DMs create new challenges for these control systems. In particular, wave front sensor (WFS) technologies may need to measure large aberrations and control systems may need to operate at very high speed with the increased number of control channels. The specific nature of aberrations can vary among applications including large range, low-spatial frequency aberrations such as is the case for field-angle-dependent aberrations, and lower-range, high-spatial-frequency aberrations such as is the case for extended atmospheric aberrations.

Various techniques have been utilized for measuring the optical system performance and generation of control signals. These include wave front measurement with technologies such as Shack-Hartmann sensors and interferometry as well as metric optimization techniques, (2) Image metric optimization techniques offer certain advantages, such as minimizing complexity, but have not been explored much for applications involving extended objects and large aberrations.

In order to significantly advance the state-of-the art and to be useful for Department of Defense and commercial applications, an adaptive optics system with the following features is desirable: A MEMS-based DM with large throw and/or high spatial resolution, a real-time control system based on wave front sensing or image metric

optimization, robust operation in the presence of large aberrations and extended object scenes, and at least one kilohertz closed-loop operating bandwidth.

PHASE I: Design and demonstrate an architecture that is consistent with the technical goals articulated above. More specifically, the contractor should develop an initial system design and then, based on this design, develop a laboratory-scale system that demonstrates the architecture feasibility.

PHASE II: Build, test, and integrate the adaptive optics system with a state-of-the-art optical system requiring this technology. This should include optimization of the adaptive optics system to function with the specific optical system. This includes achieving compatibility with regard to operating speed, optical path difference (OPD) range, and resolution as well as optimization of control algorithms.

DUAL USE COMMERCIALIZATION: This technology has the potential to be an enabling technology for laser communications and large-aperture ultralightweight airborne and space-based optical imaging systems. Military and civilian users would both benefit from the increased performance as well as reduced costs associated with dramatic reductions in the weight of such systems. Civilian applications include aberration compensation for extended-range high-data-rate laser communications, retinal imaging, optical tweezers, and high-altitude imaging for agriculture monitoring, traffic management, and law enforcement

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KEYWORDS: Adaptive Optics,Wide-Dynamic-Range Wavefront Control, Image Metric Optimization,Wavefront Sensing, Wavefront Control

AF05-004 TITLE: Laser Vibrometry System for Space Situational Awareness

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a ground-based laser transmitter and receiver system capable of performing vibrometry measurements of orbiting satellites.

DESCRIPTION: Development and delivery of a ground-based laser transmitter and receiver system capable of performing vibrometry measurements of orbiting satellites is desired. The delivered system should include all components required to perform operational testing on ground-based targets (laser transmitter, receiver telescope, detector, electronics, etc.). The receiver system bandwidth should be designed to measure vibration power spectral density from a few Hz to approximately 1 kHz. To perform ground-based vibrometry measurements of orbiting

satellites, the system should be designed to be able to interface with existing all-reflective telescope facilities with primary aperture diameters of 0.6 m or larger. When using an existing 0.6 m diameter telescope, the system should be capable of receiving sufficient signal levels to make vibrometry measurements from non-cooperative satellites (satellites without retroreflectors) at altitudes of up to 1000 km. The design should be analyzed and compared with other laser vibrometry techniques with respect to return signal levels, accuracy of vibrometry measurements, and mitigation of target-induced speckle and atmospheric turbulence effects.

PHASE I: Define the laser transmitter and receiver design, and begin development and characterization of key components. Perform research on the feasibility and capabilities of critical and/or innovative components. Evaluate and optimize design characteristics with respect to mitigation of deleterious effects caused by target-induced speckle and atmospheric turbulence.

PHASE II: Develop the component design, fabricate prototype hardware, and perform ground-based testing and characterization of the system using ground targets.

DUAL USE COMMERCIALIZATION: The Phase II prototype system would provide an interim operational capability at existing ground telescope facilities (such as Maui Space Surveillance System MSSS and Starfire Optical Range SOR) for monitoring the operating status of satellites, and providing change detection. The proposed system would find utility in remote monitoring of commercial satellite equipment operating status and health with minimal or no modification.

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KEYWORDS: Vibrometry,laser vibrometry,satellite vibrometry, heterodyne lidar,heterodyne ladar

AF05-005 TITLE: Refractory Coatings on Mechanically Resilient Insulators

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop the ability to put refractory coatings on mechanically resilient insulators.

DESCRIPTION: Develop refractory surfaces for large plastic insulators with complex shapes. Refractory surfaces are desirable for insulator-vacuum interfaces for repetitively operated electron beam tubes (such as High Power Microwave tubes), for co-axial plasma guns, both single shot and repetitively operated (for intense radiation sources and for high specific impulse thrusters), and for other pulsed power applications. Plastic insulators have more desirable mechanical resiliency properties and are much easier and more economical to form and machine into complex shapes, which are needed for some pulsed power applications. Combining the benefits of refractory surfaces and plastic insulators, for large sizes and complex shapes, will advance pulse power considerably. Test the function and durability of such insulators in generic electron beam tube discharges or plasma gun discharges. An important feature is avoiding detachment of the refractory coating from the plastic insulator. Previous attempts to do this with diamond-like coatings encountered problems with inadequate adhesion, at least for the discharge power densities and geometries attempted (see references). Develop an initial commercialization concept and plan.

PHASE I: Develop refractory surfaces for large plastic insulators with complex shapes. Develop an initial commercialization concept and plan.

PHASE II: Develop prototype refractory coated plastic insulators for practical scale HPM tubes and/or plasma thrusters and/or intense radiation sources. Design and demonstrate a prototype system for limited production of such insulators and demonstrate the feasibility of the process. Develop business and commercialization plan for a Phase III engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military uses for this include more rugged insulators for HPM tubes, particle beam devices, and other pulsed power driven devices. Civilian applications include more durable insulators for medical X-ray and particle beam accelerators, compact and portable radiography pulsers, and large research facilities.

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4. See also various NASA Tech Notes.

KEYWORDS: Refractory coatings,mechanically resilient insulators

AF05-006 TITLE: Tuneable Low Frequency Microwave Source

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop high voltage microwave source in the 100-700MHz range capable of delivering 300kV damped sine waveforms into a 100-ohm load with a repetition rate of several kHz.

DESCRIPTION: Develop and demonstrate design concepts for a compact, lightweight pulsed power generator system capable of delivering repetition frequencies of several kHz at voltages ranging from 100-300kV into an approximately 100-ohm load such as a wideband antenna or transmission line. The frequency and damping constant must be adjustable, either in one unit or in several exchangeable units. Present designs for high voltage damped sine generators are designed around a quarter-wave transmission line stub fed by a resonant transformer, then shorted at one end with a gas or oil switch. Such oscillators work well and can be charged to several hundred kV. They damp out in 5 to 10 cycles depending on the load. (Higher Q is better.) However, these oscillators are typically designed for one single frequency and damping constant, so they must be changed out to a different size when changing frequencies. For future Department of Defense applications, it is desirable to develop compact, lightweight, high voltage technology that can be tuned over some range of frequency and damping constant.

PHASE I: Develop new pulsed power generator concepts with an eye toward developing technology capable of delivering the required output. Build and test a working model capable of at least 100 kV and 1 second bursts of fast repetition rate pulses. Develop an initial commercialization concept and plan.

PHASE II: Develop and demonstrate a prototype high voltage, damped sinewave 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 uses of this technology include airborne and ground-based pulsed radar systems and high power microwave systems. Civilian sector applications include pulsed radar, electronics effects testing, counter mine, and numerous manufacturing applications.

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KEYWORDS: Electromagnetics,Pulsed Power,High Power Microwave HPM, Marx Generator, Transformers, Triggered Switch, High Voltage; Transient

AF05-007 TITLE: Solid State Ultra-Wideband Microwave Source

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Development of a high-power-solid state ultra-wideband (UWB) source for use with impulse sensor systems.

DESCRIPTION: This effort will develop and demonstrate design concepts for a compact, lightweight solid-state source capable of generating UWB transients with bandwidths of over a decade, generally from 100 MHz to 2 GHz. Voltage output needs to be over 100 kV with a sub-nanosecond risetime and a pulse duration in the range of 2-8 nanoseconds. Pulse repetition frequency range needs to exceed 2 kHz.

Current solid-state UWB pulser technology is based on either Si or GaAs technology. New developments in SiC solid-state switching devices are now making possible significant increases in power handling capability while still preserving the fast risetimes needed for UWB performance. For future Department of Defense applications, it is desirable to develop compact, lightweight, solid-state source technology.

PHASE I: Develop new UWB high power microwave source concepts with an eye toward developing technology capable of delivering the required output. Build and test a working model capable of at least 100 kV and 1 second bursts of fast repetition rate pulses. Develop an initial commercialization concept and plan.

PHASE II: Develop and demonstrate a prototype high voltage UWB source 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 uses of this technology include airborne and ground-based pulsed radar systems. Civilian sector applications include pulsed radar, counter mine systems, and numerous manufacturing applications.

REFERENCES:
1. I.V. Grekhov, "4H-SiC Inverse Recovery Diodes (IRD) for Sub-Nanosecond Power Opening Switches," AMEREM02, Annapolis MD, June 2002.

2. C.A. Frost, "Multi-kilovolt Solid State Photo-conductive Switch Studies," Proc 13th IEEE Pulsed Power Conf, Las Vegas, June 2001.

3. C.A. Frost and M.J. Walker, "Ultra-Wideband Impulse Source Based on Solid-State Switched Phased Array," National Radio Science Meeting, Boulder CO, January 2001.

4. A. Kardo-Sysoev, V. Brylevsky, Y. Lelikov, I. Smirnova, S. Zazulin, and I. Tchashnicov, "Ultra-wideband Solid State Pulsed Antenna Array," Ultra-Wideband, Short-Pulse Electromagnetics 5, P.D. Smith, et al., (eds.), Plenum Press, NY, 2002.

KEYWORDS: Electromagnetics,Pulsed Power,High Power Microwave HPM, Marx Generator, Transformers, Triggered Switch, High Voltage; Transient

AF05-008 TITLE: High-Power, Optical Fiber Coupling

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

OBJECTIVE: Optimize and demonstrate optical fibers that deliver multiple wavelengths in the mid-IR to 10-micron range.

DESCRIPTION: It is desirable to combine near infrared to long-wave length infrared lasers into a single optical fiber that can be coupled into existing systems. The fiber coupling technology and optical transport fibers must transmit multiple wavelengths with low loss and survive gigawatts per square centimeter powers over a 3 to 10 meter distance. The numerical aperture should be 0.2 or less. The fibers should have high thresholds for thermal, bending and tensile stress. There are many important applications for fiber-coupled, mid-infrared lasers. These applications include infrared countermeasures (IRCM), infrared imaging, target designation, trace gas sensing, and medical applications.

PHASE I: Identify unique fiber solutions to coupling multiple wavelengths in the mid-IR to 10-micron range into one fiber. Fabricate optical fiber samples and characterize the numerical aperture, losses and other optical characteristics for wavelengths in the near-IR to 10 microns. Coupling technology shall be demonstrated through modeling and simulation.

PHASE II: Optimize and demonstrate optical fibers that deliver multiple wavelengths in the mid-IR to 10-micron range. Demonstrate low loss, high strength and high power capability. Coupling multiple wavelengths into one fiber shall be demonstrated. Prototype optical fibers and optical coupling technology will be delivered at the end of Phase II for characterization and evaluation.

DUAL USE COMMERCIALIZATION: High-power lasers in the near-IR to LWIR are highly relevant to defense and commercial applications. The proposed technology has potential applications in gas sensing systems for environmental monitoring, explosive detection and industrial process monitoring sensors. In addition, this technology is highly relevant to homeland defense applications.

REFERENCES:
1. Y. Raichlin, E. Shulzinger, A. Millo and A. Katzir, "Fiberoptic Evanescent Wave Spectroscopy (FEWS) System and Its Application in Science, Industry, Medicine and Environmental Protection," 5th International Conference on Mid-Infrared Optoelectronic Materials and Devices, September 8 – 11, 2002.
2. J. S. Sanghera, V. Q. Nguyen, P. C. Puresa, R. E. Miklos, F. H. Kung, and I. D. Aggarwal, "Fabrication of Long Lengths of Low-Loss IR Transmitting As40S(60-c)Sec Glass Fibers," Journal of Lightwave Technology, Vol 14, No. 5, May 1996.
3. M. Mossadegh, J. S. Sanghera, D. Schaafsma, B. J. Cole, V. Q. Nguyen, R. E. Miklos, and I D. Aggarwal, "Fabrication of Single-Mode Chalcogenide Optical Fiber," Journal of Lightwave Tech, Vol 16, No. 2, February 1998.
4. J. A. Harrington and A Katzir, "Specialty IR Fibers Tackle Tough Problems," Laser Focus, Vol. 27, No. 6, June 1991.

KEYWORDS: Laser,Fiber,Coupling,Near-Infrared,Mid-Infrared,Long-Wavelength Infrared,Optical Fiber,High-Power

AF05-009 TITLE: Simulation of Extended Scene Imaging through Turbulence

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop techniques for simulating extended scene imaging through atmospheric turbulence to reduce computational requirements by a factor of ten while preserving the key characteristics of turbulence.

DESCRIPTION: Current approaches used in simulating the propagation of electromagnetic waves through atmospheric turbulence involve methods based on Fast Fourier Transform (FFT) techniques. Although these techniques are fast on a single propagation, some applications require numerous propagations of very large arrays. As an example, the simulation of incoherent imaging of extended scenes, with spatially varying point spread functions, is very computationally intensive. An application for which such computationally intensive simulations are required is furnished by the need to model laser weapons systems that engage targets surrounded by background clutter. Evaluations of tracker performance would require propagation simulations that accurately model both the target and background imagery. For the long engagement ranges that would be desirable for such a system, the isoplanatic angle can be on the order of the diffraction limit. To simulate such an image using multiple point spread functions may require thousands of propagations for each time step of the simulation. This computational burden is compounded by the need to perform time-varying, closed-loop analysis. Techniques are being sought that reduce these computational requirements by at least an order of magnitude while still preserving the essential characteristics of extended scene imaging through atmospheric turbulence. In order to simulate closed-loop turbulence compensation, the simulations should allow propagation in both directions.

PHASE I: Develop a technique for modeling the propagation of light through atmospheric turbulence that demonstrates a significant decrease (by an order of magnitude) in the computational burden compared to use of the standard FFT techniques while still preserving the essential characteristics of atmospheric turbulence. Performance analysis and modeling shall establish technique feasibility.

PHASE II: Develop the propagation algorithm and demonstrate the concept on a wide range of propagation and imaging problems using the technique developed in Phase I. Typical problems would include tracking for laser scenarios, air-to-ground propagation, and tracking targets with cluttered backgrounds. Final deliverable would include an integrated package for propagation through atmospheric turbulence using the developed algorithm.

DUAL USE COMMERCIALIZATION: It is expected that a rapid computation propagation model, based on the concepts proposed under this research would have both commercial and military applications. The military applications include all those with requirements for modeling of closed-loop laser systems propagating through turbulent media. Commercial markets include areas such as astronomy, laser communications, and power beaming.

REFERENCES:
1. L. C. Andrews and R. L. Phillips, “Laser Propagation through Random Media,” SPIE Optical Engineering Press, Bellingham, WA, (1998).

2. M. C. Roggemann and B. Welsh, ”Imaging through Turbulence,” CRC Press, Boca Raton, FL, (1996).

KEYWORDS: Adaptive optics,modeling of laser propagation, incoherent imaging,atmospheric turbulence,turbulent media,airborne laser

AF05-010 TITLE: Aero-Optics Research & Development

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop compensation methods for high-energy laser degradation suffered when an aircraft propagates a high engery laser HEL through platform-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 its effects.

The purpose of this effort is to develop advanced AO technologies to permit high bandwidth 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 "mirror" 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: Develop a subsystem or component in lieu of a complete AO system. 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 concept, or turret design, etc. Performance analysis and modeling shall establish concept feasibility.

PHASE II: Demonstrate, in a cost effective way without utilizing expensive wind tunnels, the enhanced adaptive optics capabilities and/or flow control methodologies based on the approach developed in Phase I.

DUAL USE COMMERCIALIZATION: The military applications include all those with requirements for atmospheric compensation through turbulent media and from moving platforms to moving targets. The commercial market includes such areas as astronomy, laser communications, and power beaming.

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

2. Fitzgerald, E.J. and Jumper, E.J. (2002) "Scaling Aero-Optic Aberrations Produced by High-Subsonic-Mach Shear Layers," AIAA Journal, 40(7), 1373-1381.

3. Jones, Mike I. And Erich E. Bender (2001) "CFD-Based Computer Simulation of Optical Turbulence Through Aircraft Flowfields and Wakes," AIAA Paper 2001-2798.

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5. Oljaca, M., and Glezer, A. (1997) "Measurements of Aero-Optical Effects in a Plane Shear Layer," AIAA Paper 97-2352.

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

AF05-011 TITLE: Algorithms for Stereo Image Creation from a Sequence of Two Dimensional Images

TECHNOLOGY AREAS: Information Systems, Space Platforms

OBJECTIVE: Develop an algorithm capable of selecting appropriate image pairs from a sequence of images and properly combining them to create a single stereo image.

DESCRIPTION: Ground based space surveillance sensors capture not single snapshots, but sequences of images of a satellite as it passes overhead. Due to the satellite's motion (position and orientation) relative to the sensor, the sequence contains numerous, slightly different, views of the satellite. It should be possible to develop an algorithm that would select image pairs from this sequence and combine each pair in such a way so as to create a single stereo image. The desired output is a sequence of stereo images of the satellite depicting its motion and rotation in space. Further, it should be possible to do this in real time without any human interaction. The crux of this problem lies in the fact that the satellites orientation is completely unknown. The satellite may be tumbling or slewing during the image pass and the algorithm neither has any control over this motion nor any a priori knowledge of it. Current techniques for selecting stereo image pairs either assume precise knowledge of the subject's orientation and angular velocity (e.g. National Geospatial-Intelligence Agency NGA's creation of 3D terrain data), or amount too little more than "guess and check" iteration with a human in the loop. Unfortunately, both of these approaches are inadequate when dealing with imagery of a non-cooperative space object. While the imaged space object's position and velocity may be known at any given time, its orientation and angular rotation are not. Further, the "guess and check" method is too time-consuming, subjective, and error-prone to be of any real value to a space analyst.

PHASE I: Investigate and validate one or more approaches to the problems of automatically selecting suitable image pairs for stereo image creation and properly combining them to create a stereo image. Any sequence of images is acceptable as long as the camera's frame rate does not exceed two frames per second and the algorithm does not require knowledge of either the camera's or the target's position and orientation.

PHASE II: Apply these algorithms to the space surveillance imagery collected by the Air Force. All data available at the time should be processed and the results analyzed. If necessary, optimize the algorithm for this space surveillance imagery. The data to be used in Phase II will include imagery collected from the sensors at the Maui Space Surveillance System (MSSS, AFRL/DEBI) and the data collected from both the XSS-10 and XSS-11 missions.

DUAL USE COMMERCIALIZATION: This technology could be used to enhance any sequence of images. One extension of this research would be to apply the same techniques to help the military paint a clearer picture of the air, ground and sea battlefields as well. In the commercial world, this technology could be used to turn regular surveillance video into enhanced, three-dimensional footage. The added dimensionality could aid in detecting nefarious activity. The same thing could be done for standard Hollywood movies: they could be transformed into 3D movies without requiring any new camera footage.

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1. Air Force Research Laboratory, "Success Story: XSS-10 Micro-satellite Demonstration Program," http://www.afrl.af.mil/successstories/2003/emerging_technologies/03-vs-06.pdf.
2. Air Force Research Laboratory, "AMOS User's Manual," http://www.maui.afmc.af.mil/publications.html.

KEYWORDS: Stereo Image,3D Image,Image Processing,Algorithm,Image Sequences,Space Surveillance Imagery,Image Fusion

AF05-012 TITLE: Compact Ultra-Wideband Target Identification System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Development of a very compact, lightweight, high power, solid-state ultra-wideband (UWB) transient radar system for location and identification of concealed targets.

DESCRIPTION: This effort will develop and demonstrate design concepts for a very compact, lightweight solid-state transient radar receiving and processing system for adaptation to airborne, ground vehicle, or man-portable operations. This effort should concentrate on the development of UWB receiving and data processing as very fast, solid-state transmitting systems are available elsewhere. The system should operate as a transient transmitter and receiver system with hardware and software for processing wideband scattered information in order to obtain identifying information.

Very fast transient digitizers are currently available from a number of commercial manufacturers. They are designed for laboratory use in a 19" rack mount and require 110v power. However, current military and civilian law enforcement needs are for a hand-carried, battery-powered unit that can locate and identify targets behind walls or foliage. This requires a receiver/digitizer and a processor that uses only the essential electronics for the desired function. For future Department of Defense applications, it is desirable to develop compact, lightweight, solid-state digitizer/receiver technology.

PHASE I: Develop an ultra-compact digitizer/receiver technology in support of UWB transient radar concepts with an eye toward developing technology capable of locating and identifying concealed objects. Phase I will build and test a working model and will develop an initial commercialization concept and plan.

PHASE II: Develop and demonstrate a prototype man-portable unit consisting of an UWB transient radar system capable of locating and identifying concealed objects in a clutter from a target library. Develop a business and commercialization plan for the Phase II engineering development and marketing program.

DUAL USE COMMERCIALIZATION: Military uses of this technology include airborne and ground-based pulsed radar systems. Civilian sector applications include pulsed radar for law enforcement and public safety and counter mine systems.

REFERENCES:
1. K.J. Pascoe, et al., "Target Recognition via Late Time Scattering," Ultra Wideband/Short-Pulse Electromagnetics 6, Eric Mokole, Mark Kragalott, and Karl Gerlach, eds, Plenum, New York, 2003.

2. W. A. Chamma, S. Kashyap, "Detection of Targets Behind Walls Using Ultra Wideband Short Pulse," Ultra-wideband Short-Pulse Electromagnetics 6, Kluwer Academic/Plenum Publishers, New York, ISBN:0-306-47481-6.

KEYWORDS: Microwave,ultra-wideband,target identification,radar, sensors,portable,solid-state

AF05-014 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREAS: Sensors, Electronics

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

DESCRIPTION: The Spectral Surveillance Technologies Section (AFRL/VSBYH) of the Air Force Research Laboratory's Battlespace Surveillance Innovation Center is interested in innovative techniques for the mitigation of clutter effects in an effective and computationally efficient manner to optimize the performance of space-based optical (visible and infrared) systems. Mitigation requires advanced algorithms based upon spatial, temporal and spectral techniques. Data from airborne and space-based missions has led to a database of optical data (visible and infrared) to characterize the optical properties of the environment. It is expected that the proposals will exploit these databases to explore potential space-based techniques for clutter-mitigation/contrast-enhancement techniques to develop, validate and optimize signature-based object-detection algorithms. 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 materials identification, enhanced probability of object detection in structured backgrounds and reduced false-alarm rates.

PHASE I: Conduct analyses, using real data, to develop algorithms for clutter-mitigation/contrast-enhancement techniques to optimize object detection, search and track capabilities in structured environments. Compare and contrast the candidate algorithms.

PHASE II: Perform detailed analyses and demonstrate the efficacy of algorithms for target detection, search, and track in structured environments. 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 sensor clutter induced by scene structure and the data-collection process, and spectral interferences. They will potentially also be useful for non-military applications involving autonomous detection under similar conditions of scene-induced and sensor-induced clutter and noise and spectral interferences. Potential commercial examples include a processing system for application in fields such as medicine, industrial processing, and quality control.

REFERENCES:
1. "Algorithms for Multispectral and Hyperspectral Imagery," SPIE Conference Proceedings, Orlando, FL, Apr 94, A.E. Iverson, ed.

2. Classification of Hyperspectral Images Using Wavelet Transforms and Neural Networks, T. Moon and E. Merenyi in "Wavelet Applications in Signal and Image Processing III," Proceedings of the SPIE Meeting, San Diego, CA, July 12-14, 1995, Pt. 2, Vol. 2569, 1995, 725-735.

3. Thermal Imagery Spectral Analysis, B.H. Collins et al., Proceedings of the SPIE Meeting, San Diego, CA, 28-30 Jul 1997, "Imaging Spectrometry III," 94-105.

4. Target Detection in a Forest Environment Using Spectral Imagery, R.C. Olsen et al., Proceedings of the SPIE Meeting, San Diego, CA, Jul 28-30, 1997,
"Imaging Spectrometry III," 46-56.

5. Unsupervised Interference Rejection Approach to Target Detection and Classification for Hperspectral Imagery, C. Chang et al.., Opt. Eng. 37 (3) 735 (Mar 98).

KEYWORDS: Multispectral,Hyperspectral,Ultraspectral,Visible, Infrared,Data Analysis,Data Processing,Algorithms

AF05-015 TITLE: Electronically Scanned Array (ESA) Antenna Transmit/Receive Module

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a high efficiency and high bandwidth transmit/receive module for space based electronically scanned array applications, including Space Based Radar.

DESCRIPTION: Future Space Based Radar (SBR) constellation will use the most advanced transmitter/receiver design for its payload. SBR missions include persistent near real time tracking of Moving Targets Indications (MTI), High Resolution Terrain Information (HRTI) and Synthetic Aperture Radar (SAR) imaging. SBR requires high bandwidth cross-links within its constellation and to the ground. This requires multiple beams and high efficiency transmit and receive modules. These modules will require low power and a substantial reduction in mass and volume in order to meet the 2kg/ft2 SBR goal.

PHASE I: Develop a detailed feasibility plan on how to enhance transmitter/receiver performance, how to produce such a transmitter, and how to conduct all necessary testing. When high payoff technology is identified, models predicting the potential payoff should be developed and utilized for use in Analysis of Alternatives (AOA).

PHASE II: Develop a cost-effective, lightweight, affordable prototype transmitter/receiver module. Fabricate and test the unit to verify its performance and reliability. Subsystems which can be space qualified will be designed, and any high risk implementations will be demonstrated with an appropriate ground demonstration in a relevant environment.

DUAL USE COMMERCIALIZATION: This enhanced transmitter receiver technology will benefit commercial and military communication satellite systems in terms of being lightweight and having lower cost. Provide a representative module capable of integration into a ground test-bed and later to be evaluated at a near field and far field range.

REFERENCES:
1. Ludwig, M.; Feldle, H.P.; Ott, H., "A Miniaturized X-band T/R - Module for SAR Systems Based on Active Phased Array Technologies," Geoscience and Remote Sensing Symposium. IGARSS, IEEE International Meeting, 2063-2065, July 10, 1995.
2. Tollefson, M.V.; Preiss, B.K., "Space Based Radar Constellation Optimization," Aerospace Conference Proceedings, IEEE Meeting; 379-388, March 21, 1998.

KEYWORDS: Electronics,Transmitter/Receiver,Electronic Scan Array Antenna,Transmit and Receive Modules for Space Based Applications,Space Qualified Radio Frequency Transmit,Receiver Antenna

AF05-017 TITLE: Field Programmable Gate Array Based Channelizer

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

OBJECTIVE: Develop a power efficient reconfigurable channelizer.

DESCRIPTION: Transformational Communications will require the development of many different digital processing functions, including Fourier transforms, data acquisition processors, narrowband and wideband channelizers, low pass filters, and data multiplexes. Channelization is the process of subdividing the bandwidth of a circuit into smaller increments. Typically, each channel carries an individual transmission. Channel coding refers to the class of signal transformations designed to improve communications performance by enabling the transmitted signals to better withstand the effects of various channel impairments, such as noise, fading, and jamming. Usually the goal of channel coding is to reduce the probability of bit error rate or required signal to noise level at the cost of expending more bandwidth than would otherwise be necessary. The purpose of this Small Business Innovation Research topic is to develop a hardened, low-power, Field Programmable Gate Array FPGA capable of performing the channel coding process. Field programmable technology can dramatically reduce development costs by facilitating the rapid development of customized circuits. Desirable FPGA properties include high gate counts, high throughput, low power consumption and programming flexibility. For space use, radiation effects are of paramount concern, in particular latch up immunity and single event effect suppression. Example goals for this project:

Channelizer concept must support a capability to develop up to 25 20 MHz channels that can be selectively combined into one or more 100 MHz channels.

FPGA goals include useable gate count > 10 million usable gates, access time < 10 ns, power consumption < .1 microwatt / gate. Operating voltage < 3.3 volts, operating temperature range -40 deg C to + 80 deg C, radiation tolerant to 100 Krad (Si), SEE immunity > 60 MEV, no single event latch up.

PHASE I: Develop a FPGA based channelizer concept/design, including process and utilization. Determine how radiation hardened channelizer devices will be produced by existing foundries. Provide an operational computer simulation of the channelizer design.

PHASE II: Fabricate working, programmable channelizer structures and/or devices, including test vehicles, for proof of concept and evaluation. Perform testing/analysis to fully describe all pertinent characteristics of device operation, including (among other issues) programmability, speed, operating voltage range, temperature range, and radiation characteristics.

DUAL USE COMMERCIALIZATION: Programmable Gate Arrays are not only an important military technology utilized in tanks, airplanes, helicopters, and spacecraft they have a ubiquitous appeal, but their use will also apply to a wide variety of consumer electronics, including cellular phones, electronic games, computers, and automobiles. Limited production systems

REFERENCES:
1. E. Hamdy, et. al., "Dielectric Based Antifuse for Logic and Memory IC," IEDM, 786-789, 1988.

2. Haines, "Field-Programmable Gate Arrays with Non-Volatile Configuration," Microprocessors and Microsystems, Vol. 13, No 5, 786-789.
3. John Wiley and Sons, Inc.,S. Sze, "Physics of Semiconductor Devices," 2nd Edition, 402-407, 1981.

KEYWORDS: Channelizer,Field Programmable Gate Array,Digital Signal Processing, Wideband,Narrowband

AF05-018 TITLE: Radiation-Hardened By Design Techniques for Total Dose and Single Event Upset

TECHNOLOGY AREAS: Materials/Processes, Electronics, Space Platforms

OBJECTIVE: Develop new device designs and layouts in conjunction with circuit configurations that enable the production of low power, high performance, and radiation-hardened integrated circuits.

DESCRIPTION: The ionizing radiation environment outside of earth's atmosphere poses an ever-present threat to the microelectronic devices that are employed in space vehicles. As device sizes get smaller, the susceptibility to total ionizing dose (TID) induced edge leakage, as well as to single event effects, increases. Traditional radiation hardening techniques that involve special radiation-hardened manufacturing processes are considered to be too expensive with too much required lead-time for most of today's space missions. Radiation hardening by design (RHBD), on the other hand, makes use of available commercial fabrication lines. This approach involves designing circuits in such a way as to minimize susceptibility to harmful radiation effects. Radiation hardening by design (RHBD) has produced good radiation-hardened designs such as the dog bone and re-entrant n-channel, metal oxide field-effect transistors (MOSFETs) as well as higher level layouts. Triple redundancy has also been used to combat single event transients. The drawback to these devices and circuit configurations is that design rules require a larger area, greater power consumption and reduced speed compared to the non-hardened counterparts. Consequently, the computational performance of these devices lags that of the non-hardened counterparts by several generations. Larger area, higher power consumption, and slower performance are currently accepted as a necessary compromise to obtain radiation hardness. It is envisioned that novel (RHBD) advances can be made that would ultimately close the gap between radiation-hardened and non-hardened performance. Phase I efforts should be directed toward the development of novel, radiation-hardened design concepts at the transistor and primitive cell level that are spatially compact in comparison to currently used, radiation-hardened designs. Careful attention should be given to overcoming single event latchup (SEL) and single event transient (SET) vulnerability, which increases with packing density. The key operational parameters of several different primitive cells utilizing the innovative design should be determined. Designs and device structures should be consistent with manufacturing processes available at state-of-the art commercial foundries.

PHASE I: Implement novel radiation-hardened device designs and circuit concepts in the design of several different primitive cells. Demonstrate proof-of-concept through modeling that these designs obtain improved radiation performance and can be integrated into silicon complementary metal oxide semiconductor field effect transistors (CMOS)/silicon-on-Insulator (SOI) processes. Goals are to withstand 300 Krad of Total Ionizing Dose (TID), have no Single Event Latchup (SEL), and no Single Event Upset (SEU) up to a Linear Energy Transfer (LET) of 40 MeV cm2/mg.

PHASE II: Deliver prototype primitive cells representing basic, fundamental logic functions performed as part of and in context of a higher set of defined functions. Prototypes of these primitive cells, the building blocks of more complex circuits and functions, are to be delivered for characterization and evaluation with regard to system performance and radiation hardness to (TID), (SEL), and (SEU).

DUAL USE COMMERCIALIZATION: Every federal and commercial organization that is involved in putting vehicles into space would greatly benefit by having access to high performance, radiation-hardened microelectronics that are readily produced. The Department of Defense also has many non-space applications for radiation-hardened microelectronics. High reliability aircraft avionics, control electronics for reactors, high reliability electronics use at high terrestrial elevations, medical electronics, electronics for nuclear weapons applications. Cells that were developed and delivered in Phase II should be funded by non-SBIR funds.

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KEYWORDS: Radiation Hardened,Hardened by Design,Low Power,Single Event,Upset, Mixed-Signal,Digital

AF05-019 TITLE: Combined Analog-to-Digital Converter and Demodulator

TECHNOLOGY AREAS:

OBJECTIVE: Combine analog-to-digital converter (ADC) and demodulator functions in a single package

DESCRIPTION: As data rates broadcast over satellite communications links continue to increase to meet the communication needs of tomorrow's warfighters, future communications satellites can be expected to process at significantly higher data rates. In lockstep, microelectronics gate densities are expected to continue increasing at an exponential pace enabling multifeatured mixed mode microcircuits able to process at the projected communications data rates. The front end digital processing of a communications satellite typically consists of an analog-to-digital converter (ADC) followed by the demodulator. The ADC digitizes the incoming (uplinked) data and the demodulator converts the signal information into symbols. As the conversion rate of the ADC increases timing difficulties associated with propagation delays and transmission line effects become increasingly prominent for data transfers between the ADC and the demodulator application specific integrated circuit ASIC. One means of accommodating the high data rate is to integrate the ADC and demodulator together onto a single integrated circuit (IC). The purpose of this topic is to develop a full featured mixed mode IC with a high performance ADC on the front end and a fully functional demodulator ASIC on the back end with all high speed data paths confined to a single package. Goals for the ADC/demodulator IC (ADIC) include >10 Gbps conversion rate, accuracy of ± .5 least significant bit LSB, resolution >12-bits. Additional goals include gain flatness at Nyquist of < .1dB, channel-to-channel isolation >80 dB [TBR], < 2.5V operating voltage, power consumption < 2W and operating temperature range between -40 to +85 deg C.

PHASE I: Develop a set of performance goals for the ASIC performance based on current and projected needs of commercial and military satellite programs. Survey applicable modulation modes and, in concert with the Air Force, select a promising modulation format (Guasian Minimum Shift Keying) and design an ADIC that is consistent with the desired performance parameters. Provide a computer simulation of the chosen design. In parallel develop a preliminary fabrication and test plan.

PHASE II: Finalize the design of the Phase I ASIC and fabricate >/= 10 test chips on a radiation-tolerant fabrication line. Compare performance of the test ASICs to the performance goals through appropriate demonstrations. Document the performance characteristics of test ASIC including (among other characteristics) conversion rate, power consumption, linearity, and channel isolation. Test ASIC samples shall be delivered to the government for evaluation.

DUAL USE COMMERCIALIZATION: Research and development leading to combined ADC and demodulators could benefit consumer electronics such as cell phones and television as well as military communications terminals.

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KEYWORDS: Analog-to-Digital Converter,Application Specific Integrated Circuit ASIC,Mixed Mode Integrated Circuit,Demodulator,Digital Processing,Digitizer

AF05-020 TITLE: Chalcogenide Based Field Programmable Gate Array

TECHNOLOGY AREAS:

OBJECTIVE: Demonstrate feasibility of chalocoginide based Field Programmable Gate Array FPGA.

DESCRIPTION: Requirements for satellite payload data processing flexibility are expected to increase significantly to accommodate forward compatibility, reconfigurability and to minimize non-recurring costs during the early stages of payload development. Field Programmable Gate Arrays (FPGAs) enable flexibility because of their reprogrammability and are expected to find increasing use in future satellite payload digital processing subsystems. In order to maximize their potential for insertion into future missions, however, it is important to optimize FPGA gate density, speed and radiation tolerance, all of which are impacted by the FPGA's programming technology. Program storage for FPGA devices is often based on Flash, SRAM (Static Random Access Memory) EEPROM (Electrically Erasable Programmable Read-Only Memory) or Anti-Fuse connectivity. Chalcogenide-Based Random Access Memory (CRAM) offers a radiation hard alternative to Flash, SRAM and EEPROM. By using thin film materials with relatively small, active Chalcogenide storage elements, CRAM can achieve higher densities, and higher speeds than SRAM, Flash, or EEPROM. Because it is inherently resistant to radiation effects, CRAM is an ideal choice for space-based embedded memory applications. Furthermore, chalcogenide is capable of repeatably resolving many more than two signal levels, so more information can be stored if this mechanism can be exploited. One intriguing possibility is to form programmable threshold logic elements, which may (when combined with an appropriate synthesis scheme) result in an FPGA with much greater expressive capacity than a standard architecture.

The purpose of this topic is to design, fabricate and characterize a FPGA using chalcogenide memory in place of SRAM or EEPROM. Goals include integrating three or more FPGA logic gates with CRAM cells, and fabricating several CRAM based FPGA TCV's (Test Characterization Vehicles), which can be characterized for speed, power consumption, and radiation tolerance.

PHASE I: Survey FPGA designs and select a promising design that would include a chalcogenide-based memory cell. Design a chalcogenide based FPGA and validate operation using a suitable device simulation tool.

PHASE II: Fabricate a minimum of eight chalcogenide-based FPGA test devices and characterize for appropriate performance parameters including (among others) programmability, access time, reliability, radiation resistance and operational temperature range.

DUAL USE COMMERCIALIZATION: Chalcogenide based FPGAs would be suitable for insertion in a wide range of military and consumer electronics including cellular phones and Personal Digital Assistants.

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KEYWORDS: Field Programmable Gate Array,Chalcogenide Memory, Reprogrammable,Nonvolatile Memory,Static Random Access Memory (SRAM),Electrically Erasable Programmable Read-Only Memory (EEPROM),Chalcogenide-Based Random Access Memory

AF05-021 TITLE: MicroElectro Mechanical Systems MEMS Based, Electronically Steerable, Phased Array Antenna

TECHNOLOGY AREAS:

OBJECTIVE: Develop and demonstrate a MicroElectro Mechanical Systems MEMS-based, electronically steerable, phase shifter for a phased array antenna.

DESCRIPTION: Phased array antennas have several advantages over mechanically steered antennas. They are lighter in weight, more agile, and induce no angular momentum to the satellite when redirecting the beam. Phased array antennas have traditionally used MMIC (Monolithic Microwave Integrated Circuits) phase shifters, which have two shortcomings: they can contribute substantially to the cost of fabrication and tend to introduce a relatively high insertion loss. MEMS- controlled phase shifters have recently been demonstrated that show promise in lowering MMIC cost and insertion loss with lower parasitics and higher linearity. The purpose of this topic is to develop and demonstrate a MEMS-controlled phase shifter in a multi-element sub-array design capable of space qualification. Goals include insertion loss below 1 dB, phase shift range of 0 to 360 degrees, operating temperature range of –40 to +85 degrees Centigrade, and a capacitance ratio > 2.5.

PHASE I: Design a multi-bit MEMS phase shifter, select an operating frequency band and simulate operation, including phase delay and insertion loss, across the frequency band.

PHASE II: Manufacture and integrate a minimum of two multi-bit MEMS phase shifters into a phased array antenna subarray.

DUAL USE COMMERCIALIZATION: Commercial communications satellites in LEO (Low Earth Orbit) and MEO (Medium Earth Orbit) could benefit from this technology by reducing costs, lowering power and improving performance of phased array antennas.

REFERENCES:
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3. J. Hayden and G. Rebeiz, “Low-Loss Cascadable MEMS Distributed X-Band Phase Shifters,” IEEE Microwave and Guided Wave Letters, November 1999.

KEYWORDS: MicroElectro Mechanical Systems MEMS,Antenna,Phase Shifter,Phase Delay,Transmission Line,Phased Array

AF05-022 TITLE: Radiation-Resistant Solar Cell Coverglass

TECHNOLOGY AREAS:

OBJECTIVE: Develop innovative solar cell coverglass materials and coatings with increased radiation resistance.

DESCRIPTION: The End-of-Life (EOL) power generation performance of satellite solar arrays would be improved by the use of coverglass materials and coatings with an increased resistance to radiation-induced darkening, especially in higher radiation orbits such as Half-Geo. Today's high efficiency multijunction solar cells require high performance, broadband coatings and coverglass materials. Ceria and other dopants are typically incorporated into solar cell coverglasses in order to decrease the darkening effects of radiation and to protect the coverglass adhesive from ultraviolet UV exposure. The coverglass can incorporate antireflective, conductive, and UV and near infrared IR reflector coatings. Commercially available solar cell coverglasses are capable of withstanding 15 years in geosynchronous earth orbit GEO and 10 years in low earth orbit LEO without darkening. New materials and

innovative solutions are sought to obtain similar lifetimes for coverglass in high radiation (Half-Geo) orbits. In addition, the materials must demonstrate resistance to electron and proton radiation profiles found in the half-GEO orbit. These new materials must maintain a high degree of spectral broadband transmissivity, withstand UV exposure, have high thermal emissivity, and possess a high index of refraction.

PHASE I: Develop and validate innovative technologies for the fabrication of solar cell coverglasses with increased radiation resistance, combined with broadband transmission and high emissivity. Provide demonstration of coverglass material.

PHASE II: Optimize one or more materials developed in Phase I and demonstrate radiation resistance on prototype coverglass samples. Provide detailed model for radiation-induced degradation of the coverglass and coatings.

DUAL USE COMMERCIALIZATION: This technology is applicable to both military and commercial satellite solar arrays and is enabling for higher radiation orbits. The improved End-of-Life EOL power generation capabilities of this technology will have broad application in future military space systems. Topic technology is similar for both military and commerical application.

REFERENCES:
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2. Summers, G.P.; Messenger, S.R.; Burke, E.A.; Xapsos, M.A., Walters, R.J., "Contribution of Low-Energy Protons to the Degradation of Shielded GaAs Solar Cells in Space," Progress in Photovoltaics: Research and Applications, 5 (1997) 407-413.

KEYWORDS: Solar Cell Coverglass,Coating Deposition Technologies,Solar Arrays,Optical Properties,Radiation Environments,End-of-Life (EOL)

AF05-023 TITLE: Next-Generation 30-45% Efficient Multi-Junction Solar Cell

TECHNOLOGY AREAS:

OBJECTIVE: Develop and demonstrate single-crystal, multijunction, 37+% conversion efficiency space solar cells for increased payload mass and power budgets.

DESCRIPTION: An increasingly higher level of electrical power is needed to run the ever-increasing complicated and diversified satellites that are assigned longer and more complex missions. Next-generation large satellite demands include increased power on orbit together with increased system specific power (W/Kg) and power stowed volume (W/m3) to increase satellite payload mass and power budgets. Satellite power generation is provided by solar photovoltaic cells. Advanced 37-40% efficient multijunction solar cells promise to reduce solar array size, mass, and enable significant power level scale-up. The multijunction solar cells contain multiple layers of light sensitive semiconductor material that optimize solar energy-to-electrical power conversion. Each layer in the solar cell stack optimally absorbs and converts a different part of the solar spectrum into electricity. High performance solar cells are required to provide added power for space missions without increasing solar array size or weight. This program will investigate new semiconductor material systems and solar cell device designs capable of achieving 37-45% efficiency Air Mass Zero(AM0) to increase space solar cell efficiency over recently developed 28-30% efficient solar cells. Advanced single-crystal multijunction solar cell designs will 1) Enable scale-up of military and commercial satellite power levels, 2) Significantly reduce solar array mass via increased solar cell efficiency; solar array size, mass, stowage volume and cost decrease with increasing cell efficiency, and/or, 3) Increase solar array power for constant solar array mass or size, and, 4) Provide a high volume, cost-effective production capability for space solar cells two generations ahead of any production solar cells available. For Phase I efforts, a strong emphasis should be placed on the validation of the design and component materials that are expected to provide the stated performance enhancements. The efficiency of the solar cell design should be validated through a model. The chosen material system must be currently matched for a two-terminal operation. While the preferred configuration is monolithic tandem, mechanical stacked approaches are also acceptable. Also, while a large area (>20cm2) 1-sun cell

design is preferred, concentrator solar cell designs are also of interest. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities must be provided with the proposal.

PHASE I: Develop and validate innovative approaches for producing a single-crystal multijunction space solar cell design having theoretical efficiencies greater than 37% (Air Mass Space (AM0), space spectrum). Solar cell modeling and design may be based on a wide range of semiconductor bandgaps, including ~2.0, 1.4, 1.0, and 0.7 electron volt (eV) material combinations. Appropriate bandgap values must be selected to insure current matching.

PHASE II: Develop/demonstrate the archetype production process, culminating in several >37% efficiency small area (~1-4cm2) prototype cells. Demonstrate the resulting experimental cells to mutually (Air Force/Contractor) agreed goals.

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

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2. M.A. Stan, D.J. Aiken, P.R. Sharps, et al, "27.5% Efficiency InGaP/InGaAs/Ge Advanced Triple Junction (ATJ) Space Solar Cells for High Volume Manufacturing," Proc. of the 29th IEEE Photovoltaic Specialists Conference, May 2002, New Orleans.

3. R.R. King, C.M. Fetzer, P.C. Colter, et al., "High-Efficiency Space and Terrestrial Multijunction Solar Cells Through Bandgap Control in Cell Structures," Proc. of the 29th IEEE Photovoltaic Specialists Conference, May 2002, New Orleans.

KEYWORDS: High-Efficiency Solar Cells,Multijunction Solar Cells, Space Power,Photovoltaics,Solar Arrays,Solar Energy-to-Electrical Power Conversion

AF05-024 TITLE: Design-Hardened Analog/Mixed-Signal Electronics

TECHNOLOGY AREAS: Materials/Processes, Electronics, Space Platforms

OBJECTIVE: Develop/catalogue low-cost, design hardening approaches to production of radiation hardened, continuous and sampled, analog systems for United States Air Force space systems.

DESCRIPTION: The possibility of a dwindling supply base for analog space electronics is real. Digital electronics are receiving most of the attention. Every space system however, utilizes considerable quantities of analog electronics, which are more vulnerable than digital electronics, to the effects of (total dose) radiation. This topic calls for creative solutions to making low-cost, radiation hardened analog electronics systems approaches available and accessible to satellite designers. Approaches must be based on design hardening methodologies, with the output of the research being a candidate cell library and toolset that can be used by satellite electronics designers.

PHASE I: Define and demonstrate the feasibility of important radiation-hardened analog components, circuits, processes, libraries, and/or related concepts as they apply to continuous and/or sampled analog systems. Emphasis should be placed on the synthesis of analog circuit functions relative to the realization of high performance analog-to-digital converters with the following performance goals: (1) bit resolution greater than or equal to 12 bits, (2) sample rates greater than 100 Mega samples per second, and (3) power consumption less than 250 milliwatts. Baseline radiation goals are the following: (1) total dose - 1Mrad, (2) single event latchup immune, and (3) single event upset with LET greater than 15, and bit error rates less than 1E-10 errors/bit-day. Definition of a prototype demonstration should occur with sufficient intellectual property to assure commercialization potential. This

prototype demonstration may consist of design algorithms or prototype tools and processes, which have commercial potential.

PHASE II: Provide a practical demonstration that establishes prototypical proof of the underlying concepts outlined in Phase I.

DUAL USE COMMERCIALIZATION: As all satellites require analog electronics, it is expected that this topic would be greatly beneficial for both military and commercial satellites.

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KEYWORDS: Analog,Field Programmable,Analog Arrays,Radiation-Hardened Electronics, Mixed-Signal,System-on-a-Chip

AF05-025 TITLE: Adaptive Tasking of Radar and Optical Sensors

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop approaches for adaptive tasking of radar and optical systems to optimize data collection for integrated utilization of radars and optical sensors for missile defense.

DESCRIPTION: Requirements for missile defense and space control dictate the need to apply new and evolving technologies and scientific understanding to the battlefield environment to ensure accurate detection, characterization, tracking and surveillance. This effort will explore using forecasts of atmospheric clutter to develop techniques that adapt sensor utilization to mitigate for the clutter limitations of RF and EO sensors. RF and EO sensors have signal detection limitations from background clutter or noise. These limitations can be exploited to selectively collect data based on projected quality. This would reduce the quantity collected, the processing required, and the likelihood of corrupted data, while providing more timely information. Provides the commander and operator with the capability to task sensors in real-time based on clutter forecasts; data collection based on selective smart sensing. Provides greater versatility in the battlefield and offsets capability gaps and shortfalls associated with the Space & C4ISR Concept of Operation. Ensures accurate collection of critical surveillance information in support of commanders at all levels.

PHASE I: Define and develop integrated approaches for adaptive tasking of RF and EO sensors based on backgound clutter and signal detection limitations. Explore methods for automated tasking.

PHASE II: Prototype a tool and operational concept demonstrating the strategic advantages of adaptive tasking. Develop a concept for an ACTD which will provide the new capability to the warfighter.

DUAL USE COMMERCIALIZATION: Develop the ACTD with user/operator participation to ensure the viability of the new capability. Adaptive techniques based on forecasts of sensor clutter regimes coupled with sensor noise limitations are equally applicable to commercial sensors and constellations.

REFERENCES:
1. Dikeman, R.D., Smart Data processing for Radar, Multispectral, and Hyperspectral Data, AFRL-IF-RS-TR-2002-37

2. Integrated RF Sensor Signal/Data Processing Information Analysis Center (IAC), AFRL-SN-RS-TR-2002-14

KEYWORDS: Electronics,Sensors,Clutter,signal detection, limitations

AF05-026 TITLE: Electro-Optical (EO) Signal Processing for Detection and Classification of Cruise Missiles

TECHNOLOGY AREAS: Information Systems, Space Platforms

OBJECTIVE: Develop advanced hyper-spatial signal processing algorithms for space-based electro optical (EO) sensors that detect and classify Cruise Missiles.

DESCRIPTION: Advanced hyper-spatial algorithms are needed for improved probability of detection (30-50% increase) and discrimination of low observable Cruise Missile targets while reducing false alarm rates (30 %) against high clutter earth backgrounds. Recent advances in infrared detector arrays and hyperspectral technology hold the promise of substantial improvements in the performance of space-based EO sensors. High resolution sensory information can be simultaneously gathered in a multiplicity of spectral bands (infrared and visible), and processed through algorithms that combine spatial, spectral, and temporal information to extract small sub-clutter targets and identify target type based on spectral features and spatial/temporal characteristics (hyper-spatial). Implementation of the appropriate algorithm set can lead to robust system performance for clutter-suppressed target detection, tracking, and classification. The feature extraction will support multi-sensor fusion (e.g. radar/EO) and warfare network operations.

PHASE I: Define and develop advanced hyper-spatial signal processing algorithms for use with large multi-spectral/hyperspectral arrays, and evaluate their performance against synthesized images.

PHASE II: Validate the signal processing algorithms from Phase I using government approved scene/sensor models in a laboratory environment that assesses the feasibility of real-time implementation of full mission objectives.

DUAL USE COMMERCIALIZATION: Perform a low-cost flight demonstration using a prototype sensor that demonstrates the robustness of the developed algorithms to a variety of flight conditions that are representative of the eventual space-based Cruise Missile detection system. The algorithms developed here will lead to an improved hyperspectral infrared camera system for use in 1) commercial product inspection, and 2) earth resource management. Technology interchange with the astronomical community will lead to an improved understanding of the system dynamic features.

REFERENCES:
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KEYWORDS: Cruise Missile,Focal Plane Array,Hyperspectral,Multi-pectral,Algorithms,Signal Processing,Image Processing,Detection

AF05-027 TITLE: Small Launch Vehicles (SLV) Technologies

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop Innovative Small Launch Vehicle (SLV) technologies that provide responsive, cost effective space lift solutions for Small-sat and Common Area Vehicle (CAV) architectures.

DESCRIPTION: Both Small-Sat and CAV payloads are showing increasing promise in improved mission capability. Small-Sat and CAV payloads will need a complementary responsive, cost effective SLV capability. Innovative technologies are being sought that address SLV responsiveness and cost reduction in the areas of avionics, propulsion, airframe and structures, manufacturing, integration, and/or operations. A vehicle focus identifies enabling SLV technologies using a Small Business Innovative Research SBIR time-phased, risk reduction approach. Development of these technologies will make possible the eventual acquisition and operation of a responsive (goals of alert to launch in 24 hours and order to launch in 2 hours) and cost effective (goal of $5 million per launch) SLV-based system capable of rapidly deploying small satellites and CAVs (under 2000lbs) to low earth orbit (LEO).

PHASE I: Conduct necessary feasibility and conceptual studies to develop a sub-orbital vehicle conceptual design and supporting technology requirements base, traceable to an orbit capable SLV, whereby specific technologies are identified for Phase II development/testing.

PHASE II: Refine the design of the sub-orbital vehicle and carry on the research and development of the key technologies up through the prototype phase. The prototype hardware shall emphasize launch responsiveness and cost reduction technologies, possessing sufficient design information to fabricate, integrate, and operate the selected high-risk component(s) for demonstration.

DUAL USE COMMERCIALIZATION: Dual use applications include target vehicles, sounding rockets, 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. A responsive SLV would enhance the launching of military tactical satellites for theater intelligence, surveillance and reconnaissance (ISR), and/or CAVs. A low cost SLV would enhance the deployment of commercial LEO Communications Constellations (e.g., store and forward paging communication systems). Other dual use variants of this technology include booster and/or upper stage systems for larger vehicles. If Phase II technical exit criteria are met and commercial and/or government (non-SBIR) program funds are identified for Phase III, the contractor shall design, fabricate, integrate, and flight-test the sub-orbital vehicle as defined under Phases I-II.

REFERENCES:
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KEYWORDS: Launch Vehicle Design,Sub-Orbital Vehicle,Satellite Micro-Miniaturization, Common Aero Vehicle,Technology Risk Mitigation,Flight Test and Evaluation,Small Launch Vehicle

AF05-028 TITLE: Practical Ionospheric Enhancement Technology

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

OBJECTIVE: Develop and demonstrate innovative deployable technology for programmed, flexible creation of patterns of artificial ionization enhancement in the ionosphere.

DESCRIPTION: Ionospheric plasma impacts radio wave propagation by reflecting, delaying, or distorting signals, depending on the plasma density and degree of density structuring. Deployable means of generating structured plasma density enhancements on demand are sought. Technology must function at all times of the day, including nighttime. Technology must also function under a broad range of natural ionospheric conditions: during all phases of the solar cycle, at altitudes from approximately 100-1000 km and for low, middle and high latitude regimes. Possibilities include chemionization metals released from spacecraft or rockets, particularly those metals that may not have been considered in the past due to high boiling points (>3300 K). Ionization must be delivered on-target, in precise amounts and should be able to be modulated over approximately 100-m scales. The technology developed should be capable of participation in an actual demonstration. In particular, in-situ approaches should be sufficiently compact to fit into a sounding rocket or satellite payload and must able to pass space launch qualification standards.

Technology that is innovative and affordable—with attention given to total cost of ownership including manufacturability, handling requirements and disposal—is highly preferred.

PHASE I: Demonstrate the feasibility of practical ionospheric enhancement technology through such means as analysis, numerical simulation and laboratory testing. Design a proposed sounding rocket or satellite payload, or other demonstration system if non-launched technology is feasible.

PHASE II: Build at least two sounding rocket or satellite payloads (primary and backup), or a deployable demonstration system if non-launched technology is feasible, based on the Phase I design. Support the test and evaluation of the technology by the sponsoring agency.

DUAL USE COMMERCIALIZATION: Successful practical ionospheric enhancement technology would initially supply a small but growing market in space research. Future applications of practical ionospheric enhancement technology could lead to a broader military market. Additional spin-off potential may exist for some technologies in areas such as materials research, specialized manufacturing, construction and demolition.

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KEYWORDS: Ionospheric Enhancement,Plasma Density Enhancement, Chemionization, Metal Vapor

AF05-029 TITLE: New Sensing Capabilities for Space Situational Awareness

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

OBJECTIVE: Develop revolutionary multi-waveband, high-sensitivity infrared (IR) and ultraviolet (UV) focal plane array technologies that incorporate novel detector multiplexer and interconnection strategies.

DESCRIPTION: High sensitivity, low background focal plane arrays (FPA) have benefited from recent advances in increased operating temperatures (e.g., ~140 Kelvin for MWIR mercury cadmium telluride HgCdTe), dualband (mid-wave MW & long wave infrared LWIR and dual-LWIR) capability, and low background, LWIR HgCdTe operating at 40 Kelvin with unprecedented levels of pixel uniformity. Ultraviolet FPAs have also progressed, with dark currents lowered to the point that array uniformity is limited by defects in the detector material. This topic will emphasize development of low background, thermal infrared (IR) mercury cadmium telluride (HgCdTe) FPAs with multi-waveband capability and operating temperatures above 40 Kelvin, high sensitivity ultraviolet FPAs, detector multiplexer concepts offering radiation tolerance by design, and novel interconnection strategies between the detector and multiplexer arrays. 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 read, at frame rates in the 30 to 100 Hertz regime.

PHASE I: Explore one or more innovations to decrease the dark current and improve the sensitivity of VLWIR (wavelength cutoffs exceeding 14 microns at 40 Kelvin) HgCdTe photovoltaic detectors, investigate new concepts for pixel-collocated multi-waveband capability with high pixel fill factors (which may require new approaches for

pixel and multiplexer interconnects), and consider multiplexer architectures exploiting commercial foundry capabilities to achieve space radiation tolerant architectures.

PHASE II: Refine the most promising innovations considered in Phase I. Develop prototype focal plane arrays or detector multiplexers and evaluate their levels of performance. Document potential development path for Phase III consideration.

DUAL USE COMMERCIALIZATION: Military applications of LWIR and VLWIR detectors include improved space surveillance capabilities, for which the ability to detect faint objects at great distances is critical. Commercial applications include industrial and auto-emission monitoring, tumor detection, environmental monitoring, and manufacturing process monitoring, among others. 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: Mercury Cadmium Telluride HgCdTe,Very Long Wave Infrared VLWIR, Infrared,Photovoltaic,Dark Current, Detectivity,Focal Plane Array (FPA),Ultraviolet (UV), Electro-Optics,Remote Sensing

AF05-031 TITLE: Innovative Data/Electrical Interfaces for Modular Spacecraft

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Develop and demonstrate innovative low cost, lightweight, standard interfaces for modular spacecraft components.

DESCRIPTION: The Air Force has an operational need to be able to launch satellites on demand for a variety of missions. A critical capability that is required to achieve this goal is the rapid reconfiguration or tailoring of satellites prior to launch. One impediment to this goal is the complexity and variety of the interfaces, both data and electrical, that exists for the various components of a satellite. Often spacecraft wiring harnesses and hardware/software interfaces are customized for each satellite. Furthermore, the incorporation of "commodity" components (defined as spacecraft subsystems and components that are reused or existing design) requires the development of many custom interfaces and interface converters. These customized and often unique interfaces and wiring harnesses increase the cost, complexity and time to develop, fabricate and assemble satellites.

It is necessary to investigate creative solutions to avoid the need to develop custom hardware, software, and interfaces. Ideally, complex interactions can be managed by script-driven interface concepts, blending a number of software and hardware concepts together. More primitive implementations of this concept have been referred to as "plug-and-play." More advanced embodiments can dramatically reduce the time to create a complex spacecraft system by reducing many complicated interface decisions to simpler ones. Self-organizing networking protocols (wireless examples include the Bluetooth standard) can potentially simplify not only interface design but reduce the burden of complex software development. Proposed concepts should strive for techniques that can simplify the design process, and enable a fabrication and integration time of a few days. A notional architecture to achieve this goal is that of a modular spacecraft with standardized electrical/data interfaces. Proposals can address interfaces associated with the entire spacecraft, selected sub-systems of the spacecraft bus, individual payloads, or focus on the

rapid integration of the components onto the spacecraft bus or the spacecraft onto the launch vehicle. In either case, proposers should seek approaches that can deliver low-cost and rapid prototyping, design, fabrication and/or integration over the widest range of relevant capability.

PHASE I: Develop an innovative modular spacecraft architecture that would utilize standard and public protocols for electrical and data interfaces to enable rapid spacecraft design and fabrication. Develop concepts for these spacecraft interfaces that leverage commercial off-the-shelf hardware and software. Develop concepts/technologies for simplified satellite data architectures. Define technology development and demonstration requirements to validate these concepts for application to space systems.

PHASE II: Develop engineering designs for the proposed concept and demonstrate the feasibility of the proposed technologies. Specific processes and designs will be perfected and tested. Breadboard level (or higher) hardware will be built for testing and demonstration.

DUAL USE COMMERCIALIZATION: This system should allow standard interfaces to be developed and drive the cost down on space, balloon, or glider missions. These technologies would lower costs through standardization and simplification or elimination of the wire harness. The proposed topic would benefit Department of Defense DoD, NASA, and industry-essentially all entities that integrate complex aerospace systems. They have struggled with custom made solutions for decades now, and a paradigm shift in terms of standardized interfaces would pervasively streamline costs and operational effectiveness.

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2. Michael R. Wright, Flights Systems, "Integration and Test for Small Shuttle Payloads," Integration and Test, GSFC 2002 IEEE Aerospace Conference, Big Sky, MT.

KEYWORDS: Responsive Space,Space Platforms,Avionics,Computers, Weapons,ISR,Tactical Space,Avionics,Off-the-Shelf

AF05-032 TITLE: Low Cost, Tailor able Avionics for Rapid Response Satellites

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

OBJECTIVE: Develop innovative architectures and technologies for low cost, spacecraft avionics.

DESCRIPTION: The Air Force has an operational need to launch satellites on demand for a variety of missions. A critical capability is that these satellites be relatively inexpensive, flexible and modular to permit a variety of potential missions using a common satellite. A significant element of the cost and complexity of satellites is the avionics (command and control computer, interface electronics, data storage, etc.). Furthermore, the flexibility and capability of satellites is largely dominated by the avionics architecture. This effort will develop architectures and technologies for avionics components to satisfy these mission requirements. Some potential solutions include the use of Commercial-Off-The-Shelf (COTS) components and architectures adapted for space mission. Such approaches will include common interface technologies that allow rapid assembly of the various subsystems into a working system, to allow tailoring of the capability of the avionics unit. Approaches for integrating emerging products and technologies will need to be defined to prevent system obsolescence. Another technology area of interest is a reconfigurable, or software defined avionics architecture. This concept is based on the idea of field programmable gate arrays (FPGA), extended to a complete avionics unit for spacecraft. This allows a high degree of tailor ability, while enabling some benefits of economy of mass production, since a single hardware design can be used for many missions.

PHASE I: Define innovative concepts for a flexible, modular and/or reconfigurable avionics architecture, which enables rapid response missions. Identify driving technologies required for this approach and perform cost/benefit analysis when compared to conventional new development process. Develop space avionics road map and

development/demonstration plan that will validate the approach. Possibly demonstrate selected elements of the architecture to establish feasibility.

PHASE II: Develop applicable prototype demonstrations and/or proof-of-concept devices for the tailor able avionics architecture. Perform appropriate testing to verify required flexibility, modularity, and performance. Establish cost metrics for production and utilization of the architecture.

DUAL USE COMMERCIALIZATION: Department of Defense DoD, NASA, and industry will benefit from tailor able avionics because it enhances their space-based responsiveness. There is a growing demand from DoD and the aerospace community in general to reduce the costs and especially the time needed to quickly integrate a payload and deploy that payload into space. Advanced avionics architectures, such as the one described above, will lower cost and shorten schedule for military and for commercial spacecraft.

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KEYWORDS: Responsive Space,Space Platforms,Avionics,Computers,Weapons,Intelligent Surveillance Reconnaissance ISR,Tactical Space,Avionics,Commerical Off-the-Shelf

AF05-033 TITLE: Innovative, Low Cost, Flexible Satellite Inertial Measurement System

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

OBJECTIVE: Develop innovative technologies and architectures for low cost, flexible Inertial Measurement Systems for Rapid Response Satellites

DESCRIPTION: The Air Force has an operational need to launch satellites on demand for a variety of missions. These missions are envisioned for a variety of low-earth orbits, from approximately 100-1000 km, and geosynchronous orbits, and at a variety of inclinations from nearly equatorial to sun synchronous. Furthermore, these missions may require navigation for rendezvous and agile orbital maneuvers, fine attitude knowledge and control for stable nadir pointing, and accurate orbit determination for precision orbital control. A critical capability is that these satellites be relatively inexpensive and flexible to permit a variety of potential missions and orbits using a common satellite. The Inertial Measurement Subsystem (IMS, defined as the sensors and processors used to determine inertial position and attitude) is a relatively expensive and complex element of a satellite that is usually uniquely configured for the mission and orbit. Typical attitude and inertial measurement systems for small satellites comprise approximately 20% of the cost of the satellite (References 3-5). To enable responsive space missions, a rapidly adaptable IMS that can be implemented for a variety of missions at a lower cost is critical. This effort will develop architectures and technologies for IMS and its components to satisfy these mission requirements. Some potential solutions include the use of Commercial-Off-The-Shelf (COTS) components and architectures adapted for space mission, modular or programmable attitude sensors, integrated global positioning system (GPS) for navigation and ephemeris determination, or miniaturized, high performance IMS suitable for a broad range of missions through software reconfiguration. Such approaches will include common interface technologies that allow rapid assembly of the various parts or elements into a working system. Processes for integrating emerging products and technologies will need to be defined to prevent system obsolescence.

PHASE I: Define a flexible, modular and/or reconfigurable Inertial Measurement Subsystem (IMS) architecture, possibly using COTS, ultra-miniature or software defined components, which enables rapid response missions. Flexibility is defined as the ability for a common hardware set to apply to a range of mission orbits (LEO at various inclinations and GEO) and attitude configurations (such as solar-inertial or nadir pointing). Identify driving technologies required for this approach and perform cost/benefit analysis when compared to conventional new development process. Only technologies and architectures that show a significant cost/benefit improvement over

conventional approaches are of interest. Perform analysis to establish suitability of the architecture to a variety of mission applications and orbits.

PHASE II: Develop applicable prototype demonstrations and/or proof-of-concept devices for the tailor able IMS architecture. Perform appropriate testing to verify required flexibility, modularity, and performance. Establish cost metrics for production and utilization of the architecture.

DUAL USE COMMERCIALIZATION: The Department of Defense DoD, NASA, and industry would benefit from advanced miniature IMS architectures to lower cost, shorten schedule, and provide mission flexibility. In this way, the same IMS unit could be used for commercial and military spacecraft operations. If the product development effort is successful, the aerospace market would refocus toward flexible/adaptable IMS units.

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1. West W., and White, M., "A Reconfigurable Navigational Test Bed," presented at the 2000 IEEE Aerospace and Electronics Conference.
2. Hao, ., Fedder, G., and Carley, LR., "Integrated Multiple-Device IMU System with Continuous-Time Sensing Circuitry," presented at the IEEE International Solid State Circuits Conference, February 2003, San Francisco, CA.

KEYWORDS: Responsive Space,Space Platforms,Attitude Determination,Orbit Determination,Computers,Weapons, Intelligent Survelliance Reconnaissance ISR,Tactical Space,Commercial Off-the-Shelf

AF05-034 TITLE: Reconfigurable Electronics for Responsive Space Systems

TECHNOLOGY AREAS:

OBJECTIVE: Development of more responsive spacecraft through the flexibility enabled in reconfigurable electronics approaches.

DESCRIPTION: Reconfigurable electronics refer to circuits, components, and subsystems that feature many “knobs” definable under software control. These ideas can be as simple as a micro-relay (a “software wire”) or a field programmable gate array (FPGA), in which arbitrarily complex logic, interconnect, and memory relationships can be dynamically defined under programmed control. One can consider software-defineable radios, antennas, configurable power/thermal/structural elements and mechanisms, adaptive wiring harnesses, pathways, and eventually programmable matter. It has become increasingly clear that such reconfigurable electronics offer a significant timeliness advantage over custom-built equivalents. For example, FPGAs can be programmed in minutes, whereas custom integrated circuits require months to construct. Further advantages are accrued when intelligence is combined with reconfigurability. One may consider machine-negotiated interfaces, in which the parts of a system barter over (and then implement) correct relationships at interface boundaries. This is an advanced version of what is commonly called “plug-and-play.” It is conceivable that such machine-negotiated or reactive interfaces can eliminate the error prone human-driven attempts to understand and implement correct interfaces, and even resolve errors during integration. The limit argument is a system in which elements self-organize during automated assembly to form complex platforms in a fraction of the time otherwise required. This is the vision of reconfigurability to enable responsive space.

PHASE I: Establish specific and credible concepts for the use of reconfiguration to enable satellite systems to be built more quickly. Beyond “mere” modularity and interfaces, how does this approach reduce the time and human effort in developing correct interfaces. The offeror must quantify the benefits of a proposed scheme.

PHASE II: Establish some practical demonstration, preferably one that can be applied directly to existing testbeds and satellites and used to drive design strategies in emerging satellite systems. Establish tool kits, open standards, and other coordinating mechanisms to promote wider usage.

DUAL USE COMMERCIALIZATION: Reconfigurability schemes that can speed military space systems are also keenly welcomed by civil/commercial spacecraft.

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4. D. Anagnostou, C.G. Christodoulou, and J. C. Lyke., "Smart Reconfigurable Antennas for Satellite Applications," presented at IEEE Core Technologies for Space Systems Conference, Colorado Springs, CO, November 28-30, 2001.

5. David Vreeland, C.G. Christodoulou, James Lyke, “Application of Chalcogenide-Based Materials For Use in Programmable Circuitry for a Microstrip Antenna,” 2001 IEEE AP-S International Symposium Digest USRI, 374.

KEYWORDS: reconfigurability,plug-and-play,field programmable gate arrays,polymorphous computing,adaptive antenna, software-defineable radio,responsive space

AF05-035 TITLE: The Self-Aware Satellite

TECHNOLOGY AREAS: Sensors, Space Platforms

OBJECTIVE: Development of technologies that enable Satellite-As-A-Sensor (SAAS) and self-aware satellite methodologies for improved threat warning indication and situational awareness.

DESCRIPTION: Satellite-As-A-Sensor (SAAS) is a philosophy involving the effective harnessing of all on-board satellite information to improve situational awareness. The result is an approach based on a combination of avionics (spacecraft electronics) and software. Spacecraft are, in effect, a flying network of sensors. While some of the sensors contribute to a primary mission, most sensors are static and only contribute to routine state-of-health, downloaded in telemetry. In fact, many sensors are fixed and uni-purpose, and they cannot be accessed in a way inconsistent with this originally envisioned purpose. As a result, the satellite's closed architecture: (1) does not exploit the possibilities achievable even with its baseline sensor set and (2) does not permit the satellite to analyze and react to these auxiliary sensors except by pre-scripted ground command queues.

The SAAS approach breaks these two critical limitations. In SAAS, all sensor data is posted to a centralized database, which can be freely accessed in real-time by a satellite's own processor(s). Sensors can furthermore be redirected to other purposes. For example, a timing, telemetry and control TT&C radio can be retargeted to behave as a radio-frequency RF threat-warning sensor when not otherwise engaged. Correlations between sensors can be analyzed by the platform on orbit. When combined with an autonomous ability to exploit the information for short-loop responsive actions, a "self-aware" satellite is created. SAAS and "self-awareness" are difficult to achieve without reformulating the way that avionics are built in present-day spacecraft. Part of the problem in achieving them is having intelligent and open systems in which all sensors and actuators are exposed for immediate examination, reaction, reporting, and control by the platform itself. The paradigm of a centralized bulletin-board/database can address the problem. Another part of the problem is having software that naturally attaches semantics of particular sensory information to its possible meanings, such as threats and hazards. Establishing a software-based ontological mechanism is essential to addressing this problem. This mechanism, by providing a meaning to data generated, permits more powerful associative processes to be defined, and these processes pave the way to satellites that can react to threats and mission changes at a higher level, alleviating the need for expansive ground control infrastructures to manage detailed component state. By contrast, most present-day satellites are

designed to compartmentalize ("stovepipe") and simply shuttle information to the ground, precluding any hope of making a platform take advantage of its own information. Worse, vast amounts of ground support are necessary.

This Small Business Innovation Research SBIR topic would seek creative approaches for developing an infrastructure for self-aware satellites and harnessing their intrinsic capabilities for situational awareness. It is believed that scalable, self-organizing electronic elements may play a role in creating such a framework. Tuple-spaces (e.g., the LINDA operating system in distributed processing) provide one example of a potentially fault-tolerant framework in which each spacecraft component is free to post or extract data or taskings from a virtualized bulletin-board-like structure. Spacecraft protections, even navigation, are applications that can be re-formulated to take advantage of this bulletin-board-like structure to accommodate a richer ontologically enhanced data environment. Not identically "artificial intelligence" or "cognitive information processing," such frameworks through creative hardware, software, and component middle-ware interfaces can enhance mission effectiveness and survivability with straightforward algorithms and without dramatic improvements in the baseline sensor set capabilities.

PHASE I: Establish the feasibility of a self-aware satellite approach. Specific concepts for creating a self-aware satellite framework are expected, in which information from any sensor is made available to any other. Conceivably, parts of the satellite can task other parts to improve the quality of information on a non-interference basis. The Phase I is expected to establish a convincing proof-of-principle that a SAAS/self-aware satellite can be created.

PHASE II: Establish practical demonstration of a network of satellite components having a SAAS/self-aware satellite capability. The demonstration can be based on contractor's preferred components, combined to form a SAAS/self-aware satellite system. The offeror will coordinate with the government to attempt to secure a flight opportunity for demonstrating the concept in a realistic environment.

DUAL USE COMMERCIALIZATION: Improved situational awareness is a useful capability to all satellites. Even commercial satellites must be increasingly concerned with the complexity of natural and man-made environments that exist about each satellite platform.

REFERENCES:
1. Lyke, J.; Sulham, C.; Cannon, S. "Strategy for Protection Architectures Based on Scalable, Self-Organizing Avionics Approaches," presented at IEEE Core Technologies for Space Systems Conference, Colorado Springs, CO, November 2001.
2. Rao, N.S.V., "On Fusers that Perform Better Than Best Sensor," Pattern Analysis and Machine Intelligence, IEEE Transactions in, Volume: 23 Issue: 8, 904-909, August 2001.
3. Hilland, D.H.; Phipps, G.S.; Jingle, C.M.; and G. Newton, "Satellite Threat Warning and Attack Reporting," IEEE Aerospace Conference, Vol. 2, 207-217.
4. Fu, S.J. et.al, "Determination of Ground Emitter Location," IEEE AES Magazine (Presented at 1988 Digital Avionics Systems Conference), December 1988.

KEYWORDS: Situation Awareness,Attack Reporting,Threat, Warning,Self-Organization,Sensor Fusion,Satellite-as-a-Sensor (SAAS)

AF05-036 TITLE: Enhanced Scattering of Trapped Energetic Electrons in the Inner Magnetosphere

TECHNOLOGY AREAS:

OBJECTIVE: Develop and demonstrate innovative techniques to enhance the pitch-angle scattering, and consequently the precipitation rate, of energetic trapped electrons in the inner magnetosphere.

DESCRIPTION: Energetic electrons produced by a high altitude nuclear detonation (HAND) can become trapped in the Earth's inner magnetosphere forming new radiation belts hazardous to space systems. Technologies that could reduce the natural lifetimes of HAND belts from the order of months to days have the potential to dramatically improve space system survivability and ensure the continuation of space-based services. One promising method under consideration involves enhancing the electron pitch-angle scattering rate via cyclotron-resonant wave-particle

interactions. Properly directed, this scattering will increase the electron velocity parallel to the local magnetic field and lower the altitude of magnetic reflection. If the reflection altitudes are lowered sufficiently into the upper atmosphere collisions with the neutral particles will lead to a depopulation of the electron belt. To achieve the desired scattering rates it is necessary to inject waves into the magnetosphere from space over the frequency ranges relevant to the resonant interactions. A thorough understanding of the physical processes in the near-field of a space antenna, to include sheath formation, external current structures, and plasma heating, is needed to determine the properties of injected waves in a possible non-linear plasma response regime. Techniques for transforming DC satellite bus power into far-field radiated power with rapidly changing, environmentally-induced radiation impedance must be developed to optimize injection efficiency given limited spacecraft resources and orbital coverage. Processes by which the propagating waves can be amplified through wave-particle interactions with the background magnetospheric plasma need to be studied and quantitative models developed describing the conditions required for triggering and the saturation amplitudes. Research should also be conducted to asses the viability of alternate methods of enhancing electron pitch-angle scattering rates such as those based on magnetostatic or electrostatic interactions.

PHASE I: Work should be focused on at least one, and possibly a combination, of the following critical issues: (1) modeling the plasma processes controlling the injection of waves into the inner magnetosphere from a space-based platform at frequencies of interest for stimulating the pitch-angle scattering of energetic electrons > 0.5 MeV; (2) designing a system to effectively radiate waves from a satellite system into the far-field of the inner-magnetosphere; (3) modeling of magnetospheric wave amplification processes relevant to frequencies considered for stimulating energetic electron scattering; and (4) analysis of the efficiency of alternate stimulated scattering processes to include, but not limited to, those based on electrostatic and magnetostatic interactions. Preliminary conceptual design for space experiments can be considered. In this case, the concept of operations should be discussed, the expected performance in stimulating energetic electron precipitation should be quantified, and the basic physics issues and limitations should be addressed.

PHASE II: Work should consider the research required to address the key unresolved physics issues identified in Phase I. Work should focus on experiment prototype development and validation at the component or systems level.

DUAL USE COMMERCIALIZATION: Successful research will result in satellite technologies that will protect both DoD and commercial space assets in the event of a HAND, saving billions of dollars in replacement costs. High-power, high-efficiency space-based transmitters are likely to result from Phase I and II efforts with applications in communications and space control.

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2. Abel, B., and R.M. Thorne, “Electron Scattering Loss in the Earth’s Inner Magnetosphere: 1. Dominant Physical Processes”, J. Geophys. Res., 103, 2385, 1998.

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KEYWORDS: radiation belt dynamics, radiation belt remediation, wave-particle interactions

AF05-037 TITLE: Nowcasting/Forecasting the Battlespace Environment

TECHNOLOGY AREAS:

OBJECTIVE: Develop approaches for applying real-time updates to atmospheric models in order to forecast atmospheric clutter conditions for space-based infrared sensors and systems.

DESCRIPTION: Requirements associated with missile defense and space control missions dictate the need to apply new and evolving technologies and scientific understanding to the modeling environment to ensure accurate detection, characterization, tracking and surveillance. This effort will examine the state-of-the-art in atmospheric modeling and enhance that capability through application of new scientific understanding and technology adaptation for use of real-time updates to forecast atmospheric conditions for space surveillance, missile defense and missile warning missions, and battle space awareness. Models of stressing background clutter and its spatial and temporal dependence will be developed. These models would be incorporated in atmospheric codes used for the design, development, and testing of space-based surveillance sensors and systems. In addition, the forecasting capability will allow operators to reconfigure sensors and systems in real-time to accommodate viewing conditions. Forecasting will allow selection of spectral bands, bandwidths, gain, viewing geometry, and others adaptations, as feasible, based on systems and sensors designs and operational concepts. The models also can be applied to address atmospheric attenuation of laser transmissions for communications systems. CAPABILITIES-BASED WARFIGHTER IMPACT: Precludes and offsets capability gaps and shortfalls associated with the space & command, control, communications, computers, intelligence, surveillance, and reconnaissance C4ISR Concept of Operations. Provides the capability to forecast atmospheric conditions, which will ensure accurate and timely collection of critical surveillance information in support of commanders at all levels.

PHASE I: Develop and demonstrate approaches/models for nowcasting/forecasting atmospheric conditions and applying them to future space-based sensors and systems targeted.

PHASE II: Prototype a tool and operational concept demonstrating the forecasting capability and improved accuracy of the atmospheric correction approach.

DUAL USE COMMERCIALIZATION: The new tools and operational concepts developed under this effort will be directly applicable to current and future C4ISR systems. Commercial imagery would be able to use the forecasts to task its sensors based on viewing conditions. The models would be used in designing, developing, and testing more capable and agile sensors and systems, and in developing mitigation techniques for laser transmission through the atmosphere.

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1. Dikeman, R.D., "Smart Data Processing for Radar, Multispectral, and Hyperspectral Data," AFRL-IF-RS-TR-2002-37.

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KEYWORDS: Infrared backgrounds and clutter,atmospheric correction,nowcasting/forecasting,space-based infrared,space-based surveillance,atmospheric modeling

AF05-038 TITLE: Space Qualified Nonvolatile Memory

TECHNOLOGY AREAS:

OBJECTIVE: Development of a space-qualified nonvolatile memory device adapted from off-the-shelf commercial processes and components.

DESCRIPTION: Current space electronics programs have a need for nonvolatile memory (Flash, Programmable Read-Only Memory PROM, Electrically-Erasable Programmable Read-Only Memory, EEPROM, Magnetoresistive Random Access Memory MRAM, and others) for several uses, including boot-up ROM and nonvolatile random access storage. Although many commercial off-the-shelf solutions exist, they are not designed for space use without making architectural modifications and compromises. Adaptations and modifications to off-the-shelf nonvolatile memory chips should be possible, to mitigate or eliminate the effects of latchup, total dose sensitivity, single event effects, and dose rate effects, as appropriate. The result should provide a usable product based on commercial technology that has much greater capacity than current space-qualified nonvolatile storage, at a lower cost per chip

than now required for space use. The adaptations and modifications should also enable simpler architectures for system developers, by providing a part that does not need external error-checking or backup.

PHASE I: Provide evidence, through analysis and/or hardware demonstration, that key technology developments or adaptations can provide performance and/or cost benefits for many if not all space computer systems. Develop initial concepts and designs for products using the proposed technical innovations, and describe a strategy for making a product available for space computer users.

PHASE II: Finalize detail design, prototype and test Phase I solutions. Demonstration devices must be at least 16Mbit density.

DUAL USE COMMERCIALIZATION: Commercial and civil space systems also need these parts. They are less able to afford fully rad hard Read-Only Memory ROMs and Non-Volatile Random Access Memory NVRAMs and also are often more successful in flying in less destructive orbits than military satellites.

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KEYWORDS: Chalcogenide, Magnetoresistance, Single Event Effects, Total Ionizing Dose, Latchup, PROM, Flash, Nonvolatile Memory, EEPROM, SONOS

AF05-039 TITLE: Synthetic Aperture Radar (SAR) Improved Through Waveform Diversity

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a technologically feasible system with enhanced Space Based Radar SAR performance.

DESCRIPTION: The imaging quality dependence of Synthetic Aperture Radar (SAR) systems on multiple parameters will be investigated in this study. SAR Performance to “first order estimates” should be defined and described to facilitate an appropriate appreciation of the Signal-to-Noise Ratio (SNR) performance measure and how it is critically important in SAR Image Processing.

Synthetic Aperture Radar SAR systems can be improved by several technological approaches. Increases in power, optimizing antenna efficiency, frequency and bandwidth selection, and duty cycle are a few prime candidates for SAR improvement. This work concentrates on enhancing SNR by increasing power, gain, receiver efficiency, pulse waveforms, and/or reducing the noise effects and receiver bandwidth effects, thus improving overall system performance.

System should be able to optimize carrier frequency, and SNR of 4dB or more may need to be maintained. It is well known that instantaneous bandwidth currently limits available resolution. Approaches to improve the bandwidth are also sought.

PHASE I: Study various functions, phenomena, and implementation approaches of SAR systems and document in a report. Particular attention should be made toward the identification and mitigation of noise, and identification of approaches used to provide improved receiver efficiency.

PHASE II: Develop a simulated model to verify the SAR performance enhancement.

DUAL USE COMMERCIALIZATION: Develop a new optimized SAR system to be used by military and commercial satellite systems for their image satellite system. This system should exploit the results of Phases I and II.

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KEYWORDS: Radar Imaging,Synthetic Aperture Radar,Waveform Diversity, SAR, Space Based Radar,Radar Noise Mitigation,Improved Radar Receiver Efficiency

AF05-040 TITLE: Low-Power Phased Array Control Technologies

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop low-power phased array III-V semiconductor based control technologies for highly integrated, low power, mixed signal circuits suitable for satellite communications technologies or space based radar.

DESCRIPTION: Very large apertures using ultra-low power transmit receive T/R modules have been proposed for space-based radar applications, specifically to support surveillance and tracking missions from medium earth orbit. Even though, each transmit element radiates only about 10-100 milliwatts at a 10% duty cycle (1-10 milliwatts average), total power consumption of the T/R module can be dominated by overhead (non-radiated) power used to run the low-noise amplifiers on receiver, T/R switches, phase shifters, embedded memory and control logic. Monolithic Microwave Integrated Circuit MMIC designers are working to improve transmit amplifier efficiency and reduce Low Noise Amplifier LNA power consumption, but this represents only a partial solution. A key enabler for such large phased array antennas is ultra-low-power T/R IC control technologies.

PHASE I: Provide a design for a mixed-signal Application Specific Integrated Circuit (ASIC) to provide low voltage (<1 V) and low current (<100 mA) control of advanced T/R modules, as well as to perform phase shift and T/R switch control.

PHASE II: Demonstrate the design of critical components in a prototype ASIC. Designs should use rad-hard component technologies and/or rad-hard-by-design approaches to minimize the need for shielding and allow graceful degradation from failures due to radiation and other environmental factors.

DUAL USE COMMERCIALIZATION: Produce an advanced ultra-low power T/R module for use by commercial and military satellite manufacturers to optimize phased array control for future satellite systems. This topic has a dual use application for military and commercial sectors.

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Proceedings, ICMMT, International Conference, 29-32, September 11, 2000.
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KEYWORDS: Digital Logic Circuits,Transmit and Receive Switches T/R,Phased Array Control,Radiation Hard Phased Arrays,Space Based Radar,Power Array Communications

AF05-041 TITLE: Electronic Protection for Space-borne Phased Array Antennas (EP-SPAA)

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Investigate and develop protection technologies for space-borne phased array antennas used for communications and Intelligence, Surveillance, and Reconnaissance (ISR).

DESCRIPTION: Future transformational communications and radio frequency based intelligence, surveillance, and reconnaissance (ISR) space systems will likely involve advanced, high dynamic range transmitter/receiver devices and large but light-weight apertures. Advanced technologies are needed to address satellite system vulnerabilities that are associated with high dynamic range sensors and such large apertures. Vulnerabilities include Net-centric Warfare (penetrate satellite command uplink, insert false instruction and/or data, etc.) and direct radio frequency (RF) attack (spurious signal attack, spoofing attack, etc.).

PHASE I: Develop innovative technologies and techniques to improve phased array antenna system capabilities while reducing susceptibility to potential vulnerabilities. Develop new technologies and techniques for systems that will respond to broad multi-dimensional threat emitter parameter sets with high precision and resolution. Exploit the flexibility of digital signal and data processing techniques for new, programmable, adaptive systems to enable "surgical" responses to, and suppression of, targeted opponent systems, while minimizing effects on non-targeted emitters. Develop techniques for specific (radar and communications) emitter identification and engagement, for shielding against (RF) weapons, and to optimize the effectiveness of defensive systems. When high payoff technology is identified, models predicting the potential payoff should be developed and utilized for use in analysis of alternatives (AOA).

PHASE II: Develop cost effective, lightweight, affordable prototype antenna devices. Fabricate and test subsystems to verify performance and reliability. Subsystems which can be space qualified will be designed, and any high risk mitigation implementations will be demonstrated with an appropriate ground demonstration in a relevant environment.

DUAL USE COMMERIALIZATION: This enhanced transmitter/receiver technology will benefit commercial and military communication satellite systems in terms of being lightweight and having lower cost. Provide a representative module capable of integration into ground test-bed and later to be evaluated at near field and far field ranges.

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KEYWORDS: Electronics,Transmitter/receiver,Electronic Scan Array Antenna,Transmit and Receive Modules for Space Based Applications,Space Qualified Radio Frequency Transmit,Receiver Antenna

AF05-043 TITLE: Ultra-High Performance Opto-Electronics Synthesizer

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a compact ultra-low phase noise frequency agile microwave opto-electronic oscillator (OEO) optimized for Space Based Radar (SBR).

DESCRIPTION: Local oscillator phase noise performance is often the primary limitation in modern radar systems. The impact of phase noise of the oscillator is particularly acute now that solid-state transmitters/receivers in phased

array radars have improved dramatically over the years. Critical missions planned by future SBR require the highest performing oscillators possible that are also frequency agile, and features include: light-weight, smaller size, low power consumption, low cost, and can survive the launch acceleration and vibration. Such oscillators are critical enablers for SBR, and can potentially improve system performance by several orders of magnitude, by distributing phased-locked clock signals with very narrow locking bandwidth.

PHASE I: Develop and demonstrate a breadboard frequency agile, tunable signal source with phase noise of -140 dBc/Hz at 10KHz offset from an X-band carrier, with greater than 1GHz continuous tuning bandwidth.

PHASE II: Miniaturize the breadboard demonstrated in Phase I and develop a low power consumption, high performance OEO-based synthesizer prototype. Demonstrate its frequency agility, phase noise performance, acceleration/vibration insensitivity, and phase lockable feature up to Ku-band for phased array SBR application.

DUAL USE COMMERCIALIZATION: This compact high performance and low cost opto-electronic synthesizer can be extended to a wider range of military and broadband commercial applications such as electronic warfare (EW), electronic counter-counter measures (ECCM), next generation mobile base-stations, microwave digital radios, satellite communications, and optical networking.

REFERENCES:
1. Simpson, T.B., Liu, J., "Dynamics of Semiconductor Lasers Under External Optical Injection," PL-TR-97-1143, August 1997.
2. Advisory Group for Aerospace Research & Development, "High Power Microwaves (HPM)," AGARD-CP-564Vol I, March 995.
3. E., Fledderman, C.B., Focia, R., Gaudet, J., "A Study of Advanced Semiconductor Switch Physics and Technology," Schamiloglu, PL-TR-97-1151, September 1997.
4. Cimolino, M.C., "Diode-Laser-Pumped Optical Parametric Oscillator," PL-TR-96-1105, October 1996.
5. Moreland, L. D., Schamiloglu, E., Lemke, R. W., Korovin, S. D., Rostov, V. V., Roitman, A. M., Hend, “Efficiency Enhancements of High Power Vacuum BWO's using Non-Uniform Slow Wave Structures,” PL-WS-95-5, October 1994.

KEYWORDS: Opto-Electronics Oscillator,Synthesizer,Photonic Timer,Clock,Space Based Radar,Phased-Locked

AF05-044 TITLE: Advanced Metrology Technologies for Next-Generation Space-Based Radar

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop advanced metrology technologies to support high performance next-generation space-based radar to resolve uncertainties in beam transmission and propagation using single or multiple platforms.

DESCRIPTION: Develop key technologies to address precision metrology to support integration of medium earth orbit (MEO) space-based radar into the future U.S. operational ground, airborne, Surveillance, and Reconnaissance (ISR) architecture. Potential systems in this architecture include next-generation Global Positioning System (GPS) with MEO coverage, low earth orbit (LEO) space-based radar, transformation communications. Potential technology areas to support this topic include precision clocks, on-board metrology systems for large, flexible structures, ionospheric effects mitigation, specialized waveforms, multi-platform synchronization strategies with potential reference beacons on-board, in space, or on ground, modeling and simulation of radar operation and mission performance, etc. Any metrology elements that affect radar waveform quality and mission performance metrics may be considered: precise beam formation through distribution of phase and amplitude to individual T/R modules on a large flexible structure; beam propagation effects and correction strategies; varied target types and clutter backgrounds; novel waveforms and signal processing techniques; single platform or multi-static operations that could include multiple ground, airborne, or space transmit and receive platforms.

Proposed metrology technologies should demonstrate a clear understanding of current and future system capabilities in hardware, waveforms, and timing accuracies. The physics and mathematical models should clearly demonstrate improvements to current state-of-the-art and have ground, airborne, or space demonstrations outlined to prove out

the performance improvements. For the area of on-board metrology systems for large, flexible space structures such factors should be considered as precise position knowledge of individual radar elements or panels and precise relative timing for radar operations for structures as large as 3 meters x 300 meters to include beam transmit/receive, calibration, performance prediction, etc. For the area of ionospheric effects, the objective is to mitigate ionospheric dispersion of radar beam propagation effects. Wideband space-based radar waveforms are subject to a number of potentially debilitating effects that are not an issue for other applications.

The objective of this program area is to develop and demonstrate advanced metrology technologies to improve next-generation space-based radar performance capability.

PHASE I: Develop hardware designs, novel radar waveforms, time/space metrology approaches, or modeling and simulations to improve space-based radar performance given absolute and relative timing uncertainties of multiple platform operation to include space and airborne assets. Example factors that should be considered include: relative geometry of very large space structures; frequency of operation; dispersive ionospheric propagation effects; space-based radar modes and performance metrics.

PHASE II: Build prototype hardware designs, if applicable, and perform ground, airborne, or space tests as necessary to prove out hardware performance, novel radar waveforms, time/space metrology approaches, or modeling and simulations.

DUAL USE COMMERCIALIZATION: Improvements in time/space metrology and signal processing approaches have a broad range of applications including very-large antenna structures, bistatic radar, communications, navigation, and sonar.

REFERENCES:
1. T.P. Celano, S.P. Francis, G.A. Gifford, B.J. Ramsey, T.L. Erickson, “Results of a Continuous Transatlantic Two-Way Satellite Time Transfer Test Using Commercial Modems”, Proceedings of the 32nd Precise Time and Time Interval Conference, December 200.

2. Judah Levine, “Time Synchronization over the Internet Using an Adaptive Frequency-Locked Loop,” IEEE Trans. On Ultrasonics, Ferroelectrics and Frequency Control, vol. 46, pp. 888-896, July 1999.

3. Calhoun, M., Kuhnle, P., Sydnor, R., Stein, S. and Gifford, A., “Precision Time and Frequency Transfer Utilizing SONET OC-3”, Proceedings of the 28th Precise Time and Time Interval Conference, November 1996.

4. A. Gifford, S. Pace, J. McNeff, One-Way GPS Time Transfer, 32nd Annual Precise Time and Time Interval Meeting (PTTI), pp. 137-146, November 2000.

5. DW Hanson, “Fundamentals of Two-Way Time Transfers By Satellite”, Proceedings of the 43rd Annual Symposium on Frequency Control, 1989.

KEYWORDS: Metrology,Radar,Multi-Static,Time Synchronization, Advanced Sensing

AF05-049 TITLE: Air Traffic Control (ATC) Tactical Briefcase

TECHNOLOGY AREAS:

OBJECTIVE: Develop a mobile air traffic control system for austere operations that provides network-centric capabilities for increased situational awareness and control.

DESCRIPTION: Defense Planning Guidance requires US military forces to be highly mobile and capable of rapid global deployment in response to a full range of operations. As a key enabler, a mobile air traffic control (ATC) system is essential to initiate airbase support needed before a full-scale deployment can be accomplished. Such a system should not be limited by traditional ATC concepts however. Rather a more network-centric approach is desired to increase the user’s situational awareness, decision-making ability and control needed for these unique

situations. For example, there is a desire to display virtually any data from supporting aircraft to facilitate tasks such as directing air strikes against hostile ground forces, reconnaissance team rendezvous with recovery aircraft, in-flight refueling, and forward airstrip activity.

Given that the completeness and complexity of data in these deployment situations can vary greatly, the ATC Tactical Briefcase should be implemented to enable the user to gain a cohesive understanding of the situation without requiring "mental pictures." In order to accomplish this, functionality that is not currently available on a single system may need to be fused in a logical manner. For example, one might first obtain flight position and other data from a small select group of aircraft using Automatic Dependent Surveillance-Addressed (ADS-A, routinely used in Oceanic airspace); use secure data links to provide the point to point communications; or include conventional surveillance data from variety of radio frequency (RF) sources. In order to develop the ATC Tactical Briefcase, cognitive science principles will need to be applied in addition to systems engineering.

Many elements of the technology to be used in this project are likely either in widespread use, available as commercial off-the-shelf (COTS) products, or have been previously demonstrated. The primary task envisioned for this project is to assemble these components to facilitate ATC activities. In addition, the demonstration should include various levels of service for each type of connectivity. The connectivity and data options to be considered include Automatic Dependent Surveillance–Broadcast (ADS-B) data via secure data link, RF data link provided by existing radios, randomized data link to avoid tracking, conventional ADS-B data, conventional surveillance data via point-to-point land communications, direct RF communications to Airborne Warning And Control System (AWACS) and satellite communications to data collection facility.

PHASE I: Develop an initial work-centered design for the ATC Tactical Briefcase. The design should include both hardware and software specifications, and costs associated with each including COTS products, facility requirements, development requirements and production time.

PHASE II: The ATC Tactical Briefcase designed in Phase I will be developed and demonstrated. The first demonstration will minimally cover ADS-A data delivered to the ATC display system by secure data link.

DUAL USE COMMERCIALIZATION: With some modifications, such a system could be used for various types of mobile deployments in defense, humanitarian campaigns and the private sector. The system could also be used for emergency ATC situations in cases such as terrorist strikes to control towers.

REFERENCES:
1. Packard Richard P., (1998 with recent revisions) Operational Requirements Document I (ORD) for a Mobile Approach Control System (MACS), ACAT Level III, HQ USAF 001-96-I-A.

2. Vicente, K. J. (1999) Cognitive Work Analysis: Toward Safe, Productive, and Healthy Computer-Based Work. NJ: Lawrence Erlbaum Assoc.

3. Scott, R., Roth E. M., Deutsch S. E., Kazmierczak, T., Eggleston, R.G., Kuper, S.R., Whitaker, R. (2003) Using Software Agents In Designing Work-Centered Support Systems. IEEE Intelligent Systems (Special Issue).

KEYWORDS: Air traffic control, mobile, Automatic Dependent Surveillance, man-machine interface

AF05-051 TITLE: Novel Methods for Delivery of Lifesaving Fluids and Medications

TECHNOLOGY AREAS:

OBJECTIVE: Develop a novel method of delivering lifesaving fluids/blood products/medications to patients in austere environments in cases where standard intravenous (IV) access is difficult or not feasible.

DESCRIPTION: Rescuers of wounded military personnel often need to establish intravenous access in order to administer lifesaving treatments including intravenous fluids, blood products, and medications. When a patient goes into severe shock the veins frequently collapse, causing standard intravenous access procedures to be difficult or

impossible. Alternative intravenous access procedures may be lengthy, unsuccessful, or result in further complications--particularly in austere conditions. Small children have another ready alternative--intraosseous infusion into the bone marrow. Recent advances have produced several new devices that are being used to establish intraosseous access in adults. While these devices represent a leap forward, they have shortcomings for battlefield use. The devices may not be resilient enough to function after moderate impacts, extremes of temperature, or wet/sandy conditions. Battery-powered devices may have potential pitfalls such as the additional weight of batteries, shorting out in wet conditions, and discharge/leakage in desert heat. Current devices might also cause complications such as a bony fracture or an embedded cannula that cannot be removed without a surgical team. Utilizing a physically-powered (e.g. windup) device may solve some of these issues. The topic is to develop a device to establish access for lifesaving fluids that overcomes the pitfalls discussed above. The device should be small and lightweight, resilient in conditions mentioned above, and be reliable, safe, and fast in establishing access. Picture a Special Operations pararescueman adding the device to his 70 pound pack, parachuting or fast-roping onto land or water, and quickly using the device to establish an IV on a severely injured patient in a swamp, sandstorm, or inflatable raft. Idealy, the device should allow insertion at different body sites, as a combat casualty may suffer from limb avulsions or sternal trauma.

PHASE I: Consider various concepts/designs, select one, demonstrate its feasibility, and show that the prototype will be small/light, will have the resilience to survive in the austere conditions described above, and can rapidly, safely, and reliably establish fluid access (preferably into different body locations). The device is not limited by power source or interosseous route--any novel solution is invited.

PHASE II: Build a prototype, and arrange/perform appropriate testing to demonstrate readiness for FDA approval and combat medicine use.

DUAL USE COMMERCIALIZATION: Air Force use will primarily be for delivery of lifesaving fluids in austere battlefield environments. Dual use applications for this technology are all emergency response systems, mass casualty response, emergency departments, and veterinary medicine. Additionally, geriatric patients and drug addicts often have significant problems with IV access.

REFERENCES:
1. Bellamy, R.F., The causes of death in conventional land warfare: Implications on combat casualty care research, Military Medicine, 1984, 149: 55-62.

2. Cummins, R.O., Advanced Cardiac Life Support: Principles and Practice, Dallas TX, American Heart Assn, 2003.

3. Dubick, M.A. and Holcomb, J.B., A Review of Intraosseous Access: Current Status and Military Application, Military Medicine, 2000, 165: 552-558.

KEYWORDS: intravenous, intraosseous, bone marrow, IV fluids, blood products, combat medicine, combat casualty, pararescue, Special Operations, Combat Search and Rescue, shock

AF05-052 TITLE: Helicopter Aircrew Restraint

TECHNOLOGY AREAS: Human Systems, Weapons

OBJECTIVE: Develop innovative technologies that can be incorporated into a safer and more effective helicopter aircrew restraint system.

DESCRIPTION: Helicopter aircrew members need restraint systems that allow them the flexibility to perform their mission while still providing adequate restraint in the event of a severe maneuver, crash or other impact event. Current restraint systems must either be locked in place for expected crashes or impacts, or loosened to allow crewmember movement. New Joint Cockpit Airbag Systems, that AFRL/HEPA helped develop in conjunction with the Navy and Army, are designed for crash protection only. These systems are inadequate in that during evasive maneuvers, the aircrew member may be “tossed” around the aircraft putting him/her at risk of severe injuries. A “smart system” is needed that will automatically self-adjust to a level of restraint based on flight maneuvers or

anticipated impact events. The restraint should allow the crewmember to move around during normal flight, but incrementally increase the restraint tension as the level of acceleration increases during violent maneuvers or crashes. Adaptive seat structure to enhance lateral support can also be part of such a restraint system. A recent safety mishap report documented the need for improvements to the current system.

PHASE I: Apply emerging technologies to restraint systems that can provide maximum protection to the helicopter aircrew by preventing him/her from being "tossed" around during emergency conditions, yet provide adequate freedom of movement during normal flight conditions. Define criteria for evaluating these restraint systems and identify inadequacies in current restraint systems as based on these criteria. Propose specific new designs to include drawings and proposed materials that will meet the defined criteria.

PHASE II: Validate the solution(s) identified in Phase I to include testing, prototypes and initial operational assessment to assure aircrew equipment/aircraft compatibility

DUAL USE COMMERCIALIZATION: In addition to the military applications referred to above, this technology would have commercial applications such as car restraint systems which are currently similar to the helicopter "locked/unlocked" restraint systems. Also, this technology could be used in commercial aircraft such as evacuation or fire-fighting aircraft where high-g maneuvers routinely take place, but crewmembers need the freedom to conduct their missions.

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

2. AF Aircrew Protection Roadmap endorsed by MAJCOM/CVs

3. Crash Protection Performance of a Helicopter Cockpit Airbag System
Robert F. Gansman and Anita E. Grierson, SAFE Association Proceedings, 1999.

4. Aircraft Crash Survival Design Guide by Simula Inc., Report # USAAVSCOM TR 89-D-22A & 22B (Volumes I and II), December 1989 (approved for public release).

KEYWORDS: Helicopter restraints, restraint systems, inertial reels, adaptive pretensioner, lateral seat support,

AF05-053 TITLE: Carbon Monoxide Detector Kit

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Human Systems

OBJECTIVE: Develop innovative ways to detect carbon monoxide levels on military airlift aircraft.

DESCRIPTION: The overall requirement is to develop and qualify for fielding an aircraft installed device that can warn aircrew members when they are exposed to high levels of carbon monoxide.

PHASE I: Investigate current and emerging technologies that can easily and rapidly detect carbon monoxide levels. The technical approach should result in a miniaturized, safe, highly reliable, accurate, rapid response, and low or no power stand-alone device. Propose methods to develop devices that can operate as intended in an operational (military) environment. Preferred approach would use solid state technology and/or nanotechnology. The device should be capable of operation in a military airlift aircraft between cabin altitudes of sea level and 25,000 feet and not create a hazard during aircraft normal or emergency operations. Further, the device must weigh less than 8 ounces, have a continous operating life of 4,000 hours, and not require replenishment of consumable chemicals. The device must continuously update a carbon monoxide concentration display in parts per million by volume and alert the aircrew at detection thresholds of 35 parts per million (warning threshold) and 200 parts per million (danger threshold). The device should provide distinctive visual and audible warnings at the detection thresholds. A breadboard device will be demonstrated.

PHASE II: Continue work on the device to include necessary bench tests and the development of prototypes that can be further tested in a military environment.

DUAL USE COMMERCIALIZATION: This technology could potentially be widely applied in both the commercial and military sector for early detection of carbon monoxide levels.

REFERENCES:
1. NIOSH Pocket Guide to Chemical Hazards, U.S. Dept. of Health and Human Service, Centers for Disease Control and Prevention, Jun 94.

KEYWORDS: Carbon monoxide, carbon monoxide levels, carbon monoxide detection devices in military aircraft.

AF05-054 TITLE: True 3-D Display

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop an innovative technical approach to promote true 3-D displays that can help the warfighter's situation awareness and decision making capability in a simulated and/or real world environment.

DESCRIPTION: Current displays depicting the mission environment do not give a true picture of the situation because 2-D displays do not appropriately represent a 3-D environment. A number of studies have been done and a number of attempts have been made to develop displays that give 3-D effects. However, no such displays exist at this time that can adequately exhibit a real world 3-D environment. These studies and the related research work was based on techniques such as holographic image generation, developing displays comprising of multi-layer 2-D images, developing displays that mechanically oscillate perpendicular to the plane of the image, using displays that create two sets of images (one for the right eye and one for the left eye) and use polarizer or shutter to view 3-D effects, etc. However, none of these techniques has so far been successful in producing a real 3-D picture in fast moving environment. This effort will develop an innovative approach to display a true 3-D image and demonstrate the new technology by developing a prototype. The proposed solution should overcome the drawbacks (such as jitters, distortion, ghosting, inability to show moving objects, image processing bottlenecks, etc.) of current 3-D display technologies such as stereoscopic displays, lenticular displays, multi-layer displays, and holographic displays. True 3-D display should not require the use of 3-D glasses or other accessories and should show the object just like seeing it in free space. Mechanical approach should not be considered to avoid jitters in the image. True 3-D display should be capable of showing as object at video rate if the object is in motion. The warfighters have universally expressed desire to use displays that do not just show the flat picture but also the depth perception. The output of this technology will go a long way in satisfying the warfighter's need. The proposed research is not solely restricted to defense applications and has many non-defense applications. There is a risk that this research may not be able to achieve all its objectives.

PHASE I: Propose an innovative technological scheme most suitable for generating a true 3-D display. Conduct risk analysis and list risk reduction plans. Develop a preliminary design to demonstrate the proof of principle. Generate final report to list the technological achievements made and the recommended direction of the future research.

PHASE II: Develop a comprehensible design based on the technological scheme developed in Phase I. Develop and demonstrate a prototype system in a simulated or real world environment. Develop evaluation criteria for the prototype performance. Characterize the prototype meeting or exceeding the minimum levels set in the evaluation criteria. Deliver a working prototype for future evaluation and reliability studies. Generate and deliver final report.

DUAL USE COMMERCIALIZATION: This system could be used in a broad range of military and civilian applications where depth perception considerably helps in decision making. In particular, this type of display could be used in initially a simulated tactical environment and finally in a real world tactical mission. Examples will be tactical situation awareness for Air Force application and CAD/CAM, medical surgery and architectural design for commercial applications.

REFERENCES:

1. Optics and Photonics applied to three-dimensional imagery (IMAGE 3-D): presented as part of the Optics, Photonics, and Iconics Engineering Meeting (OPIEM), November 16-30, 1979, Strasbourg, France/ organized by European Photonics Association; editors, Michel Grosmann, Patrick Meyrueis

2. 3-D machine perception: April 23-24, 1981, Washington D.C. / Bruce R. Altschuler, chairman/editor. Proceedings of SPIE --the International Society for Optical Engineering; v. 283

3. True three-dimensional imaging techniques and display technologies / 15-16 January 1987, Los Angles, California / David F. McAllister, Woodrow E. Robbins, Chairs/Editors: sponsored by SPIE--the International Society for Optical Engineering; in conjunction with the Center for Applied Optics/University of Alabama in Huntsville; v. 761

4. 3-D visualization for engineering graphics / Sheryl A. Sorby, Kim J. Manner, Beverly J. Baartmans; published in 1998 by Prentice Hall, Upper Saddle River, New Jersey, 07458

5. Three-Dimensional Imaging Techniques by Takanori Okoshi; published in 1976 by Academic Press (subsidiary of Brace Jovanovich, Publishers) New York

KEYWORDS: Real world environment, flat panel display, polarizer, shutter, holographic image generation

AF05-055 TITLE: Portal Workstation Development: Multi-Sensor Network-Centric, Open Systems Portal

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a common set of workstation portal technologies based on standard architecture service to support future distrubted ground systems.

DESCRIPTION: The goal is to enhance the common operations picture by development of workstation portal systems that will be Web-based and set up for information to be ported and displayed on the common workstation. There will be a need to further evolve the underlying mechanisms for information handling and control through standard architecture services (XML, web services and other emerging technologies). Through use of these standards, the portal environment will meet the interoperability requirements specified in Joint Vision 2010. Specific areas of research include:
1. Application of open-standards technologies, such as XML and Web Service
2. Integration of indications and warnings (I&W) for MULTI-INT heterogeneous sensors.
3. Portal environments developed for tailoring to the user requirements.
4. Distributed monitoring and alerting
5. Operator-centered approach to workstation design empasizing situational awareness maintenance.

PHASE I: Develop an overall architecture for the Portal detailed enough to provide framework for design and implementation of the portal workstation. J2EE architecture should be used. Messaging should be done via XML. Architecture must address heterogeneity of distributed data sources. Phase 1 results should identify specific software development and design tools. Contractor needs to ensure their solution can be integrated into an HLA/DIS compliant simulation suite composed of human-in-the-loop (HITL) and constructive elements.

PHASE II: Build and integrate a prototype into AFRL/HEC's SAFIRE network of HITL constructive simulations supporting TST activities hosted on Linux or PC Windows operating systems.

DUAL USE COMMERCIALIZATION: 1. Portal environments for Homeland Security
2. Near-real time monitoring and alerting for large scale distributed critical infrastructure assets, (e.g., electrical grids, water systems)to ensure continuity of operations and major disasters.

KEYWORDS: Portals; Network-Centric Warfare; Indications and Warnings;Web Standards;Monitoring; Alerting; Human Computer Interfaces (HCI)

AF05-056 TITLE: Network-Centric Communications: Distributed Real-Time UAV Access

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop Human-Computer Interface Design Requirements to Support Network-Enabled User Access to Uav Imagery and Tasking.

DESCRIPTION: Development of the Global Information Grid (GIG) architecture is being addressed by several agencies, e.g., DARPA. There is however, scant research attention being directed, "at the outset," to development of necessary Human Computer Interfaces (HCI)that will realize the stated goals for expanded interoperability among and between UAVs assets (See Ref#1). At present, these netcentric HCI capabilities DO NOT exist for any AF UAV platform. This effort will focus on developing the appropriate HCI design requirements for network-enabled access to UAV imagery, collection plans, and UAV sensor/aricraft retasking from different UAV remote location control centers (e.g., surveillance or combat types). Research issues that MUST be addressed for this effort include:
1. Tailoring UAV access information to UAV users based on decision and action needs requirements pertinent to specific operational missions.
2. Tailoring pertinent information to user's display/input device, e.g., laptop, PDA, or AOC workstation.
3. Tailoring information to user level of access authority (e.g., sensor operator or battlespace commander).
4. Detailed analysis of tradeoffs associated with a semi-automated distributed UAV access system (items 1-3 above).

PHASE I: Using a Time Sensitive Targeting (TST) scenario, provide a demonstration of two possible candidates for development of a distributed UAV access system. Contractor must describe how their solution would be integrated into an HLA/DIS compliant simulation suite of both human-in-the loop and constructive elements. Assume that a GIG architecture is in place and providing a secure web based imagery server that can be accessed remotely from a laptop or pocket PC by authorized users. From a laptop, the users must be able to access the UAV's current mission plan, modify the plan, and visually compare the plans in real-time.

PHASE II: Build the best solution prototype from Phase 1 for integration into AFRL/HEC's SAFIRE network which is composed of HLA/DIS compliant human-in-the-loop and constructive simulations to support time sensitive target detection, identification, and prosecution. Prototype must operate on standard PC environments under Windows or Linux operating systems.

DUAL USE COMMERCIALIZATION: This technology should transition directly to a variety of homeland defense scenarios such as: law enforcement arenas, including border patrol agencies and real-time coordination of disaster teams across the US that include surveillance assets (e.g., perimenter UAVs and blimps).

REFERENCES:
1. OSD Unmanned Aerial Vehicles Roadmap 2002-2027. Office of Secretary of Defense (Acquisition, Technology, & Logistics), Airwarfare. 11 March 2003.

2. Joint Robotics Master Plan: http://jointrobotics.com/activities_new/masterplan.shtml

3. Navy UUV Master Plan at http://www.onr.navy.mil/02/baa/baa01_012/pip/uuvmp.pdf

4. Defense Advanced Research Project Agency (DARPA) Strategic Plan. February 2003.

KEYWORDS: Network-Centric Warfare, UAV Interoperability, Real-Time Web Based Distributed UAV Access, HLA/DIS compliant.

AF05-057 TITLE: Advanced Subminiature Loudspeaker/Earphone Driver

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate an advanced high output subminiature loudspeaker/earphone driver for use in an in-the-earcanal active noise reduction (ANR) earplug system.

DESCRIPTION: Subminiature loudspeaker/earphone driver targeting 130dB sound pressure level output into a 1cc trapped volume. Must have a smooth frequency response, ie no discontinuities until at least 3.5 kHz, and low distortion. The driver must fit within a 6 mm diameter by 7 mm long cylindrical volume. In the ANR earplug application, phase delay is very important and can be the limiting factor in the system performance. A goal is having the first discontinuity in the frequency response to be 5 kHz or greater.

PHASE I: Develop a system analysis including examination of performance of existing designs (output, magnitude and phase of the frequency response, total delay, size), structure (coil, balanced armature, piezoelectric, etc) vs performance analysis, feasibility analysis with risk analysis and risk mitigation planning, and prototype fabrication and test plan.

PHASE II: Design, fabricate and test 3 different prototype advanced high output subminiature loudspeaker/earphone driver designs. From knowledge gained, design, fabricate, test, and deliver 10 working advanced high output subminiature loudspeaker/earphone drivers from a final design.

DUAL USE COMMERCIALIZATION: Hearing loss is endemic to high noise activities worldwide. This technology has immediate commercial application to civilian industrial sectors including airline industry, firefighters, law enforcement, search and rescue, industrial high-pressure paint removal, mining, and other high noise industrial settings. Additionally, there are potential applications in hi-fi audio applications.

REFERENCES:
1. DoD Design Criteria Std., Mil Std. 1474D, Noise Limits, 12 Feb97, page 65, par 4.2.1, Aircraft Noise

2. DoD Instruction 6055.12, Hearing Conservation Program

3. AFOSH Std. 48-19, Hazardous Noise Program

4. AFOSH Std 161-20, Hearing Conservation Program

5. OSHA 29 CFR, Occupational Noise Exposure

KEYWORDS: Active Noise Reduction, Earphone, Transducer, Earplug, hearing protection devices, hearing loss, ANR

AF05-059 TITLE: MEMs Co-located Integrated Microphone/Earphone for Active Noise Reduction

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop, fabricate, and test a co-located integrated microphone/earphone device for active noise reduction earplug applications and in the ear communication earplugs using MEMs technology

DESCRIPTION: Using MEMs technology, develop co-located microphone and earphone driver (speaker) technology for use in in-the-earcanal active noise reduction & communication system applications. The co-location will minimize the delay thereby enhancing the active control bandwidth, plus enable more space for other desirable technology onboard custom plugs (bio-sensors, etc). The integrated device must fit within a 6 mm diameter by 7 mm length volume. Desirable characteristics include high acoustic output (105 - 130 dB), wide bandwidth, linear amplitude response, minimum phase delay, smooth frequency response, small size, low power consumption and water resistancy.

PHASE I: Perform a feasibility analysis including multiple system concepts, performance assessment plans, risk analysis, risk mitigation plans, and a review of existing applicable technologies.

PHASE II: Design and fabrication of prototypes of candidate designs (2-5), performance assessment of the prototypes, design, fabrication, test, delivery of a final design with delivery of 10 working co-located integrated microphone/earphone devices. Production planning, estimated unit cost, and potential commercial applications in the private sector will be discussed.

DUAL USE COMMERCIALIZATION: Hearing loss and poor voice communication difficulties are endemic to human activity in intense noise fields. Active Noise Reduction is currently limited by phase delays due to the physical separation between the microphone and earphone. This device minimizes this delay thereby maximizes the potential performance of an active noise reduction system. This technology has immediate commercial application to civilian industrial sectors including airline industry, firefighters, law enforcement, search and rescue, industrial high pressure paint removal, mining, and other high noise industrial settings. Additional applications may occur in the consumer audio sector.

REFERENCES:
1.DoD Design Criteria Std., Mil Std. 1474D, Noise Limits, 12 Feb97, page 65, par 4.2.1, Aircraft Noise

2.DoD Instruction 6055.12, Hearing Conservation Program
AFOSH Std. 48-19, Hazardous Noise Program

3. AFOSH Std 161-20, Hearing Conservation Program

4. OSHA 29 CFR, Occupational Noise Exposure

KEYWORDS: Transducers, Microphone, Earphone, Active Noise Reduction, MEMs, ANR, Hearing Protection, Earplug, Active Noise Control, Active Noise Cancellation, Communications, Special Operations

AF05-060 TITLE: Helmet Mounted Image Source/Display for Tactical Air Combat Operations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate an innovative core image source technology for use with full color, ejection-safe, day/night, high-resolution, see-through helmet mounted displays.

DESCRIPTION: Helmet-mounted displays have become more and more important in today's fighter aircraft. As current systems get propagated into contemporary fighter aircraft, and pilots gain experience in their use and the operational advantage that they provide, they are asking for more and more capability. Wider field of views (greater than 80 degrees (H) by 40 degrees (v)), larger exit pupils, full color display, lighter head borne weights, smaller, lighter optical elements, low power, full motion video, still imagery, symbology, high resolution, and day night capabilities with both see through and look-at types of displays are being requested. New emerging technologies such as high resolution liquid crystal displays (LCDs), Active Matrix Organic Light Emitting Diode (AMOLED) displays, retinal scan displays, and field emissive devices (FEDs) all promising significant capability improvements in miniature displays. Newer non-mainstream devices may offer further capability enhancements. This effort is to produce a conceptual design and prototype for an innovative helmet-display subsystem solution that solves these needs to the maximum extent possible.

PHASE I: Develop and demonstrate an innovative working laboratory prototype helmet-mounted display that can be used to demonstrate the basic operating characteristics of the selected core display technology. Compare applicable competing technologies and presents a technical rationale for down-selecting to a final candidate. Identify operating parameters and essential characteristics for evolving the selected display technology, which is robust enough to operate with good life characteristics in both military tactical aircraft and man-mounted applications. A technology integration risk matrix shall also be developed.

PHASE II: Development of a flyable brass board, prototype display demonstrating full color wide field of view capability with sufficient luminance to meet requirements.

DUAL USE COMMERCIALIZATION: Commercial and military applications could include a wide variety of lightweight head mounted displays for industrial, entertainment, medical, aviation, or business use. Many applications exist where enhanced performance can be obtained by keeping the user's eyes on the task at hand while receiving additional information. This requires a see-through capability with sufficient contrast that bright backgrounds or high-resolution background scenes do not obstruct the viewing of the display to any significant degree. Existing users of monochrome versions include the medical community, CAD/CAM users, makers of head-mounted electronic test and instrumentation systems, and automotive repair organizations can benefit from the use of color-coded of information.

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Proceedings of the Meeting, Orlando, FL, Apr. 7-9, 1999 (A99-45176 12-31), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 3690), 1999, p. 2-25

KEYWORDS: Helmet Mounted Display, Head Mounted Display, Personal Display, Private Display

AF05-061 TITLE: Hands Free Data Collection for Aircraft Maintainers

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Research technologies to enable Aircraft Maintainers to interact with maintenance, supply, or other logistic's legacy and emerging IT Systems hands-free at the point of maintenance.

DESCRIPTION: In the aircraft maintenance environment, technicians must access various systems and subsystems carrying various tools and test equipment. As maintenance actions are taken by the technicians, maintenance technical orders must be accessed, and discrepancies, job orders, and part ordering data must be entered into the legacy data systems to record the actions and order the required parts to complete the maintenance actions and return the status of the aircraft to Full Mission Capability (FMC). Research is needed to explore various innovative cutting-edge technologies that can enable the technician on the flight line to access and enter data into a wide variety of logistics systems in real-time during the maintenance actions without having the technician stop working. The technology needs to be robust enough to withstand the noise, vibration, and generally harsh environment of the flightline. The technology also needs to be open and flexible enough to enable interoperability with existing legacy logistics systems, as well as,the future joint autonomic logistics systems of the F-35. As a precursor to this research, bidder should be familiar with DoD and relevant commercial literature on hands-free data entry.

PHASE I: Determine feasibility to include 1) a requirements analysis of areas within the logistics process that could use hands free data collection and entry technologies to improve the timeliness and productivity of maintenance, 2) an analysis of innovative, cutting-edge technology alternatives, for data collection and input at the point of maintenance, 3) a preliminary architecture comprised of the most promising approaches, and assess its feasibility, 4) an initial design for a prototype, and 6) a final report that documents the research done, lists the requirements, analysis of alternatives, initial prototype design and architecture, and recommendation of future research and demonstration focus for the phase II.

PHASE II: Develop and demonstrate a prototype capability in a limited operational environment. Develop evaluation criteria for prototype performance and evaluate the prototype. Deliver a working prototype for future evaluation, demonstration, and marketing purposes. Generate and deliver a final report to document the technical achievements during Phase II.

DUAL USE COMMERCIALIZATION: This capability could be adapted to a broad range of military and civilian applications where timely and productive work performance would benefit from hands-free interaction with IT systems. It is anticipated that the greatest benefit would be to military and commercial aircraft and ground systems maintenance domains. Technology that enables the technician to interact with logistics systems as he/she is performing maintenance can decrease down time considerably. Hands free manipulation of information systems could have far-reaching implications with information systems in general and the medical surgery field as well.

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1. Sharma, R. et. al, "Speech/gesture interface to a visual-computing environment", IEEE Computer Graphics and Applications, Vol 20, No. 2, March-April 2000, pp. 29-37.

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3. Corradini, A., et. al, "Multimodal Input Fusion in Human-Computer Interaction on the Example of the on-going NICE Project", Proceedings of the NATO-ASI conference on Data Fusion for Situation Monitoring, Incident Detection, Alert and Response Management, August 18th-29th, Yerevan (Armenia), 2003, www.limsi.fr/Individu/martin/research/ articles/NATO-ASI_1.pdf

KEYWORDS: aircraft maintenance, hands free maintenance information systems, hands free data collection and entry, passive data collection, digital images to text conversion, voice activated command recognition, multi-modal input, multiple modality data fusion, gesture recognition, wearable camera data conversion, data input alternatives

AF05-064 TITLE: Aircrew Flash Blindness Goggle

TECHNOLOGY AREAS: Human Systems, Weapons

OBJECTIVE: Development of eye protection against high-intensity, rapid-onset flashes, such as would be encountered during a nuclear blast

DESCRIPTION: Flashblindess is a temporary visual impairment caused by a tremendous amount of light emitted by a nuclear weapon's explosion. This visual impairment can affect the aircrew's member to control the aircraft. The current thermal flash blindness (TFB) protection device operates on the same principle as a pair of polarized filters which will block all light from passing when oriented 90 degress to one another. Under normal light conditions the TFB lens look like ordinary sun shades with allows light transmission. During an explosive bright event a photocell and electronics cause the lens to become opaque with some limited visual acuity, similar to welder's type glasses. Response time is in microseconds and protection remains until source is reduced to a nominal level. The TFB goggles were affixed to helmets given a threat potential. The TFB goggles (soon to be obsolete) are big, bulky, heavy, and logistically unsupportable. The continued requirement for flashblindness protection is documented in the AF Aircrew Protection roadmap dated Feb FY03 and is included in the FY06 POM submitted to AFMC.

PHASE I: Investigate material solution approaches (active and passive) to provide protection against high-intensity, rapid-onset flashes, such as would be encountered during a nuclear blast. The material solution should allow for easy donning to be used by aircrew when encountering a threat situation.

PHASE II: Validate the solution(s) identified in Phase I to include testing, prototypes and initial operational assessment to assure aircrew equipment/aircraft compatibility.

DUAL USE COMMERCIALIZATION: This technology can be applicable to commercial application such as welders mask, sun visors, etc., and for the military, it can be used for pilots helmet visors.

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

2. AF Aircrew Protection Roadmap endorsed by MAJCOM/CVS

KEYWORDS: Aircrew Flash Blindness goggles, high-intensity flashes, nuclear flashes

AF05-065 TITLE: Network Health Monitoring and Diagnosis for Distributed Mission Operations (DMO) Training

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Human Systems

OBJECTIVE: Develop an embedded network monitoring system that can be used to efficiently measure and optimize the interactive performance of entities within and across DMO training simulations.

DESCRIPTION: Current simulation network analysis tools allow measurements to be made during real-time; but collected data can only be analyzed after the data has been transferred and combined after the simulation run. Innovative tools are needed which will allow data to be gathered and problem areas to be identified for specific entities within DMO simulations. The developed tools must enable system and training evaluations to be displayed while the simulation is running so that real-time adjustments, where possible, can be made to the simulation. Additionally, having the data available as the simulation progresses will permit simulation engineers and training researchers to better understand the potential negative aspects associated with delays in any contributing aspect of the simulation. In some cases, the identification of a network problem could result in a graceful degradation of capabilities while minimizing the impact on the training experience and on transfer of the training benefits to live operations environments. The tools must not impact the quality or the interactivity of the simulation as data is transferred between data collection units. The tools should also be compatible with the current DIS and HLA standards, and be able to display entity attributes. The developed system should display the information in a format that is easy to understand and pinpoint potential weaknesses in the quality of the simulation while the simulation is being conducted for diagnostic and remediation purposes. The tools will be used to determine the quality of the simulation while it is being conducted and identify problems and system bottlenecks that prevent effective DMO training.

PHASE I: Develop prototype measurement tools and provide a demonstration and report.

PHASE II: Produce a fully integrated performance monitoring and measurement capability, useable in real time in a DMO environment, and that provides the capabilities outlined above. It will also result in test and evaluation of the developed tools and will provide documentation of results in a technical report.

DUAL USE COMMERCIALIZATION: The military will realize a significant reduction in on-the-job training requirements while substantially increasing the capabilities of the operational forces in theater due to the improved training and performance transfer resulting from improved and more realistic training and rehearsal. Dual Use potential is significant since both the military and commercial sectors have devoted considerable resources to the development of highly complex operational systems.

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2. Kniola, T., Thompson, S., Valentino, G., Carlisle, C., Khalil, S., Beatty, D. (1998). SNAPPY: An SMP-Based, Low-Latency, Network Interface Unit and Latency Measurement System – Final Report. AFRL-VA-WP-TR-1998-3051.

3. Bryant, R., Douglass, Capt. S., Ewart, R., Slutz, G. (1994). Dynamic Latency Measurement Using the Simulator Network Analysis Project. I/ITSEC conference.

4. Andel, Lt. T., Zydallis, Lt. J (1998). Coyote '98 Data Evaluation. AFRL/VACD report.

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KEYWORDS: Distributed Mission Operations (DMO), Training Simulation, Distributed Simulation, Network Monitoring, Latency, Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Real-Time Simulation

AF05-066 TITLE: Role Based Real-Time Virtual Collaborative Toolkit for TST

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Devleop innovative real-time role-based virtual tookit for transforming collaborative information sharing connectivity for analysts, mission managers, and warfighters.

DESCRIPTION: The majority of real-time collaboration tools (COTS and DoD) support communication and sharing among predefined and ad-hoc teams. When dealing with decision making and tasking related to Time Sensitive Targeting (TST) uncertainties, traditional collaboration tools are not always sufficient to ensure that the right data gets to the right person at the right time. Instead, there is a need for new workflow-based collaboration tools that can build virtual collaborative teams based on the type of INT, the priority, skill sets required, and availability of personnel with those skills. In such a new system approach, the collaboration would support both assignment and re-assignment of user roles. MULT-INT data would be dynamically pushed to the appropriate people. Specific "Awareness" capabilities will let the system know who is on-line and who can take on the new task. Role-or policy based security should ensure data are only sent to personnel with predesignated authority and appropriate clearance levels. Also, the system should permit on-line personnel to build ad-hoc teams and perform non-routine collaboration functions in addition to screen sharing and whiteboard. The system must be developed to provide both operator-computer and computer-operator role based awareness capabilities to ensure ease and efficiency in building appropriate skill based ad-hoc teams from personnel available anywhere in the world.

The research issues to be addressed are: (1) Development of detailed requirements analysis for determining role-based (i.e., operator-compter and computer-operator collaboration Toolkit features; (2) Determining how to incorporate role-based collaboration into the systems such as next generation DCGS architecture; (3) Determining how to tailor the system to the user's collaboration display input devices; and (4) Determining methods/procedures for maintaining security within the system.

PHASE I: Develop a proof-of-concept prototype that demonstrates functionality and feasibility of the Role-Based Real-Time Virtual Collaboration Toolkit within the context of a Time Sensitive Targeting (TST) environments. Develop an initial high-level architecture for the proposed system. Design and describe how solutions will be integrated into an HLA/DIS compliant simulation suite of HITL and constructive elements.

PHASE II: Build a prototype of the best solution from Phase I and demonstrate in an operational setting, e.g., a high fidelity Air Force modeling and simulation environment such as AFRL/HEC's SAFIRE network.

DUAL USE COMMERCIALIZATION: Collaboration and instant messaging systems are gaining acceptance within the corporate marketplace and becoming part of corporate infrastructures [5]. As the market matures, secure role-based collaborations systems will be used for functions such as: custom management, project management, and

distributed design. The military applications will providing TST battlespace operations the tools for:(1) REAL and EFFICIENT reductions in the timelines from "sensor to shooter;" and (2) fast, reliable real-time collaborations are expected to improve TST decision-making by at least a factor of 50%.

KEYWORDS: Real-Time Role Based Collaboration, Groupware, Workflow, Computer Supported Cooperative Work (CSCW), operator-computer/computer-operator role awareness

AF05-069 TITLE: The impact of cultural factors on human performance modeling and simulation

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To determine the predictive value of cultural factors in human performance for use in modeling and simulation technologies

DESCRIPTION: A wealth of behavioral research describes normative differences between individuals from different cultures. Researchers report qualitative and quantitative differences in such areas as cognition, interpersonal processes and belief structure, and several researchers have developed taxonomies of cultural differences. For example, Hofstede (2001) and Nisbett (2003) have proposed several cultural dimensions which affect behavior. Hofstede's dimensions in particular have been explored for their applicability to military command and control. But research to date has not determined which cultural factors are most statistically relevant as performance moderators. The predictive role of culture in interaction with other variables such as organizational training, stress or fatigue remains unclear. This lack of sufficient data on culture as a performance moderator stands as a barrier to accurate human behavior representation (Silverman, 2001).

Innovative approaches are needed to empirically determine the most relevant and influential cultural factors for a range of human behaviors. Furthermore, moderating variables which shape or bound the influence of culture need to be identified. Innovation is needed to move from theory to statistically supported application.

PHASE I: Conceptualize and design an innovative approach to quantifying the role of cultural factors in human performance. Demonstrate the feasibility of this concept for improving cross-cultural human behavior representation.

PHASE II: Develop, demonstrate and validate the proposed concept in a prototype tool which statistically models cultural differences in military-relevant behavior. The tool must capture the relationship of culture to other important predictor and moderator variables.

PHASE III DUAL USE APPLICATIONS: A validated model will be of utility in a variety of civilian and military modeling and simulation applications, from aviation to security to entertainment.

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KEYWORDS: Culture, cross-cultural psychology, human behavior, modeling and simulation

AF05-070 TITLE: Decision Support Technologies for Logistics Readiness Center

TECHNOLOGY AREAS: Materials/Processes, Human Systems

OBJECTIVE: Develop new decision support technologies and algorithms for used in a Logistics Readiness Center environment.

DESCRIPTION: In order to provide Air Force and DOD warfighters with integrated space-based capabilities, it is essential for the AF Space community to have a cohesive understanding of the health and status of space systems and assets both from an operational and equipment standpoint. It is critical the AF Space Command understand not only the current operational capabilities of space systems, but also current logistics and sustainment activities and their impact on operations. Research is needed in developing new algorithms to help determine the probability of failure of ground segments based on system components reliability in order to develop new decision support tools to aid in resource management of logistics assets and personnel.

PHASE I: Analyze single points of failure within ground support segments of various space systems such as Defense Support Program (DSP), Military Satellite Communications (MILSATCOM), Global Positioning Satellite (GPS), Space Based Infrared Systems (SBIRS), and Air Force Satellite Control Network (AFSCN). Algorithms will need to be developed that can model the reliability of system components and provide the probability of system failure based on system components and their relationship to the function of the system and impact to the overall mission. Purpose of Phase I is to determine the feasibility of developing the algorithms into a prototype capability.

PHASE II: Develop algorithmic reliability models for system components of various space system ground segments into a prototype demonstration..

PHASE III: Integrate and test concept developed in Phase II in a Logistics Readiness Center.

DUAL USE COMMERCIALIZATION: Work accomplished will be applied to the Power/Utility and Communications/Networking industries. Military application will include algorithms that will determine the probability of failure of ground segments of various military space systems.

REFERENCES:
1. Virtual Space Logistics Readiness Center (VSLRC): Concept of Operations (ASC 04-0054 1/14/2004)

KEYWORDS: Mission Capability (MC), Space Systems, Supply Chains, Logistics, Maintenance

AF05-071 TITLE: Embedding Cognitive Systems into Systems Engineering Practice

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

OBJECTIVE: Develop a process and toolset to embed the application of the emerging practices and technologies of cognitive systems into the traditional practice of systems engineering.

DESCRIPTION: The primary goal of this effort is to speed decision-making and exploit human potential in the system development process, by blending the emerging technologies and practices of cognitive engineering within traditional systems engineering. Achieving the goal will require development of an integrated process that extends today's practice of system engineering with new features that incorporate cognitive engineering as a key element of systems engineering. It will also require the identification and development of a set of tools that engineering practitioners can apply to make the new process efficient and affordable. Researchers in this area are trying to create an environment where people can work effectively any time, anywhere. This applies to situations ranging from a single operator working in a single location to many operators working in multiple locations. This program will draw from earlier work that developed the concept of human-centered design, current industry standards for software development, and guidelines and processes for human-computer interfaces. The outcome is envisioned to be an end-to-end process and supporting tools that span development from concept exploration through operational validation.

The outset of the 21st century has been accompanied by a revolution in military affairs and unprecedented efforts at every level to transform defense organizations, priorities and practices in order to confront the new era with its threats from terrorism and the proliferation of weapons of mass destruction. The Air Force has charted its course toward the future with its Transformation Flight Plan, which outlines a set of new and compelling operational challenges and the capabilities needed to confront them. A recurring theme is the critical importance of speeding information to the warfighter at every level from ground troops and flight crews all the way up to the Joint Force Commander, that enable communication of a clear and unambiguous picture of the battlespace and much more rapid decision-making that will dramatically reduce the time to perform missions. At every level in such operations, humans will necessarily interact with equipment, and therefore it is essential that the equipment interfaces be developed in a manner that fully exploits the human capabilities of information processing and decision-making, based on the best possible understanding of human cognition. Traditional systems engineering practice does not emphasize that needed facet of development. To meet the need, a new discipline is emerging that is advancing the state-of-the-art for cognitive engineering. A barrier to bringing the two communities together is that they lack a common and accepted process, often use different languages to communicate, and lack effective software tools for the analysis, simulation and evaluation of decision-making performance. This effort is intended to bridge that gap.

PHASE I: Develop a model process for cognitive systems engineering and identify improvements that would be needed to make the process attractive to government acquisition managers and industry. Identify barriers to implementing cognitive engineering in major system integration programs and recommend a remediation plan to overcome the barriers. Develop a maturation plan for Phase II, to include specific tasks for verification and validation both for the model process and needed support tools.

PHASE II: Develop executable software tools that instantiate the model process in the context of an extension to classical systems engineering. It will also develop and demonstrate the feasibility of software support tools in an example application. It will include development of performance assessment at each stage of development to assure that progress is adequate to proceed to the next stage. It will include a configuration management plan to assure that the improved process and support tools can be commercialized.

DUAL USE COMMERCIALIZATION: Phase III will include hosting and demonstration of the Phase II products at an Air Force-approved location for the purpose of demonstrating the products in a real-world Air Force C4ISR application. The products will be provided to at least one company developing a C4ISR application for the DoD and its use will be monitored for effectiveness.

REFERENCES:
1. “The U.S. Air Force Transformation Flight Plan,” November 2003, Future Concepts and Transformation Division, Hq USAF/XPXC

2. "Systems Engineering Fundamentals", January 2001, Defense Acquisition University Press, Fort Belvoir, VA 22060-5565

3 "Cognitive Systems Engineering," Jens Rasmussen, Annelise Mark Pejtersen, L.P. Goodstein., August 1994, John Wiley & Sons, Inc.

KEYWORDS: Systems Engineering,cognitive engineering,cognitive systems,decision making,cognitive systems engineering, human-centered design,command and control

AF05-073 TITLE: Developing Bioinformatics Tools for Proteomics Research

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

OBJECTIVE: Develop innovative bioinformatics software to aid in the analysis and interpretation of proteomics data.

DESCRIPTION: The DoD is using recent advancements in biotechnology to identify changes in gene and protein expression following several types of exposures, including directed and kinetic energy, infectious agents and their toxins, and low-level toxic compounds. These state-of-the science, broad-screening, sensitive biotechniques are capable of producing a tremendous amount of data. Bioinformatic tools are essential for the analysis and interpretation of these data. Software programs have been developed to identify each protein, but not to relate the expression of these proteins to upstream or downstream events. Linking these upstream and downstream data to those from other biotechnologies (e.g., genomics, high pressure liquid chromatography) will provide the scientists with tools to extract the biologically-significant molecular responses. This information will aid in the understanding of their influence on physiology and pathology. Also, the output of this software should be displayed as images, such as showing "roadmap" linkages, as well as written to a database file, such as Microsoft Access. Use that information as input into software that identifies the relationships among the significantly-altered proteins and their relationship to upstream and downstream events.

PHASE I: Define concepts for the software that will be used to identify or link to databases that identify altered protein expression. Develop and demonstrate a prototype system on a PC.

PHASE II: Develop, demonstrate, and validate software for identifying significantly-altered proteins and their relationship to upstream and downstream events. The software would be easily modified to incorporate future understanding of upstream and downstream events.

DUAL USE COMMERCIALIZATION: Development of proteomics and bioinformatics tools in support of military, academia, and commercial research are rapidly-growing scientific endeavors. The proposed bioinformatics tools would be extremely useful to these biotechnology efforts by helping provide data on the health and safety of personnel exposed to environmental toxins, chemical/biological warfare agents, and battlefield weapon systems.

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2. Harvard Institute of Proteomics (http://www.hip.harvard.edu)
3. ExPASy Molecular Biology Server (http://us.expasy.org.

KEYWORDS: Bioinformatics, Biotechnology, Genomics, Proteomics.

AF05-074 TITLE: Laser Eye Protection Contact Lens

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop Laser Eye Protection (LEP) in a contact lens format for aircrew and ground forces.

DESCRIPTION: Lasers play an important role in current military operations; their use as target illuminators, range finders, guidance systems for smart bombs, aircraft self-protect, and secure communications systems is extensive and expanding. Along with these increased capabilities comes an increased risk of laser injury, particularly to the eye. The risk of "buddy lasing" is at least as great as a hostile illumination simply because of the sheer number of "friendly" lasers in use in the battle space at any given time.

Laser eye protection currently used by USAF combat forces incorporates cutting edge technologies (principally advanced dyes and dielectric coatings) to provide protection from lasers at a variety of wavelengths in the infrared and visible portions of the electromagnetic spectrum. However, available eyewear formats can pose problems with regard to integration of LEP with protective equipment (helmets, goggles, and chem/bio gear), life support equipment (visors and oxygen masks), and avionics (head/helmet mounted displays and night vision goggles). Also, current methods of providing LEP eyewear with vision correction, while usable, can exacerbate the equipment integration problems.

Because of these equipment integration issues, many warfighters who require vision-corrective prescriptions wear contact lenses instead of spectacles. Furthermore, during our regular contacts with operational aircrews we are often asked about the possibility of putting LEP in contact lenses even by operators who do not require vision correction.

This suggests that these aircrew are more willing to "put up with" the annoyances of contact lenses than the annoyances of standard spectacles. In addition to solving systems integration issues, contact lenses would provide superior field-of-view coverage. Since the contact lens sits on the eye, the entire cornea and pupil are covered, so there is no chance of a reflection, or high angle incident beam, sneaking behind the LEP. Therefore, coupled with the appropriate laser protection technology, contact lenses provide a perfectly sized defense against eye injury, eliminating direct and off-axis retinal hazards from today's most dangerous military lasers that operate in the far red and near infrared spectrum (670 nm – 1200 nm).

This effort will focus on the design, fabrication, and validation of LEP in a contact lens format. The technical challenges in developing LEP in contact lenses are significant. The proposed technology must provide high luminance transmission (threshold of 45%, goal of > 70%) while delivering protection at a minimum optical density of 3 in infrared protection from 670 nm to 1200 nm. In terms of optical quality, it is paramount that negative factors such as haze, distortion, aberration, prism, and artifacts are minimized so as not to impair visual performance or create distractions in the visual field. These lenses must also cover the entire cornea, be comfortable enough to wear, even by individuals unaccustomed to wearing spectacles or contact lenses, for several hours, and be safe to use for the period of wear.

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

PHASE II: Execute the technology development plan proposed in Phase I and demonstrate the solution by delivering a suitably comfortable prototype contact lens with supporting performance data.

DUAL USE COMMERCIALIZATION: This device would enjoy a host of applications in any field that employs lasers and/or laser eye protection. Medical laser surgery, dental laser surgery, laser operators, lab technicians, wielding, manufacturing, and laser researchers are but a few markets that would readily make use of the proposed device. Additionally, there would be tremendous interest and use by the military and other government agencies.

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Sheehy, James B.and Morway, Phyllis E. in Laser-Inflicted Eye Injuries: Epidemiology, Prevention, and Treatment, SPIE Proceedings Vol. 2674, pp 208-218, Stuck, Bruce E. and Belkin, Michael, Eds. (1996).

KEYWORDS: Contact lens, Laser eye protection (LEP), Laser eye protection format, Laser defense, Corneal defense, dye dielectric stack,hologram, rugate, laser filter

AF05-075 TITLE: Visualization of Propellant Residues From Shoulder-Fired Rockets Upon Skin and Clothing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Human Systems

OBJECTIVE: Enable warfighters to identify hostile combatants that have recently launched shoulder-fired rocket weapons.

DESCRIPTION: Warfighters have a problem identifying hostile combatants in the current asymmetrical threat situation. Hostile combatants especially in urban terrain use the local population as shield against coalition forces. The hostile forces use sporadic though often deadly shoulder-fired rocket attacks to disrupt nation-building efforts, undermine local authorities, and to attempt to induce overreaction by US Forces, which would alienate the local population. These rockets are readily available, easily concealed, transported, and launched by hostile forces that then blend in with the innocent population. The development of standoff method of detecting propellant residues on person firing these weapons would enable the warfighters to capture the hostile fighters without causing harm or disaffection to the innocent local population.

PHASE I: Determine the feasibility of developing or applying an existing technology that can recognize rocket propellant residue on skin, hair, or clothing. Determine what residues are present on personnel after launching a shoulder-fired rocket and find methods of detecting the residues.

PHASE II: Further develop the methodology from the phase I research into a technology that enables the warfighter to detect rocket propellant residues at a distance of a few meters.

DUAL USE COMMERCIALIZATION: This product could be used by other US government agencies, private industry, and foreign governments to identify terrorist who use rocket propelled grenades or shoulder-fired anti-aircraft missiles.

REFERENCES:
1. Title: Analysis of Gun Tube and Case Base Residue From Experimental M829E3 Tank Ammunition Firings AD Number: ADB241086 Corporate Author: ARMY RESEARCH LAB ABERDEEN PROVING GROUND MD Personal Author: Pescue-Rodriguez, Rose A. Report Date: January 01, 1999 Media: 45 Page(s) Distribution Code: 03 - U.S. GOVT. ONLY

2. Title: Abbreviated Test Report for the Preproduction Qualification Test of the Grenade, Launcher, Smoke: MMW/IR Screening, XM81 AD Number: ADB230796 Corporate Author: YUMA PROVING GROUND AZ Personal Author: Patterson, Fred Report Date: September 01, 1995 Media: 205 Page(s) Distribution Code: 03 - U.S. GOVT. ONLY; DOD CONTROLLED Report Classification: Unclassified Source Code: 383350 From the collection: Technical Reports

KEYWORDS: rocket propellent residues, rocket propelled grenades, shoulder-fired antiaircraft missiles

AF05-076 TITLE: Immunotoxicity Monitoring Method for Unknown Noxious Exposures (IMMUNE)

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop and evaluate an immunotoxicity measurement method for estimating the adverse health effects of complex, chemical, biological and radiological exposure scenarios on the immune system.

DESCRIPTION: An increasingly important issue in force protection is the toxicology associated with unknown hazardous exposures at contaminated deployed sites (i.e. chemical, biological and radiological). Assessment of exposure is a critical element in risk assessment and management, and is especially important for armed forces deployed in hostile or environmentally contaminated sites. Current methods of determining toxic exposures to the warfighter are not adequate to prevent serous health effects such as was induced by Agent Orange in Vietnam or to predict and prevent medically unexplained physical symptoms (MUPS) associated with military deployment. One of the most scrutinized hypotheses of a causative factor of MUPS is immune reactions to administered drugs, or immunizations, to protect against chemical and biological warfare threats. Recent tests of 400 Gulf War veterans indicated that 95% of them were found to have antibodies to the vaccine adjuvant squalene; incorporated into vaccines to accelerate, enhance or prolong immune responses (1). This compound is also found in some dietary sources such as shark liver oil and some vegetable oils. Dr. Jeffery Bland of the Institute for Functional Medicine, (Gig Harbor, WA) has stated that the first sign of chronic toxicity in Gulf War veterans may appear as neuro- or

immunotoxicity. These two types of toxicity are highly sensitive to oxidative stress (i.e. reactive oxygen species). It is becoming increasingly clear that a large number of environmental contaminants can alter immune function, presumably through induction of oxidative stress, thereby, leading to increased susceptibility to infections, autoimmunity, allergies and cancer (2). Enhanced capabilities that allow for real- or near real-time assessment of immunotoxic exposure will provide military field commanders with viable options for preventing or minimizing mission degradation due to these types of exposure, as well as preventing or minimizing latent disease or disabilities following deployment. The latter would have dire consequences on force readiness for future deployments, as well as affecting the quality-of-life of force members and their families. Therefore, monitoring immunotoxic exposures of deployed forces can be a valuable and cost-effective method for force protection.

PHASE I: Develop a non- or minimally-invasive measurement method for estimating the adverse health effects of complex, and often poorly characterized, CBR exposure scenarios on the immune system of deployed personnel. Agents to be evaluated will be selected on the basis of Air Force priorities concerning chemicals known, or believed, to be found at deployed sites (e.g. heavy metals, depleted uranium and organophosphate pesticides).

PHASE II: Develop, test and validate an immunotoxicity field kit to assess risk associated with uncharacterized human exposure to CBRs and complex mixtures.

DUAL USE COMMERCIALIZATION: A portable immunotoxicity monitoring device could be a highly marketable item to industry for monitoring pollution and contamination exposure at manufacturing facilities or for any other types of industry where industrial processes have the potential to lead to pollution or contamination of soil, water or air. This device would also be highly marketable for homeland defense for monitoring CBR threats to the general population.

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KEYWORDS: force protection, warfighter, immunotoxicity, oxidative stress, deployed toxicology, radiological agent, chemical agent, biological agent, mixtures, field kit, occupational health

AF05-077 TITLE: Training Simulations for Decision Effectiveness in Computer Network Defensive Operations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a simulation capability including automated performance measurement and feedback for training decision effectiveness in computer network defensive operations.

DESCRIPTION: Computer network defense involves planning and executing responses to unauthorized activity directed toward computers and computer networks. Defensive activities include analyzing computer and network activity to determine the appropriate course of action to protect, detect, and react to internal and external threats.

Defense of computers and networks depends on procedural training and realistic exercises to support effective decision making in evaluating networks, traffic, usage trends, patterns, and anomaly detection. Technology advancements in the domain of simulation and modeling could be exploited for this purpose. Computer-driven, simulations represent a sound approach to training decision making in complex domains (Pleban, R.J., Eakin, D.E., Salter, M.S., and Matthews, M.D., 2001). However, as training simulation technology matures, technology obstacles remain in the area of automated performance feedback. Currently performance measurement is accomplished by instructors who observe trainee performance, compare it to performance standards, diagnose performance discrepancies, and provide performance feedback. For higher-level skills, these are complex interactions that exceed the capabilities of computer algorithms but for lower-level, decision making skills, tools for automated performance feedback could be developed as instructional aids. For example, automated performance measures in the form of probes and behavioral checklists could be combined with standards to serve as a basis for automated performance feedback. Such feedback should address decision effectiveness regarding situational awareness, intrusion detection, knowledge of trusted software and the trusted computing base, vulnerability scanning, disaster prevention and recovery, malicious insider detection, and forensics. Although, team training is an important goal for advanced instruction, for economy of effort the objective is to concentrate on individual training for decision effectiveness. It is critical that simulation and performance feedback software be reliable and secure. Innovative and creative approaches to meeting the technical goals are requested. This topic falls in RDT&E budget activity 4 through 7, therefore, the topic problem solicits R&D - i.e., projects involving a degree of technical risk- rather than procurement.

PHASE I: Generate a top-level design and develop a proof-of-concept training environment exemplar, assess risks and feasibility associated with the advanced technology development effort.

PHASE II: Develop, demonstrate, and field test a training simulation capability including automated performance measurement and feedback focusing on decision making effectiveness including situational awareness, intrusion detection, knowledge of trusted software and trusted computing base, vulnerability scanning, disaster prevention and recovery, malicious insider detection, and forensics.

PHASE III DUAL USE APPLICATIONS: Prepare detailed plans for implementing demonstrated capabilities for applications in the domains of homeland defense, banking, finance, e-commerce, medical, 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: decision effectiveness, training simulations, automated performance feedback, computer network attack, intrusion detection, computer network defense, information systems security.

AF05-078 TITLE: Force Cueing Technology Integration and Feedback Metrics to Improve DMO Simulator Effectiveness

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop metrics and a software suite for quantifying the impact of simulator fidelity (e.g., force cueing systems) on pilot combat mission performance in aircraft training simulation environments.

DESCRIPTION: Until recently, flight simulators have been used principally to train instrument flight, takeoff and landing, and limited combat tasks. But since the late 1990s, the Air Force has been increasingly using simulators to support full combat mission training, and has initiated the Distributed Mission Operations (DMO) program to transform Air Force training capabilities to enhance warfighter preparedness and combat effectiveness. The fidelity of these simulations must be adequate to effectively train the tasks intended for the training simulator. It is widely believed that effective full combat mission training requires a more highly realistic and complete simulation of the environment than for more limited flight training applications. However, it has proven difficult in practice to measure the effects that increased (or differences in) environmental realism has on training effectiveness. Further, there are very few automated tools and methods that permit routine tracking of the impact of changes in environmental fidelity on pilot and team performance. An aircraft pilot in a live fly situation constantly experiences various kinetic forces resulting from pilot control inputs, the environment, and aircraft state, including aircraft damage/failures. While the pilot's primary perception of the aircraft position, attitude, and accelerations is through out-the-window visual observation, these kinetic forces provide additional cues, consciously and subconsciously, about the accelerations of the aircraft. In a static simulation environment, these cues are absent. Force cueing devices, such as a motion platform, dynamic seat, G-suit, etc., can be added to the simulator to approximate some of the force cues, but the contribution of force cues to improved pilot performance and training effectiveness has not been established. As the simulation fidelity is improved for tactical aircraft training simulation devices, the contribution of force cueing simulation fidelity to improved training effectiveness needs to be established. Objective human performance constructs and metrics must be identified to address this issue. Moreover, a software system that permits these metrics to be instantiated, applied, and validated in systematic assessments of differing levels of fidelity must be developed and validated. The capability to quantify, in human performance terms, the trade space associated with different aspects of environmental fidelity, such as force cueing devices and feedback, has not been developed and is critical to training utility and return on investment assessments that must be in the US and in coalition training acquisitions.

This effort will develop, demonstrate, and validate human performance constructs and metrics as well as a software suite that instantiates the metrics for evaluating the impact of force cueing systems on pilot combat mission performance. The developed suite shall include objective measurement techniques for determining changes in pilot behavior and performance resulting from the introduction of specific force cueing systems and methods. The capability must be able to isolate the effects of simulation fidelity changes such as various types of force cues. Results obtained through these tools, methods, and processes should be usable to define the fidelity requirements for simulation of specific force cues in new training simulators, and to identify the most effective compromises (when necessary) for engineering changes to operational training simulators. There is currently no commercial measurement capability to objectively define the "trade space" associated with specific fidelity levels and changes to those levels. Moreover, there is no system that has the capacity to track the impact of integrating force cueing devices, as an example, on human performance in a simulation environment. As US forces and multinational military organizations struggle to define and assess how much fidelity is needed to truly train for realistic combat employment, a suite of tools such as this would have broad appeal and commercial potential.

PHASE I: Identify appropriate human performance metrics related to combat mission performance in live and simulation-based environments, Develop an approach for instantiating and automating metrics such that comparative assessments of the impact of different levels of fidelity can be conducted. Of particular relevance are comparative studies of the extent to which different levels of force cueing add to or detract from successful performance on the identified metrics. A preliminary demonstration of metrics and their instantiation in a routinely available system will be a deliverable in Phase I as will a detailed summary of relevant human performance constructs and metrics.

PHASE II: This phase will complete the development of metrics and algorithms and will demonstrate their utility for evaluating changes in environmental fidelity associated with different approaches and levels of force cueing. As

part of this phase, a demonstration of the power of the metrics and system for isolating human performance effects associated with force cueing will be accomplished. Finally, phase II will develop and demonstrate a simulation environment decision support system and specifications for evaluating tradeoffs in simulator fidelity related to force cueing and feedback to facilitate better simulation design and upgrade decisions.

DUAL USE COMMERCIALIZATION: Phase III would include application of the system to commercial and multinational training systems. While many commercial airlines have opted for very expensive motion platforms and feedback systems, there is limited empirical data that suggests that these systems provide incremental training validity above and beyond that obtainable from a fixed simulation system. The suite proposed in this effort will have significant potential as a way to determine flight simulator force cueing and feedback system effectiveness. The suite also has application to evaluating actual aircraft feedback and cueing systems using simulation during the design and subsystem testing phases prior to production.

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KEYWORDS: Acclimation, Flight Simulation, Combat Mission Training, Distributed Mission Training (DMT), Force Cueing, Motion Cueing, Distributed Simulation, Training Effectiveness Evaluation, Simulation Certification (SIMCERT), Simulation Based Design and Acquisition

AF05-080 TITLE: Innovative Pharmaceutical Delivery Device for Use in Military Operations

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Develop a valid technological approach to permit safe and expeditious delivery of a mild pharmaceutical aid to extend a warfighter cognitive performance or to rapidly induce sleep.

DESCRIPTION: Mission-related stressors threaten to adversely impact the operational readiness of aviators, UCAV operators, command-and-control (C2) personnel and others. Sleep deprivation (a common operational stressor) substantially reduces performance accuracy and slows reaction while adversely affecting mood. High workload demands (commonly encountered by pilots, battle management staff and others) can overwhelm one's capacity to effectively process information and manage complex systems under the time pressures typically found in operational settings. Oral pharmaceuticals effectively provides warfighters with some control of alertness or sleep-induction effects but is subject to variations in effectiveness based on a variety of typically uncontrolled factors (e.g., recently ingested food and drink). For sustained operations in excess of 24 hours, bolus deliveries of alertness aids via ingestion result in pharmaceutical level "peaks and valleys" potentially leaving the warfighter vulnerable. Survival may depend on rapid uptake of alertness aids. The development of technology systems for safe and rapid uptake of mild pharmaceuticals may maintain performance (or sleep) without the "peaks and valleys". New drug-delivery technologies, such as transdermal patches, offer the biotechnological advantage of pharmaceutical delivery to the capillaries resulting in a more rapid uptake and improved maintenance of alerting affects – hopefully avoiding adverse effects (e.g., jitters) associated with bolus delivery. These devices have the advantages of being discrete so as not to interfere with normal military operations, yet simple. We see the need for a capability to deliver pharmaceutical agents to give operators in the field the capability to rapidly prepare and adjust for mission extremes. The device should also be small, unobtrusive to performance, wearable, and able to deliver a variety of dosage schedules for approved military use.

PHASE I: Determine effectiveness of employing proposed drug delivery technologies for (1) safe administration of pharmaceuticals and (2) assess utility of device for ground and aviation military environments. Propose development of a prototype device under Phase II.

PHASE II: Develop prototype drug delivery device and test with mild alertness aid in laboratory and field settings.

DUAL USE COMMERCIALIZATION: AF Phase III applications include application in a multitude of operational environments including multi-crew aviation, maintenance, security force, air operations center, and UAV and other console based operations to name a few. Unobtrusive, wearable, and adaptable drug delivery technologies will enhance cognitive performance in a variety of commercial applications including: aviation, transportation, security, nuclear power, and other vigilance demanding applications.

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KEYWORDS: Pharmaceutical delivery devices, transdermal, alertness, sleep-induction, cognitive load, fatigue, workload

AF05-084 TITLE: Fusion of Entity Information from Textual Data Sources (e.g. HUMINT)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a capability to extract and fuse useful information on entities (e.g., people, equipment) from unstructured text, for effective exploitation of textual data sources.

DESCRIPTION: Information analysts need a fast, effective means to extract all information on entities of interest from unstructured text sources (e.g., HUMINT, IMINT, reports, open source, e-mail),. Entities are "things", such as people (e.g., terrorists), facilities, equipment (e.g., potential targets), places (e.g., countries) and organizations. Currently, analysts may read 100s of potentially relevant documents to find and manually extract such information. This takes considerable time and effort, negatively impacting their ability to provide timely, high-quality analyses. A high-accuracy capability is needed to extract useful entity information from large volumes of text, and consolidate it into a single record known as an Entity Profile (EP). E.g., a "Person Profile" may pull together the following information, extracted from 1000s of documents, into a single record: name, aliases, position, descriptors, location, associations with other people/organizations, relationships they are involved in, and events they participated in.

While Information Extraction (IE) technology now supports the creation of simple Entity Profiles, these profiles suffer from low recall. For a given document, IE can merge information extracted from sentences that contain the exact same entity name (e.g., both sentences contain the name Osama Bin Laden) or a closely related alias (e.g., one sentence contains Osama Bin Laden, and another contains Bin Laden). However, IE technology is not as good at figuring out when different words refer to the same entity. E.g., figuring out when "Bin Laden" (a name), "the terrorist" (a descriptor), and "he" (a pronoun) all refer to the same person in a document. Once you know all those references actually refer to the same person, you can consolidate their information into a single record. This challenge is known as "within-document" co-reference resolution".

While there are a number of technical areas that need to be addressed in order to achieve consolidated Entity Profiles, the specific area of interest for this SBIR topic is within-document co-reference resolution. Of particular interest are hard co-reference problems that still need considerable research, and can significantly improve the amount of relevant information extracted and consolidated in Entity Profiles. E.g., for pronoun co-reference, genderless pronouns ("I","it") and plural pronouns ("we", "they") are particularly challenging. Other challenges include nominal co-reference, and co-reference problems associated with porting to new domains.

In terms of the Payoff and Impact, this will contribute to the goal of Multi-INT Fusion by enabling effective exploitation of entity information from HUMINT and IMINT reports. It will support Homeland Defense by automatically extracting information on people and organizations, for analysts who keep watch-lists on terrorists and terrorist organizations. It supports Information Discovery because Entity Profiles provide the names of all entities (people, organizations, equipment, etc.) found to be associated with a given person/ organization/facility in text, not just those analysts already know about. Finally, more effective text exploitation contributes to faster, higher-quality Situation Awareness.

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 high accuracy Entity Profiles using information extracted from large volumes of text. Develop and demonstrate the prototype baseline capability using candidate actual data from operational systems.

DUAL USE COMMERCIALIZATION: The ability to quickly and accurately extract information on people and organizations, from 1000s of unstructured text documents, would be of tremendous benefit to Homeland Defense analysts. It would provide them with fast, detailed information on terrorists and potential terrorists on their Watch Lists. It would also provide them with a powerful tool for information discovery, which could help them identify previously unknown terrorists and terrorist organizations (e.g., by identifying people/organizations who are found to have an association or relationship with known terrorists or terrorist organizations). Law Enforcement would similarly benefit from Entity Profiles. It could help detectives and investigators by providing them with fast, detailed information on criminals, suspected criminals, and suspect organizations, extracted from 1000s of textual reports. Business Intelligence applications are very interested in using Entity Profiles to help automate research on competitors from huge volumes of open source text (newspapers, trade publications, magazines, etc.). Broadcast News organizations, that need information fast, would greatly benefit from the ability to quickly and accurately extract all available information on individuals or organizations that are the subject of investigative reporting, from 1000s of text documents.

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KEYWORDS: Information Extraction, Text Mining, HUMINT, fusion, Homeland Defense, Intelligence analysis

AF05-085 TITLE: Multi-Level Security for Dynamic COP

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide approaches to accommodate rapid and dynamic fusion of multi-security level Satellite Attack detection and intelligence data into an operational picture and release appropriately classified composite data to multiple security domains.

DESCRIPTION: The fusion and integration of bounded actionable data across multiple security domains is critical for commanders (US, Allied, Coalition) to monitor, assess, plan and execute mission-critical operations. The problem domain is for bounded, structured space system attack data products versus unbounded data sources such as email messages and text chat. Guard-based cross-domain solutions already contribute to the above mission need with rule-based inspection and multi-level security connectivity to facilitate dissemination of rapid dynamic fused COP when the security level of data is properly identified using security tags and integrity/attribution seals (e.g. PKI-based digital signatures). However, no method currently exists to accurately and reliably classify/tag the space system attack detection and products output from fusion engines where the data inputs span an assortment of classification levels, data pedigree needs to be retained to the maximum extent possible, and sanitization for multi-domain distribution needs to maximize information content. Commercial applicability of the above is manifested in the need for similar secure technologies and approaches in the private sector.

PHASE I: Develop an approach and associated proof-of-concept demonstration of a Satellite Attack detection and intelligence multi-domain aware fusion engine which interfaces with a guard-based cross-domain solution in order to deliver fused products to recipients in peer or lower domains. This engine would analyze data from satellite systems, intelligence products and real-time intelligence data from intelligence broadcast systems. The engine would then output an attack determination with associated confidence level and proper security classification.

PHASE II: Develop a prototype of the Satellite Attack detection and intelligence multi-domain aware fusion engine and deliver it for interface with a guarding solution in an experimental environment to simulate and evaluate contributions to a realistic operational implementation scenario.

DUAL USE COMMERCIALIZATION: The new tools and approaches developed under this effort will be directly applicable to current and future C2 systems (CCIC2S, SBMCS, MCCC, SEWS) as well as commercial systems fusing heterogeneous data and controlling publication across information sensitivity domains (intranets, etc.).

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KEYWORDS: Multi-level security, Common Operating Picture, fusion, guarding solutions

AF05-086 TITLE: Neuro-Networking Techniques for N/UWSS

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Investigate techniques for improved data access, integration, storage and control using neuro-networking approaches for space-based sensors across C2 systems (CCIC2S, SBMCS, TBMCS).

DESCRIPTION: The implementation and integration of actionable data across a community of interest or multiple communities of interest is critical for commanders to monitor, assess, plan and execute mission-critical operations. Technologies such as neural-networking, evolutionary algorithms (EA) or genetic algorithms (GA), as applied to data mining and filtering, can help ensure accommodation of the above. Ways to integrate with sensor networks built using cognitive and data/knowledge base techniques should be explored. Recent experiments at the Space Warfare Center explored and validated the application of neural networks to monitoring C2 data for the purposes of identifying space system attacks and anomalies. It is believed that neural networks, EA or GA approaches could be used to monitor mission-critical operations for a multitude of tasks important to the warfighter. First, common data used in COPS could be monitored and then updated only when the neural network, EA or GA system indicated the behavior was out of family from the expected behavior, thus allowing analysts to only focus on activities that are changing or anomalous and reducing network traffic by only updating when data changes warranted. Further, neural networks, EA or GA techniques working separately or in conjunction with intelligent sensors also show great promise in monitoring sensor and infrastructure status and alerting operators when systems supporting space superiority and even information superiority are at risk of decreased or halted operations. This approach will, for example, allow multiple sensors on one platform to inference and fuse data and information from all its sensors for alerting purposes. The proposal should evaluate neural network, EA or GA solutions to the above problems/issues via the application of evolving neural network, EA or GA techniques and technologies and integrate with innovative sensor approaches. Commercial applicability is also evident as neural network and pattern recognition algorithms are explored and implemented in multiple commercial systems that require similar monitoring or display of COP-like data, i.e. Telecom switching centers, financial analysis institutions and satellite command and control systems.

PHASE I: Develop and demonstrate approaches for the application of neural-networking and EA or GA techniques to identify data requiring updates in a common operating environment and monitoring infrastructure status to including filter tuning and network traffic reduction across sensors.

PHASE II: APPLICATIONS: The new tools and approaches developed under this effort will be directly applicable to current and future C2 systems (CCIC2S, SBMCS, TBMCS, RAIDRS, SISP, MCCC, SEWS).

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

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KEYWORDS: Intelligent Systems, Software, Adaptive Computers, Knowledge Base, Networking, Agent-Based Tools, Data Mining

AF05-087 TITLE: Priority/Preemptive Capability within IP

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop Quality of Service (QoS) aware mechanisms to provide reliable and assured information transport in TCP/IP based low and/or mixed bandwidth networks.

DESCRIPTION: Develop Quality of Service (QoS) aware mechanisms to provide reliable and assured QoS information transport in TCP/IP based networks that include bandwidth limited environments such as space applications and mixed high and low bandwidth military environments that provide information to the warrior in the battlefield.Typical TCP/IP networks lack the functionality necessary to implement true Quality of Service. This effort should investigate the technology and mechanisms necessary to effectively implement a communications infrastructure that supports mission aware QoS utilizing QoS aware mechanisms. Solutions should consider bandwidth management, prioritization, preemption, resource reservation, admission control, packet scheduling, packet/message type/classification, traffic management and power management to manage the unique requirements of a military packet-based network. The solution should also consider the management of UDP and other transport protocols in low bandwidth situations. The solution should also consider how the security layer interacts with TCP functions. The network traffic under consideration includes email, voice, video, file delivery, person-to-person real-time communications, and machine-to-machine automated data exchange. The solution should be scalable to large network environments, and able to operate over a wide range of bandwidths (1000 bits/sec to 1 Gbits/sec) and channel characteristics including high error rate and half duplex. Any solutions identified will be required to operate in both an IPv4 and IPv6 environment. Current work in this area such as Integrated Services, Differentiated Services, IPv6 and IPSec are a step in the right direction but provide only part of the solution

PHASE I: Identifiy and/or develop potential mechanisms to implement mission aware Quality of Service based on and/or utilizing existing TCP/IP QoS mechanisms in the commercial market. Present the pros and cons of several candidate solutions. Use simulation or limited prototype techniques as appropriate or necessary, and analyze performance and robustness of solution(s). Develop a system architecture design to implement a mission aware QoS solution that is compatible and practical to use with the existing network infrastructure.

PHASE II: Implement a prototype system based on the design generated in phase 1. Characterize and analyze the performance of the system over a wide range of communications media and media characteristics. Special consideration should be given to low bandwidth environments such as space applications and mixed high and low bandwidth applications that must provide mission information to the war fighter.

DUAL USE COMMERCIALIZATION: By using the developed mission-aware QoS transport mechanisms, low and mixed bandwidth applications can be managed to ensure the limited communication infrastructure can be utilized to acheive mission priorities. These techniques will be applicable to military environments and space applications as well as other commercial settings. Commercial application includes but not limited to nomadic personal computing devices such as next generation cellular phones, pagers, and PDA's.

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KEYWORDS: Internet Protocol, Mission-aware Quality of Service, Bandwidth limited communication, Mixed high and low bandwidth military environments,

AF05-088 TITLE: Integrated Cognitive Architectures for Synthetic Environments

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop cognitively based human behavior models to provide realistic decision making representation for synthetic environments

DESCRIPTION: There are numerous models of human behavior in Synthetic Environments (SEs) for military simulations and commercial applications such as multiplayer games. Human behavior representation is the modeling of the processes and effects of human behavior at the individual level and at various levels within the organization. The behaviors that are important are those that can be observed by the other participants in the simulations and should be based on psychological, organizational, and sociological theory. At the individual level, important underlying processes include attention and multitasking, memory and learning, decision making, perception and situation awareness, and planning and at the team level, command and control structure, processes, and products. Added realism can be achieved by including behavior moderators such as workload and emotional stress, level of training, and use of standard operating procedures. The military and commercial user communities recognize the limited state of current capabilities and the need to incorporate more realistic human and organizational behavior.

For several years, research has been underway on unified theories of human behavior implemented as integrative architectures that incorporate submodels for sensing, perception, memory, cognition, motor behavior, etc. into a coherent framework. Such integrative frameworks include Adaptive Control of Thought (ACT-R), Cognition as a Network of Tasks (COGNET), Executive Process Interactive Control (EPIC), micro Saint, neural networks, Operator Model Architecture (OMAR), Situation Awareness Model for Pilot in the Loop Evaluation (SAMPLE), and Soar. The military has recognized the need to represent the behavior of individual combatants, teams, and larger organizations in simulations for training, systems analysis, systems acquisition, and command level decision aiding. Observable actions must be based on realistic decision making with communications between entities that can be interpreted as a result of sensible plans and operations.

The objective of this research is to develop and demonstrate an innovative methodology for developing cognitively based human behavior representations including cultural effects and a flexible architecture to integrate models from multiple existing cognitive architectures. Military simulation environments, such as the Joint Synthetic Battlespace (JSB), require advanced models of human decision-making and performance. New research is needed to allow JSB users to specify behaviors and responses of human behavior models in a flexible and dynamic fashion, at multiple levels of fidelity, and to support the insertion of specific models of individual decision-makers and teams across a range of roles from individual vehicle operators to high-level command structures. The developed models must provide significant flexibility and adaptive capability to minimize the effort required to set up individual representations of constructive entities at run-time. The approach should allow for integration of multiple existing cognitive architectures supporting end-user selection of appropriate tools for specific applications. The 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. The effort should employ a standards based architecture to support interfaces to other engineering and simulation modeling tools.

PHASE I: Development of specifications and design for flexible human behavior representation architecture including cultural effects. Provide a proof-of-feasibility demonstration of key enabling concepts that integrate human behavior representations from multiple cognitive architectures.

PHASE II: Design, develop, and demonstrate a prototype system for human behavior representation supporting multiple cognitive architectures and capable of integration with a real-time military simulation environment such as JSB. 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 human behavior representation framework that has applications in many arenas requiring constructive representation of human operators, such as air traffic control system development, transportation system analysis, and human in the loop communications and information systems. Constructive simulation can also support training applications, decision aid development, and the multiplayer game industry.

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KEYWORDS: Joint Synthetic Battlespace, Human Behavior Representation, cognitive modeling, cognitive architectures

AF05-089 TITLE: Asymmetric Adversary Tactics and Strategy Generation

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop the capability to model the tactics and strategies employed by asymmetric adversaries for use in simulated battlespaces

DESCRIPTION: Recent events have demonstrated the use of non-traditional military tactics to offset US military power. The use of non-traditional tactics and strategies by our potential adversaries, i.e., asymmetric warfare, has come into the forefront of national security issues. The purpose of this research is to define and develop an

asymmetric adversary simulation environment that can support existing military simulations such as the Joint Synthetic Battlespace and the Air Force M&S Foundations initiative for Air Force acquisition and training.

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 potential dangerous environment for homeland security, emergency preparedness, and military operations. Readiness for emergency situations, including terrorist attacks, requires a complex ongoing process of situation assessment and awareness of a wide range of potential chemical, biological, radiation, nuclear or cyber threats from a multiplicity of world-wide social and cultural groups.

The researcher shall develop and demonstrate innovative simulation technologies to assess, generate, and visualize potential adversary tactics and strategy for improved decision support for emergency preparedness, anti-terrorism, homeland defense, and military operations. The research shall consider decision theoretic methodologies to gather data and build adversary models to describe, assess, and predict the activities of individuals, teams, and organizations. The researcher shall consider factors such as the social, cultural, political, economic, religious, ethnic, and ideology of the adversary. The methodology and resulting adversary models shall be capable of interfacing with simulation environments and providing adversary tactics and strategy to the simulations. Military simulation environments, such as the Air Force's Joint Synthetic Battlespace (JSB) for the acquisition and training domains, are keys to provide a persistent synthetic battlespace infrastructure to support military training, mission rehearsal, and the exploration, design, development, analysis, and testing of new warfighting systems and concepts. For example, JSB will provide realistic representations of battlespace entities (friendly, adversary, and neutral forces), natural and cultural features (terrain, locale), and physics-based effects. JSB will provide a framework to support the rapid integration of these synthetic representations across all simulation levels. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Any graphical depiction and output should comply with industry or international standards. Methodologies implementing the adversary 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 specifications and design for a standards based adversary simulation environment that generates tactics and strategy for military battlespace simulations like JSB, 2) a proof-of-feasibility demonstration of key enabling concepts.

PHASE II: The researcher shall design, develop, and demonstrate a prototype adversary simulation environment capable of interfacing with existing military simulation environments, such as JSB, and assessing an air campaign tactical scenario. The researcher shall also detail the plan for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust, off-the-shelf asymmetric adversary simulation environment for use in emergency preparedness, anti-terrorism, homeland defense, and military operations. Within the DoD community, an automated tactics and strategy generation tool for asymmetric threats has tremendous commercial implications for the development of next-generation simulation facilities. Direct applications also exist for development of advanced mission planning and emergency preparedness decision support systems. Within the commercial domain, the development of automated tactics and strategy generation has high relevance to the recreational software industry, where applications are readily apparent to military conflict and strategy video games.

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KEYWORDS: Asymmetric Warfare, adversary behavior, adversary model, Joint Synthetic Battlespace , cultural modeling

AF05-090 TITLE: Enabling Visualization of Event Information from Unstructured Text

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop technology for high accuracy event extraction from unstructured text, in order to enable visualization of event information from unstructured text on timelines and maps.

DESCRIPTION: Information analysts need the ability to monitor world events visually, on timelines and maps. While event information from structured text (e.g., formatted messages) can already be visualized, a significant source of useful event information comes from unstructured text (HUMINT and IMINT message traffic, open source, newswire, etc.). The goal of this topic is to develop those technologies necessary to achieve high accuracy extraction of event information from unstructured text, in order to enable visualization of such event information on timelines and maps for operational use.

Information Extraction (IE) technology has been developed that can extract and visualize simple event information from unstructured text (action = verb, plus explicit location and time). However, the technology is not yet mature enough to achieve the level of accuracy required for operational use. For example, sometimes the event time and/or location are not explicitly stated in the same sentence as the event. In these cases, capabilities are needed to determine the correct time and location to associate with the event with a high level of accuracy. Likewise, the capability to determine an event's time and location when they are stated in relative terms is needed (e.g., normalizing "2 weeks later" and "16 miles east of the capital city" into absolute time and location representations that can be visualized on timelines and maps). The ability to extract events represented as nouns rather than verbs (e.g., "the explosion", "the hijacking") would also improve the accuracy of event extraction. Finally, the ability to customize event extraction software to a user's area of interest would increase the accuracy of event extraction. Additional capabilities that are desirable, but less critical for achieving a baseline event visualization capability, include concept-based event extraction and identifying actors in events.

In Terms of the Payoff and Impact, the ability to visualize event information from unstructured text in a more conceptual form, such as on timelines and maps, will make it easier/faster for warfighters to gain Situation Awareness, and to detect potentially significant changes. It supports multi-INT Fusion by providing event information from textual data sources like HUMINT. Event extraction technology will also enable high-accuracy retrieval of event information from unstructured text sources (based on user parameters like event-type, location of interest, timeframe). Finally, it will support other analytical tools that need event information from unstructured text as input.

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 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: The ability to extract events from unstructured text, and to accurately visualize them on timelines and maps, would be of enormous benefit to analysts and investigators in both Homeland Defense and Law Enforcement. It would enable them to process very large volumes of textual information and more quickly assess "who did what to whom, when and where". The ability to accurately visualize events on timelines and maps would help them see patterns and trends that they otherwise might not see. Business Intelligence would also benefit from faster, higher-quality Situation Awareness. Timely knowledge about events that influence a business area (e.g., how customers are reacting to a new PR campaign or product) allows businesses to react faster and smarter, which can save them substantial amounts of money. Broadcast News is another area that has a significant vested interest in fast, accurate "Situation Awareness". News organizations would greatly benefit from

the ability to monitor world events reported in text to a degree well beyond their current capacity, and to detect "leads" faster than their competition.

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KEYWORDS: Information Extraction, Natural Language Processing, Event Visualization, Timelines, Maps, Homeland Defense, Intelligence Analysis

AF05-091 TITLE: Modeling and Executing System and Operational Architectures with Representational Languages

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a methodology for integrating and executing models of system and operational architectures for complex information systems

DESCRIPTION: Over the past several decades significant progress has been made in the development of representational languages that can be used to describe and analyze complex information systems found in commercial and military applications. Each representational language, such as Unified Modeling Language, (UML) Colored Petri Nets (CPN), and other object oriented design and analysis (OODA) languages, has strengths that have been built in to it by its developers to meet a set of design goals, and, subsequently, a user community that favors it use because it satisfies their particular needs. A legacy of various design models in differing languages exists in many organizations. As the need for understanding of more complex systems grows, problems of integrating design models developed in languages with different syntax and semantics becomes a serious problem. For example, UML is a very well established representational language that can be used to create text-based models of complex information and command and control system architectures, but which, as a stand-alone language, does not lead directly to architecture execution. Many government organizations employ Colored Petri Net based tools because of their ability to describe concurrency, time synchronization, and asymmetric warfare.

The objective of this research is to develop and demonstrate an innovative methodology for integrating models of operational/system architectures of complex commercial and military information systems created in different representational languages. The intent of this effort is to form a synthesis of multiple techniques such as UML, Colored Petri Nets, and other approaches. The end result would be enhanced interoperability among tools and models, a better understanding of how representational languages can be translated and creation of a representational modeling methodology that appeals to a broad spectrum of OOAD and CPN users. Research emphasis should be placed upon approaches that will result in rapid payoff rather than in obtaining a general solution to the language-translation problem. Innovative approaches to the synthesis of language elements and leveraging design and execution methodologies used in commercial and military applications are desired. Research priority is given to improving the execution of model architectures and the representation of executable model architectures in an object-oriented representational language. 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. The design architecture should be open to support interfaces to other engineering and network simulation and modeling tools.

PHASE I: Phase I activity shall include: 1) development of specifications and design for a methodology to integrate models described in different object-oriented representational languages, 2) a proof-of-feasibility demonstration of key enabling concepts that integrate several models in different representational languages.

PHASE II: Design, develop, and demonstrate a prototype tool that implements the Phase I integration 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 integrating 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 architecture, simulation, representational language, object-oriented design, unified modeling language, color Petri nets

AF05-092 TITLE: Hardened or Deeply-Buried Target (HDBT) Optimization Techniques for Detecting Obscure Geomorphic States (HOTDOGS)

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop an accurate, effective methodology (and training aides) to detect terrain objects of interest, which will support measurements and signatures intelligence (MASINT) imagery analyst activities.

DESCRIPTION: The National Air and Space Intelligence Center (NASIC), Headquarters United States Strategic (HQ USSTRATCOM), et al., and the Intelligence Community (IC) at large, require more effective means to detect terrain objects (e.g. ADITS [A Door In Tunnel System], ventilation, power cable, etc.) or "hidden" targets of interest. A HOTDOGS (Hidden Object or Target Detection in Obscure Geomorphic States) capability is direly needed to support the training of "new" imagery analysts utilizing MASINT technology at NASIC and USSTRATCOM. Some examples of these objects or targets are: vegetation changes or inappropriate vegetation in an area; excavations or other soil disturbances; "sink holes"/surface subsidence and physical changes to natural or man-made objects due to construction or inappropriate "fill" (e.g. roadbed fill/tunneling spoils) in an inappropriate geographic area, demolition, natural disasters, or battle damage. The problem in detecting such entities is due to the fact that many of these object/target phenomena (O/TP) are highly geomorphic - closely resembling or obscured by the surrounding earth environment. An effective object/target detection methodology (O/TDM) is required. It is anticipated that such a methodology would need to address many or all of the following technical issues: a. Use of effective decision-tree methods (e.g. training aides) or other decision-support methodologies; b. Integration of different sensor products (sensor fusion) as well as various layers of metadata from sensor products (information

fusion); c. Matching the correct exploitation strategy and detection algorithms to a situation (observation dynamics, environment, geographical location), as some objects/targets (O/T) are highly peculiar to such variations; d. Sequence-of-events (timeline) analysis, linked to databases and algorithms, to use situational dynamics, trends, and patterns as detection attributes; e. Spectral and spatial queuing (training aides) and matching techniques; f. Cross-sensor (multi-mode) sensor fusion at the sensor and/or the product level, to potentially include combining visual, thermal, spectral, temporal or SAR/SLAR imagery in an effective detection procedure (training aid).

PHASE I: Determine the feasibility of producing an effective, reliable HOTDOGS object/target detection system (O/TDS), to enable imagery analysts to rapidly and accurately identify targets to support war fighter operational needs. The O/TDS should be developed as a “repeatable process” in order to facilitate being a “training aid” for new imagery analysts as well as to support basic imagery analysis.

PHASE II: Develop a beta-level prototype object/target detection process (O/TDP), based on the chosen technology, shown to be feasible in Phase I. Test and validate the process using accepted, quantitative results from existing object/target (O/T) sensor data or valid O/T detection experimental results. Deliver and demonstrate the beta-level HOTDOGS technology process.

DUAL USE COMMERCIALIZATION: Develop a final (O/TDM) process, with user's documentation (training aids) and use-case examples, for integration with other processes or analysis toolkits, to support government and commercial users. Other government uses for the HOTDOGS process would include other agencies active in MASINT activities (NGA, Dept of Interior, and Dept of Energy). Commercial applications for the HOTDOGS toolkit would include mining or underground surveying/exploration support, other mining industry support applications such as tunnel construction, monitoring landfills for toxic leakage, or monitoring natural disaster areas for objects that would impact relief operations.

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KEYWORDS: Hard and Deeply Buried Targets - Detection (HDBT-D); Under Ground Facility - Detection (UGF-D): Measurement and Signatures Intelligence (MASINT); Hyperspectral (HIS), Multispectral (MSI), SAR, SLAR, Weapons of Mass Destruction (WMD); Weapons of Mass Effect (WME); Automated Techniques / Training Aides; ADITS [A Door In Tunnel System].

AF05-093 TITLE: Secure TCP/IP Broadcast/Multicast

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Investigate and provide methods of assuring a secure network-centric approach for broadcast/multicast to mobile and coalition forces, to include wireless and SATCOM connectivity.

DESCRIPTION: Management of CONUS-based Integrated Broadcast System (IBS) is structured and adaptation takes time. Transformational Communications Architecture (TCA) supports real-time adaptation through addressable, packet-based communications over the Global Information Grid (GIG) and TCA satellite constellations. Through the GIG/TCA super-network, commanders can reach fixed resources and POP terminals (JTARS, etc.) for communication to mobile forces. The implementation and integration of network broadcast and multicast information is critical for commanders to disseminate rapid, complete and consistent mission-critical orders, information and data. The advent of SATCOM and wireless networking introduces unique challenges in these communities of interest. Technologies that ensure secure, selective, networked information delivery are key solutions to the above mission challenges, including Over-the-Air (OTR), adaptive algorithm/key management (real-

time, secure algorithm/key distribution). The proposal should evaluate solutions to the above problems/issues via the application of new or evolving techniques and developing technologies. Commercial applicability of the above is manifested in the need for similar secure technologies and approaches in the private sector.

PHASE I: Develop technical approaches for the application of secure networking and adaptive algorithm/key management (real-time, secure algorithm/key distribution) for broadcast/multicast information, including SATCOM/wireless domain.

PHASE II: Prototype a network demonstrating a secure, SATCOM/wireless broadcast/multicast approach.

DUAL USE COMMERCIALIZATION: The new tools and approaches developed under this effort will be directly applicable to current and future C2 systems (CCIC2S, SBMCS, MCCC, SEWS). Commercial applications include broadcast distribution of protected content (e.g., pay per view, subscription services, etc.) over satellite and terrestrial radio networks.

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KEYWORDS: Secure IP, Broadcast, Multicast, SATCOM, wireless, key management

AF05-095 TITLE: Predictive Analysis Tools for PBA/IPB

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop concepts and techniques needed to demonstrate feasibility of anticipating adversary actions in a timely manner for operational in a military environment.

DESCRIPTION: The Air Force requires analytical tools to aid automated-assistance methods, processes, and techniques to predict adversary actions necessary to create and maintain possible enemy courses of action. These actions cover the full spectrum of armed conflict to include all phases of conventional war. Adversarial prediction will be based on well-understood enemy doctrine and deployment patterns that are observed during exercises, maneuvers and war-games. Current and planned ISR sensors will have the ability to create a comprehensive view of everything on the battlefield.

This SBIR topic is less relevant to situations that are based on a few observations of an organization that operates without a perceived pattern (e.g. terrorist groups and cells) and conducts hit-and-miss operations. In order to attack that problem may require creating extraordinarily large data sets and developing new search and processing approaches which are not suitable for Air Force application.

The Chief of Staff of the Air Force has identified the need to develop Predictive Battlespace Awareness (PBA) as a revolutionary concept that will transform the Air Force and will be pivotal to achieving his vision for Global Awareness and Global Strike. The pay-off of this predictive capability is to give Commanders timely, decision quality information that provides sufficient time to adjust his ISR assets and warfighting forces in response to a dynamic battlespace. In order to achieve the required operational capability, a suite of predictive analysis tools must be developed. Predictive tools that are required include behavior estimates, course of action modeling, and behavior pattern recognition. Important technologies requiring investigation include: prediction algorithms, behavior/hidden Markov/signature models, inferential/deductive/inductive methods, dynamic Bayesian networks, gaming theory and pattern recognition. Predictive analysis tools should be developed using open software standards (e.g. C++, JAVA, etc). The goal is to demonstrate the ability of the tool to analyze ISR sensor data and intelligence information to provide a timely and complete predictive analysis used to assist the target nomination process. Instead of being reactive to adversarial actions, this capability would help to anticipate likely adversary courses of action. This capability would enable the Air Operations Center (AOC) to plan for the right munitions to be applied at the right location at the right time. This would reduce the need to respond to ad-hoc combat missions and allow for single-digit minutes from target detection to engagement. Suitable tools will be transitioned into existing Air Force systems, such as, Automated Assistance with the Intelligence Preparation of the Battlespace (A2IPB) and the Intelligence Preparation of the Information Battlespace (IPIB) systems. A2IPB&IPIB provides an initial IPB capability for the Air Force's Air Operations Center (AOC). A2IPB&IPIB assists analysts/operators to create IPB products, such as information templates, matrices, graphical overlays, etc, but not prediction assessments. Predictive analysis tools will provide A2IPB&IPIB with an important capability against difficult targets (concealed, time critical, urban and buried) by reducing the required search areas and improving the use of existing sensors. In summary, a predictive analysis capability is required to assist the Commander and his staff to anticipate what might happen in the battlespace and provide timely, actionable information needed to adapt to the new situation when it happens. It will give the Commander a predictive view of his area of responsibility and insight to exploit emerging opportunities while mitigating the impact of unexpected adversary actions.

PHASE I: Assess and evaluate several predictive analysis concepts, methods and techniques for operational use. Assess capability against the following measures: utility, scalability and integration risk. Demonstrate key concepts in a laboratory environment.

PHASE II: Implement and deliver a prototype device that demonstrates predictive analysis of potential adversary actions. Prototype will assist an operator in conducting a predictive analysis and provide a visual display of anticipated actions.

PHASE III DUAL USE APPLICATIONS: 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 and conduct data mining and on-line analytical processing; all directed toward identifying customer trends and satisfying their purchase needs.

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KEYWORDS: Information Management, Joint Intelligence Preparation of the Battlespace (JIPB), Intelligence Preparation of the Battlespace (IPB), Predictive Battlespace Awareness (PBA) and Metadata Generation.

AF05-097 TITLE: Dynamic Enterprise Workflow Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a web-based capability that links the warfighter's information needs to timely information production and dissemination.

DESCRIPTION: This effort is concerned with improving and optimizing the flow of operational information through an enterprise based on a Commander's tasking guidance. The capability will leverage information provided other systems associated with the identification and mitigation of system failures. As background information, current workflow management approaches provide tools that capture and/or construct enterprise business rules but are limited to monitoring and controlling static information processes. These workflow management approaches are comprised of several elements to include: (a) a set of tasks to be executed, (b) task rules, (c) data to be processed, and (d) a schedule for task completion. Because of the information-intensive nature of today's enterprises, the Air Force requires a dynamic capability that can use the emerging Net-Centric Enterprise Services (NCES) standards for the development and distribution of timely information products for the warfighter. A next-generation workflow management capability needs to be more adaptive during the mission planning and execution cycle to enable the enterprise to access information needed to effectively deal with rapidly changing mission tasking (e.g. Time Sensitive Targeting). All information sources and services within the enterprise should be linked to the production/shift supervisor which can use this insight to manage each information resource and process. The capability would allow tailoring by coupling/de-coupling and re-routing individual information sources, processes and work packages without stopping the overall enterprise workflow. This would enable the enterprise to complete high priority tasks ahead of lower priority tasks in response to the Commander's guidance. This capability should be linked to and leverage data provided by other system that monitor and control overall system resources. As an example, the AFRL Master Caution Panel (MCP) provides the following capabilities: (a) monitors and assesses the status of all networked physical resources (e.g. servers, client workstations, LANs, etc), (b) provides prompt alert messages when faults are detected and (c) provides a plan for minimizing the impact. The MCP capability is scheduled for fielding with TBMCS v 1.1.3. The end goal of this SBIR effort is to provide a workflow management capability that provides the required flexibility, scalability and end-to-end task management to tailor multiple information resources and processes to meet dynamic mission needs. This will ensure that the warfighter has all the relevant information needed to make timely combat decisions. An desired element of the workflow management capability is the creation of an enterprise information model and its use to manage processes, work tasks and events. This information model will aid in managing the enterprise to meet changing mission needs and provide insight into workload sharing strategies among distributed systems that collectively create a federated capability. Techniques and tools developed under this effort should be capable of transitioning to the AOC weapon system (e.g. targeting workflow manager) and the DCGS weapon system (e.g. ISR sensor workflow manager). As an example, the ISR sensor workflow manager would have responsibility for the overall information flow from requirements generation, to exploitation tasking to intelligence product creation, validation and dissemination.

PHASE I: Develop an overall system design that includes a feasibility demonstration of the critical aspects of the system design.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to demonstrate that this approach is scalable and adaptable to changing user conditions.

DUAL USE COMMERCIALIZATION: This system could be used in a broad range of military and civilian applications where automatic information production and dissemination are necessary. An example of a military application involves providing critical decision-quality information to a decision-maker. A commercial application would involve adjusting automobile production based on changing customer demands and regulatory policies.

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KEYWORDS: Workflow Management,Enterprise Information Management, Network-Centric Information Services

AF05-098 TITLE: Automated Assistance with Metadata Generation (A2MG) Tools for PBA/IPB

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop the concepts and techniques needed to demonstrate feasibility of automatically generating Intelligence Preparation of the Battlespace metadata in a timely manner.

DESCRIPTION: The Global Information Grid (GIG) and the new Enterprise Services will depend on emerging technologies of Web Services to identify and retrieve all manner of Military relevant information. The Air Force has developed software tools to aid automated-assistance methods, processes, and techniques to predict adversary courses of actions (COA). These COAs cover the full spectrum from terrorist attacks to conventional war. USAF has identified the need to develop PBA as a revolutionary concept that will transform the Air Force and will be pivotal to achieving the vision for Global Awareness and Global Strike. In order to achieve the required operational capability, the data assembled and documented in PBA and IPB tools needs to be metadata tagged before being stored in a repository. Current metadata tagging methods rely on the individual intelligence analyst or military operator to prepare a rigorous analysis of the IPB product to complete a metadata template with the required eXtensible Markup Language (XML) fields before product storage. Metadata already embedded in imported imagery, reports, databases, or other Intelligence Products is lost in this process. Automatic Metadata Generation tools should be developed using open software standards (e.g. C++, JAVA, etc). The goal is to demonstrate the ability of the tool to analyze IPB data and intelligence information to provide timely and complete predictive metadata. The Concept of Operations for the development of an Automatic Metadata Generation tool is to have the software tool open with the application (A2IPB or IPIB) and operate in the background gathering metadata tags from imported data, the computer operating system's parameters, and the data created by the analyst or operator. Upon completion of a product, and before nomination for publication, the author would be presented with a completed Metadata Nomination prepared by the tool in the background. The Metadata should include the DOD XML Metadata Standards for Joint IPB and Security. The tool should present the Metadata for review, editing, approval, and electronic signature by the author. The Metadata Nomination is then date stamped and sealed to prevent further tampering with the signed product. The Metadata Nomination is now ready for Supervisor Review and Publication. Suitable tools will be transitioned into existing Air Force systems, such as, Automated Assistance with the Intelligence Preparation of the Battlespace (A2IPB) and the Intelligence Preparation of the Information Battlespace (IPIB) systems. A2IPB & IPIB assist analysts/operators to create IPB products, such as information templates, matrices, graphical overlays, etc, but not prediction assessments. Automatic Metadata Generation tools will provide A2IPB & IPIB users with an important capability to find data on difficult targets (concealed, time critical, urban and buried) by reducing the required data searches and improving the use of scarce analyst and operator resources. In summary, an Automatic Metadata Generation capability is required to assist the Commander and his staff to anticipate what might happen in the battlespace and provide timely, actionable information needed to adapt to the new situation when it happens. It will give the Commander rapid access to the data relevant to his area of responsibility and facilitate insight to exploit emerging opportunities while mitigating the impact of unexpected

adversary actions. The Commander and his staff will be allowed to spend their time evaluation the information instead of looking for it.

PHASE I: Assess and evaluate several Automatic Metadata Generation concepts, methods, and techniques for operational use. Assess capability against the following measures: utility, scalability, and integration risk. Demonstrate these integrated tools in an unclassified environment.

PHASE II: Implement and deliver a prototype device that demonstrates automated assistance with metadata generation for simulated military products. Prototype will interface to unclassified data sources. Assist operator in conducting a visual display of actual metadata tagging for simulated messages, IPB data and IPB products by presenting a Metadata Card for Operator approval and digital signature.

Phase III: Integrate the Automated Assistance with Metadata Generation (A2MG) tool with actual military applications. Integrate the Automated Assistance with Metadata Generation (A2MG) Tool(s) into A2IPB and/or IPIB to demonstrate Military Mission PBA and IPB workflow using the new tools. Demonstrate these integrated tools in an unclassified environment.. Demonstrate these integrated tools in a simulated Military environment using simulated General Military Intelligence data, unclassified imagery, and unclassified messaging traffic.

DUAL USE COMMERCIALIZATION: This software-based tool will prove useful throughout the retail marketplace (e.g. Wal-Mart, Target, etc). Automated Assistance with Metadata Generation (A2MG) tools will allow the use of Web Services to serve up data to accomplish all manner of modern electronic commerce. It will augment their current efforts to assemble large, dynamic data warehouses, and conduct data mining and on-line analytical processing.

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KEYWORDS: Information Management, Joint Intelligence Preparation of the Battlespace (JIPB), Intelligence Preparation of the Battlespace (IPB), Predictive Battlespace Awareness (PBA), and Metadata Generation.

AF05-099 TITLE: Automated Tools to Assist FDO Duties

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Facilitate multi-domain operations (e.g. coalitions) via disclosure analysis tools able to process free text information and establish/present new rich metadata entries based on meaning.

DESCRIPTION: The Air Force has made a large investment in information technologies that ensures that the right information is received by the right person at the right time for effective decision-making. However, there is an immediate need for improved information security technology that protects against unwanted release of information to inappropriate recipients. The problem has grown more acute as the Air Force increasingly collaborates with our coalition partners. Boundary control is a family of approaches that are used to prevent unauthorized information release. Today, in order to promote inter-security domain information sharing, which is controlled by security and dissemination policies, human review is required of products containing free text. The ever increasing percentage of products with free text (including XML) is putting a significant burden on release authorities including the Foreign Disclosure Officer (FDO) in multi-national operations. This effort explores various automation techniques to lessen the human workload. In the past, the boundary control problem was addressed with a keyword (e.g. dirty word) approach which has shown to be inadequate. Under this effort, a more sophisticated approach is sought that

leverages natural language processing (NLP) techniques, such as, information extraction and/or 'gisting' technologies to act as an FDO force multiplier. The intent is to advance the state-of-the-art in NLP techniques that will help develop a boundary controller that would promote information sharing while protecting sensitive high accuracy information. NLP techniques to be advanced include topic ID using word sense disambiguation and user-guided automated customization for specific domains (topic areas). Initial activities will focus on a gisting-based automated FDO which monitors controlled interface traffic (such as guards), identifies a topic, compares the topic against alert criteria, and alerts an information system security officer if a match occurs. The security officer would monitor the information exchange and terminate the session if warranted. It is envisioned that this capability would monitor several sessions, in parallel. Enhancements will move the monitor and alert capabilities to one where the FDO function is fully automated in a very limited capacity (e.g. text chat between non-FDO/FDR trained US person and non-US Coalition member).

PHASE I: Develop and demonstrate a proof-of-concept NLP tool in the implementation context of supporting an FDO responsible for monitoring tens of simultaneous cross-domain chat sessions between a US AOC and a Combined (multi-national) AOC (CAOC).

PHASE II: Develop and demonstrate a proof-of-concept NLP tool which interacts with a guard-based controlled interface to aide a human releaser in the disclosure inspection of files containing large amounts of free text across a diversity of context domains. Evaluate the performance of this capability against sample data and measure its utility (e.g. information correctly blocked, information correctly released, etc). Compare this NLP-based approach against a keyword approach.

DUAL USE COMMERCIALIZATION: Military applications for this technology are widespread. Greater cooperation with our coalition partners will require the flow of sensitive information. Commercial applications abound. Today, product development often requires sharing of information among corporate sponsors. This capability would ensure that crucial intellectual property is well protected against unauthorized disclosure. The banking community has similar needs since all communications must be in compliance with security regulations.

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KEYWORDS: natural language understanding, NLU, natural language processing, NLP, information extraction, foreign disclosure officer, guards, guarding solutions, controlled interfaces, information sharing, cross-domain, multi-level security, MLS

AF05-100 TITLE: Web-Enabled Information Sharing and Data Distribution

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop net-centric methods and tools needed to facilitate distribution and Web-enabled information sharing of integrated time-sensitive information products.

DESCRIPTION: C2ISR systems for US and coalition forces produce enormous amounts of information that cannot be processed with traditional, conventional approaches requiring intensive human interaction to analyze and distribute information products. This effort addresses the distribution portion of this problem by developing net-centric methods and tools for rapidly handling Intelligence information from multiple C2ISR sources. These methods and tools are a critical need in realizing the post-then-process paradigm of net-centric warfare. Specifically, this effort will develop methods and tools to identify and create software connections to new data sources, and provide for automatic web-based posting of time sensitive information products from those sources, to support the

user community(C2/TACS nodes, JTF/JFACC, DCGS nodes and national/coalition). For Web services, which are being increasingly used to accomplish data access and exchange of XML-based information products, task sharing, and process automation, this effort will examine insertion of latest XML-based parser and indexer tools needed to facilitate information content discovery and sharing. It will provide a capability to create Web sites that are dynamic and data base driven that users can interact with using standard browsers. Significant manpower savings can be realized by automating the manual tasks that are currently used to create and maintain Web sites for information dissemination. These manual tasks included page generation and Web site maintenance tasks that require the creation of scripts and HTML products. Automating these processes enables users to spend more time doing analysis instead of Web site maintenance tasks. The end goal is providing the warfighter with increased interoperability, lower cost of software integration and simple, non-proprietary standards that allow information sharing and distribution regardless of location, operating system and programming languages.
PHASE I: Develop a data distribution system that has automatic web-based posting of time sensitive information products from various types of data sources that are combined into an integrated product. Provide a proof-of-feasibility demonstration.

PHASE II: Develop and demonstrate a prototype system that would allow information sharing and distribution regardless of location, operating system and programming languages.

DUAL USE COMMERCIALIZATION: Dual use would be applicable wherever there is a need to facilitate information content discovery and sharing. Air Force application would include support to the Warfighter such as mission planning and execution within the Air and Space Operations Center (AOC) and the Deployable Common Ground System (DCGS). Within the public sector, the automated delivery of information could be used to enhance inventory control and product introduction to the marketplace.

REFERENCES: Technical POC: Mr. Richard Loreto, AFRL/IFEB, 315-330-3793; loretor@rl.af.mil

KEYWORDS: Net-centric Data Distribution

AF05-101 TITLE: Integration of Composable Simulations with Real-time Applications and Databases

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop ontology-based modeling and simulation technologies to support next generation simulation architectures for real-time decision support .

DESCRIPTION: The commercial and defense sectors are making greater use of distributed simulation, web technologies, product and process modeling, generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications. By employing web-based standards, commercial software systems are composably scaling to worldwide scope. The general simulation community is examining web service based frameworks with efforts like the Extensible Modeling and Simulation Framework (XMSF) to drive IEEE High Level Architecture (HLA) standard simulations with Extensible Meta Language (XML) protocols. However, emphasis has been placed on interfaces and the syntax of data exchange and little focus on the semantics of composability.

The purpose of this research is to develop innovative technologies for next generation architectures that can be used to implement modeling tools and frameworks that can assemble simulations from model components while preserving syntactical and semantic correctness. In addition the architectures must be able to semantically integrate information from external databases, other existing simulations, and commercial and military unique applications to support real-time decisions.

New research is needed so that future frameworks and tools can provide: an ability to create an abstract ontology-based model that relates real-world entities whose instance level data can be generated on the fly from simulations or retrieved from databases; combine database, simulation/web services and messages into a single middleware that executes this model; resolve semantic differences between different types of information within the model ;

provide analytical tools to query information across simulations and databases based on this model, i.e., query attributes of simulation entities from real-time databases and vice versa; and drive decision support interfaces from this abstract model. An example Air Force utilization of this technology is in efforts such as M&S Foundations and the Joint Synthetic Battlespace (JSB), a common simulation architecture and core services, which will be capable of supporting the future emerging simulation needs ranging from acquisition, research and development, to training. One of the key challenges of JSB is to seamlessly integrate the simulation framework with mission applications, intelligence databases and C2 systems. The Air Force needs to be able to integrate functions such as Air Tasking Order in an Aerospace Operations Center with Time Critical Targeting by combining data, events, rules and actions across the command and control, simulation and intelligence domains. The problems relate to the different fidelity of data represented within databases vs. applications and simulations and the impedance mismatch between different access protocols. While simulations support event-driven interfaces through HLA, applications are exposed with process-based interfaces and databases support query-based interfaces. Resolving the syntax of these interfaces through a composite middleware in addition to solving the semantics integration challenge is a key barrier to realizing the Air Force vision..

PHASE I: Phase I activity shall include: 1) development of specifications and design for an ontology-based modeling and simulation architecture that is standards based and can facilitate the interoperability of real-world equipment such as command and control assets with IEEE High Level Architecture standards compliant simulations in real-time scenarios, 2) a proof-of-feasibility demonstration of key enabling concepts that integrate several system objects in real-time from geographically dispersed locations.

PHASE II: The researcher shall design, develop, and demonstrate a prototype ontology-based modeling and simulation framework employing real world equipment integrated with a simulation testbed and databases supporting a real-time Air Force application, such as Time Critical Targeting (TCT). The researcher shall also detail the plan for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust, off-the-shelf semantically driven ontology-based modeling and simulation framework for use in defense and commercial product planning, development, and manufacturing. Semantically correct simulation and application integration frameworks are applicable to financial and manufacturing industries, biotechnology, healthcare, transportation, communications, and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design frameworks with supporting modeling and simulation to bring products to market quickly.

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KEYWORDS: simulation, HLA, Enterprise Architecture, Collaborative workflow, Semantic Web, Business Ontology, Data Fusion, Interoperability, web services, XML, XMSF

AF05-102 TITLE: Dynamic Resource Reservation on satellite Communication Links

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a system with the capability to provide dynamic resource reservation on satellite communication links.

DESCRIPTION: Develop a system that will allow for real-time bandwidth management of SATCOM links. In the current environment, satellite communication frequencies tend to be statically managed by a central authority and assigned to projects or programs on a perpetual basis, whether or not the frequencies are transmitting data or not. Since satellite bandwidth is so scarce, higher utilization would be useful for any program using satellite communications.

The system will consist of three main components. The first component will be the development of a combination of hardware, software, and protocols that will permit for dynamic allocation of satellite frequencies and bandwidth. The second component will combine hardware, software, and protocols to provide a set of features to users. The three primary features will be reservation of bandwidth, prioritization of bandwidth use among users, and emergency overrides. The third component will be a centralized management system with distributed components that can be integrated into current management and scheduling systems.

Additional critical considerations in the design will require high availability and redundancy, security of the system (including user authentication), and a reasonable total cost of system. This last aspect is intended to provide guidance to the contractor when determining the mix of physical versus logical solutions. bandwidth already available, rather than requiring additional systems. The system can be used on any individual communications satellite or frequency range, or be applied across all ranges or satellites within a constellation. It could even be used to permit military emergency use of commercial systems.

Furthermore, while some aspects of the system may be specific to satellite communications, at least the software and protocols should be relatively easy to translate to any wide-area communications link if desired. This will potentially allow for greater utilization of any government or commercial backbone system that currently assigns bandwidth to customers.

PHASE I: Determine the mix of hardware, software, and network protocols that it will use in completing the stated objectives. Provide a preliminary end-to-end system design, including interface specifications as needed among the components utilized. A critical design element will include a mechanism by which priority traffic can supercede existing traffic.

PHASE II: Develop a working system to provide dynamic resource reservation for a satellite communication circuit. In the case of hardware, the deliverable will include a working prototype as well as designs and cost estimates for production units. Develop a system security specification which will outline the mechanisms used to ensure that the system operates only as authorized, and monitors the use of bandwidth by its users. This will accompany the final specification on operations and management of the developed system.

DUAL USE COMMERCIALIZATION: By using the developed system, satellite communication channels can be reserved at any time by various parties for their diverse purposes, but utilized by the party with the greatest need at a particular point in time. This will allow government (DSCS, AEHF, Milstar) or commercial satellite constellations to more fully utilize the communications bandwidth already available, rather than requiring additional systems. The system can be used on any individual communications satellite or frequency range, or be applied across all ranges or satellites within a constellation. It could even be used to permit military emergency use of commercial systems.

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KEYWORDS: satellite communications, resource reservation, quality of service

AF05-103 TITLE: 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 intelligence sensor 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, far more than can be exploited by today’s analysts. Analysts are at the breaking point in obtaining 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 approaches to exploit the modulation, compression, coding 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 new scientific and technical problem area that requiring innovative solutions not currently being adequately addressed:

Develop real-time innovative communications intelligence technology to enhance the signal detection, identification, location, demodulation, processing and collection of data to enable the analysis and extraction of received information.

Develop real-time audio signal processing technology to improve the analysis and extraction of information, in real-time, for tactical C3I decision makers.

Develop real-time signal processing techniques and algorithms to accomplish spectral radio frequency emitter identification and tracking. Assess the feasibility of developing and transitioning on-board, automated sensor management and wideband horizontal integration methods to enable collection of modern and future signals.

Develop and assess the implementation of measures and signatures intelligence architectures and techniques to exploit heretofore unaddressed sensor signals. Assess new approaches to foster equipment interoperability and functionality associated with production tasking of measures and signatures intelligence data for collection, processing, exploitation, and dissemination.

Develop automated techniques to assist in the exploitation, processing, tracking, and dissemination of video intelligence information. Assess video information content for information assurance and tamper detection.

Develop novel technologies in the areas of steganography, watermarking, steganalysis and digital data forensics for information assurance, tracking and exploitation. Assess feasibility to perform validation, authentication, pedigree and embedded data detection for the security of multimedia objects.

The end goals addressed under this topic area include:

- Real-time location and exploitation of modern modulation signal emitters
- Assisted and automated operators' activities for signal de-modulation, de-multiplexing, de-coding
- Airborne intelligence, surveillance and reconnaissance processing in dense urban environments
- Integrated multiple intelligence exploitation environments (IMINT, SIGINT, MASINT) for improved operator performance
- Uniform procedures and tools, run on a common platform to fully support and complement analyst activities for end-to-end imagery and video exploitation
- Dynamic exploitation environments that can automatically adjust to new format data signals exploitation requirements
- Joint Seamless Network-Centric Systems' sensor tasking and exploitation
- Audio steganalysis and counter-deception techniques and measures for information assurance and information operations
- Imagery/motion imagery steganalysis information assurance and counter-deception measure exploitation
- Collection, analysis and exploitation of modern data modulation and coding sources and revolutionary sensor suites for difficult targets using non-conventional sensors

PHASE I: Assess the feasibility of architectures and innovative signal processing tools for data collection and information exploitation intelligence production; propose and present conceptual proof-of-concept prototypes to improve information extraction of modern modulation signals and implementation of revolutionary order-of-magnitude improvements in information intelligence analysts' productivity. Accomplish a plan for developing and applying the technology for potential commercialization of the Phase I conceptual approach.

PHASE II: Develop a working prototype with sufficient fidelity to: -demonstrate the exploitation of heretofore difficult or unexploited modern modulation signals; -improve current manual analyst activities with new automated and semi-automated capabilities. Emphasis shall also be placed on developing the commercialization strategies for the resultant capabilities created under Phase II.

DUAL USE COMMERCIALIZATION: 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: MASINT, COMINT, ELINT, SIGINT, IMINT, Motion Imagery, Steganalysis

AF05-104 TITLE: Innovative Approaches to Behavioral Modeling, Threat Modeling and Threat Prediction

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Development of innovative approaches to Behavioral Modeling, Threat Modeling and Threat Prediction for improved Situational Awareness.

DESCRIPTION: The Joint Directors of Laboratories (JDL) Subpanel on Data Fusion has defined Data Fusion as "a process dealing with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimates, and complete and timely assessments of situations and threats, and their significance. The process is characterized by continuous refinements of its estimates and assessments, and the evaluation of the need for additional sources, or modification of the process itself, to achieve improved results".

To date the majority of data fusion research, development, and applications focus primarily on the lowest levels of data fusion (e.g., Level 1 – Object Refinement). The higher levels of information fusion, referred here as Fusion 2+, are inadequately being addressed, in particular the areas of Behavioral Modeling, Threat Modeling, and Threat Prediction. This SBIR effort will therefore address the previous three domains.

Specific areas of research within Fusion2+ for improved Situational Awareness are:
1. Research, development and application of novel methods in knowledge representation and information fusion is desired, as applied towards Behavioral Modeling, Threat Modeling, and Threat Prediction;
2. Techniques that are able to combine data-driven inputs with learned knowledge structures, to establish multiple hypotheses of interpretation are strongly desired;
3. Inputs are to be obtained from multiple modalities of sensing as well as text-based data;
4. The derived knowledge structure should be able to support learning of new relationships and higher-level concepts, and support human-guided learning. This is crucial to new model development for behavior and threat.

PHASE I: Develop an innovative approach to a subset of the Behavioral Modeling, Threat Modeling, and Threat Prediction area that directly supports improved Situational Awareness.

PHASE II: Develop a prototype Information Fusion system based on the Phase I design. Demonstrate the developed Situational Awareness prototype to prove feasibility for a Behavioral Modeling, Threat Modeling, and Threat Prediction capability.

DUAL USE COMMERCIALIZATION: There are many dual use applications of Information Fusion techniques. For example in the law enforcement community, this research could be applied to counter narcotics arena. On the commercial side, this research is applicable to business intelligence, where companies attempt to determine what their competitors are doing by collecting and analyzing data available over the web.

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KEYWORDS: Information Fusion, Fusion 2+, Data Fusion, Knowledge Discovery, Situation Assessment, Threat Assessment, Impact Assessment; Behavioral Modeling; Threat Modeling; Threat Prediction

AF05-105 TITLE: Information Mangement

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop the ability to capture and reason about the provenence (pedigree) of information published into a Joint Battlespace Infosphere[1] (JBI) or JBI-like information environment to support quality assessment cornerstone technologies for an information management (IM) foundation for military applications including mechanisms to assess information quality, control the IM environment, collaborate.

DESCRIPTION: A shared information management infrastructure (e.g. [1]) must be robust in a complex operational environment and service the needs of information producers and consumers reliably. In a net-centric environment supporting diverse communities of interest[4], the ability to assess trust in information is simultaneously more important and more challenging. Assessment of information quality and trustworthiness may be partially based upon its provenance. This may be captured using information pedigree mechanisms to record and analyze the history (e.g., source, trust), descent (e.g., version and change history), lineage (e.g. ownership), and genealogy (e.g., derivative sources) of information objects. In addition, as collaborative communities become larger and more diverse, it will become increasing difficult to assess trust in information sources. Mechanisms to establish trust are sought, such as corroboration of information with that of trusted sources to assess the probability that other information provided by the unknown or questionable source is of value and feedback other mechanisms to increase levels of trust. References [2] and [3] are examples of relevant technology standardization activities.

PHASE I: Define algorithms and architectures, design systems, and provide proof of concepts demonstrations for technologies that enable the pedigree of information to be captured, retrieved and reasoned about.

PHASE II: Design, develop and demonstrate prototype systems that enable the effective use of pedigree for information assessement.

DUAL USE COMMERCIALIZATION: As military operations increasingly rely upon larger and non-traditional communities of interest, such as civil law enforcement and non-governmental organizations; mechanisms to provide trustworthy information in a complex operational environment will become increasingly critical. This technology will have application to other governmental departments including the Dept. of Homeland Security, and commercial applications such as data mining, and management of enterprise information environments.

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KEYWORDS: Information management, IM, pedigree, semantic web, JBI, Joint Battlespace Infosphere, metadata, trust, collaboration, grid computing

AF05-106 TITLE: Cyber Operations

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop cyber attack assessment techniques that provide the network defender with the capability to perform network defense, cyber attack assessment and defensive response through the use of advanced information fusion and digital forensics techniques.

DESCRIPTION: Cyber attack assessment is a critical aspect of defending today's emerging large-scale, network-centric computing environment. A cyber attack assessment capability will gather input from traditional information cyber sensors (intrusion detection systems, firewalls, network management systems, etc...), filter the input, fuse the filtered information with other relevant information, and provide that information to the network defender for the purpose of assessing the details of an adversary cyber attack and producing credible, irrefutable digital evidence. This digital evidence will then be used to develop and execute the appropriate defensive course-of-action thus ensuring the survivability of the network-centric computing environment. The key technologies for this work are: digital forensics, information fusion, data mining, decision sciences, and course-of-action planning. The overall goal of this work is to provide the network defender with accurate, irrefutable, "just-in-time" digital evidence that can then be used to ensure that the network can survive an adversary cyber attack and maintain continuity of operations.

PHASE I: Produce a design document.

PHASE II: Produce a proof-of-concept demonstration.

DUAL USE COMMERCIALIZATION: The Cyber Operations technologies to be developed enable capabilities required by other U.S. Government agencies, law enforcement and the commercial sector. Specific dual-use technologies include intrusion assessment, cyber forensics, situational awareness and defensive cyber operations course-of-action planning.

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2. C2&ISR Capability Statements, AF C2&ISR Center, July 2002

3. Casey, Eoghan, Digital Evidence and Computer Crime, Academic Press (Elsevier), 2004.

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KEYWORDS: Cyber Operations, Information Warfare, Information Assurance

AF05-107 TITLE: Command and Control

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate new technologies for the continuous, interactive, allocation of assets in a dynamic environment of real-time information updates, competing/changing priorities and changing resources.

DESCRIPTION: "Control of military force is central to the American way of war. The United States will always need to improve its ability to gather and assimilate vast amounts of data, discern pivotal information and communicate knowledge to the right place at the right time." US Air Force Transformational Flight Plan.

A common complaint with the current air tasking cycle and Air Tasking Order (ATO) product is that it is not responsive to dynamic changes in the battlespace. While this complaint overstates historic experience, a 1996 USAF Scientific Advisory Board (SAB) Report on Vision of Aerospace Command and Control for the 21st Century found enough merit in it to propose changes that allow operations in a "nonlinear, asynchronous, and interactive manner." The characteristics of such a planning system include: 1) real-time, interactive, collaborative planning tools to evaluate and update plans; that include nonlinear, reentrant/iterative, and asynchronous planning cycles, i.e., is continuous; 2) rapid rehearsal using modeling and simulation; 3) near real-time updates of mission/weapon profiles, battle-damage assessment overall campaign effect; 5) dynamically generated tasking orders and 6) universal access to required information.

The challenge is the development of decision support (problem solving) capabilities that can interactively and dynamically build then alter plans in a continuous manner to achieve an established set of goals or objectives in an environment consisting of real-time information updates, competing and changing priorities and shifting resources.

Key is the ability to establish a desired outcome or end game and then build a plan that is continuously adjusted – maximizing the results and minimizing the cost. Artificial Intelligence advances in problem solving methodologies and technologies have made it feasible to construct such decision support capabilities.
The goal of this topic is to empower the decision maker by developing and demonstrating new technologies for continuous, effects-based (outcome-based) allocation of campaign assets. A preponderance of current tools for campaign scheduling are batch oriented and provide little support for rapid, minimally disruptive response to changing execution circumstances, fleeting opportunities or unexpected execution results. Moreover, current tools tend to focus narrowly on the allocation of strike assets, with insufficient linkage to the underlying effects-based (outcome-based) strategy.

This effort offers new approaches to the problems of dealing with emerging, time sensitive or time critical events by exploring dynamic tasking concepts. This will also provide the decision-maker a comprehensive, coherent, predictive, time-sequenced view of past, current and future activity in terms of planned/on-going actions, attained/predicted effects (outcomes) and emerging/realizable opportunities.

PHASE I: Design an interactive planner that addresses the following characteristics: 1) continuously and dynamically plans/replans to meet a set of established objectives, 2) considers and adapts to real-time information updates in its planning/replanning, 3) considers competing and changing priorities and, 4) accounts for changes in the status of resources.

PHASE II: Demonstrate a prototype interactive planner that continuously allocates assets in a dynamic environment of real-time information updates, competing/changing priorities and shifting resources.

PHASE III: Leverage continuous, mixed initiative air campaign planning and scheduling technologies with dynamic tasking concepts to build automated capabilities for dealing with emerging, time sensitive or time critical targets that addresses the inherent limitations in the legacy ATO process.

DUAL USE COMMERCIALIZATION: Planner and scheduling technologies have a significant commercial opportunity in applications where an optimized set of objectives is to be attained in a dynamic environment of competing priorities and changing resources. Transportation (automated traffic management, airline flight scheduling), workflow management of the assembly process for manufacturing, computer network flow, computer resource management and independent autonomous operation of robotics are some possible commercial applications. Opportunities also exist for this research to enhance Air and Space Operations Center (AOC) modernization activities by transitioning a dynamic tasking module.

REFERENCES:
1. Report on Vision of Aerospace Command and Control for the 21st Century, Scientific Advisory Board (Air Force), Oct 1996, SAF/AQ, SAB-TR-96-02, DTIC Accession #: ADB217170
2. Network Centric Warfare: Developing and Leveraging Information Superiority, 2nd Edition (Revised), Alberts, Garstaka and Stein, August 1999, DoD C4ISR Cooperative Research Program, Washington DC
3. Effects-Based Operations: Change in the Nature of Warfare, Aerospace Education Foundation, Defense and Airpower Series, 2001.
4. Effects Based Operations, Alberts, November 2002, DoD C4ISR Cooperative Research Program, Washington DC
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6. Toward a Theory of Qualitative Reasoning Plans, Karen L. Myers, Proceedings of the ICAPS-04 Workshop Connecting Planning Theory with Practice, 2004
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KEYWORDS: dynamic tasking, mixed initiative, dynamic planning, effects based planning, dynamic scheduling

AF05-108 TITLE: Connectivity Technologies for the Warfighter Network

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative applications of radio and networking technologies to effectively increase the digital bandwidth to wirelessly connected users. Exploit the dense concentrations of wireless users to support high bandwidth but bursty applications such as image and video transfers.

DESCRIPTION: There is a large base of legacy radios and radio networks installed that will coexist with new equipment, such as that based on DoD's Joint Tactical Radio System (JTRS), for decades. There is a need to develop mobile ad hoc wireless networking techniques that can provide digital data transfer among individual devices. These techniques would allow devices to: 1) relay information to other devices via multiple hops, and 2) segment information objects or streams so as to make use of multiple simultaneous routes. This would have the benefits of globally conserving energy as well as increasing the effective bandwidth of the system. The energy conservation approach must also respect the local needs of individual devices (e.g., not penalize a device that is in an advantageous relay location).
Current mobile ad hoc networking (MANET) approaches focus on homogeneous collections of devices; the need is for an approach that utilizes multiple (and, today, incompatible) radio networks. Location-aware devices (such as those equipped with GPS) may use this information to route more energy-efficiently than those that must constantly poll their neighbors. Quality of Service (QoS) based on Service-Level Agreements (SLAs) would be needed to establish a cost-effective structure.

Future capabilities that would be built from this foundational innovation include: persistent, global continuous Line of Sight (LOS) and Beyond Line of Sight (BLOS) communications, on-demand network access, seamless addition/deletion of nodes to scale network capacity and accessibility, information gateway services for translation of information formats, self-configuring and self-healing networks, covert secure communication for exfiltration of data from fighters & weapons, enterprise management across AF, Joint, and Coalition Domains, Space, Airborne, Ground, Sea networks, policy-enabled networks that dynamically change configuration based on mission, commanders intent, and security required.

PHASE I: Define wireless networking architectures and initial designs that provide high bandwidth, energy efficient, communication links between disparate wireless networks. Identify the best two routing algorithms and projected throughput enhancement from their use. Provide approaches to model and simulate their performance.

PHASE II: Complete the design, develop, and demonstrate prototype systems that enable energy efficient ad-hoc networking amongst heterogeneous devices including at least one JTRS compliant device.

DUAL USE COMMERCIALIZATION: Improved networking technologies benefit both DoD's objectives for the JTRS program and have extensive application to homeland defense initiatives for network interoperability and increased information throughput.

REFERENCES:
1. Space & C4ISR Capabilities CONOPS

2. Airborne Networking Management Strategy Initiative

3. Global Strike Task Force Infostructure Capabilities Roadmap

KEYWORDS: Radio Frequency Communications, Antennas, Mobile and Ad-hoc Networking, Enterprise Management, Network Modeling and Simulation, Power and Energy Management

AF05-109 TITLE: Computer Architectures for Understanding

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop computer architectures with greater sophistication enabling attainment of dynamic mission objectives under constraints imposed by C4ISR systems.

DESCRIPTION: Current architecture approaches provide computational capacity for the ever increasing volumes of data which are collected and processed. For example, as transistor sizes are shrunk to increase processor speed or more processors are added to attacking the problem to reduce computation time (ie. beowulf clusters or supercomputers with more nodes). This increased computational capacity has served well the ability to process the data and signals and create information for warfighter. However, information overload is a real problem, as the volume of data processed continues to rapidly increase. In order to avoid information overload and reduce decision latencies, one must climb the cognitive pyramid of computation by increasing the processing sophistication. As the processing sophistication is increased, the data turned information continues its cycle into knowledge and eventually into understanding. It is this on-demand intelligence that we seek to provide the warfighter. The architectures of today which are tuned to numerical processing, must change to handle non-numerical information challenges as well as be capable of agile processing to support dynamic mission objectives. Example architectural changes might include memory systems which are addressed by content rather than by address, context processing units rather than arithmetic processing units and many small specialized context processors as opposed to a large general purpose processor. These architectures will require an ability to morph between variations in a stable manner as well as be able to handle control of dynamic resources and remapping to achieve greater sophistication. Finally, number crunching architectures of today do well by measurements of raw processing speed, such as operations/second. However, architectures that have climbed the computational pyramid will be measured by their cognitive functioning such as the number of decisions made per second or by the number of items compared and searched in a second.

PHASE I: Develop an overall system design that includes a feasibility demonstration of the critical aspects of the design.

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

DUAL USE COMMERCIALIZATION: This system could be used in a broad range of military and civilian applications where an increase in the intelligence of the processing would reduce the decision making cycle. Such an increase in processing sophistication would allow military leaders access to decision quality information in a more timely manner. Commercial application could be seen across medical, production and corporate applications.

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3. W. Kintsch. Comprehension: A Paradigm for Cognition. Cambridge, UK: Cambridge University Press. 1998.

KEYWORDS: cognitive processing architectures, processing sophistication, non-numerical processing, intelligent memory, computing architecture, symbolic processing

AF05-110 TITLE: Situation Awareness within a Network Centric Operations Construct

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Investigate information technologies as they relate to providing Situation Awareness services within the overall Network Centric Warfare (NCW) environment.

DESCRIPTION: Vice Admiral Arthur K. Cebrowski1 defines Network-Centric Warfare (NCW) as a shift from attrition style warfare to a much faster and more effective warfighting style characterized by "Speed of Command" and "Self-Synchronization". Key to the concept of Speed of Command is the ability for the force to achieve information superiority.

Today we live in the data age and the NCW environment has the potential to make matters worse. This environment is distinguished by myriads of sensors and fusion nodes. Yet as we continue to build and deploy new sensors the amount of data continues to grow exponentially while the information is lost. Building more sensors and collecting more data without investing in the ability to better filter, aggregate and assist in overall situation awareness and understanding will greatly hamper Information Superiority and the Speed of Command – a major and vitally important component of NCW. Current capabilities are limited to data visualization of dots on the battlefield and rely on users to develop both an awareness and understanding of the situation. Current capabilities quickly confuse the user with a vast array of icons on the screen and are limited to displaying geo-registered data. There is no integrated display providing geographic, event and report data in a cohesive interface, let alone the aggregation of this data in the form of information.

To get the right information to the right person at the right time cannot be achieved without first the ability to have information rather than data. Incoming data must not only be accessible, but filtered, analyzed and connected to develop an overall situational picture. If we are to speed up our ability to respond we need to develop capabilities that can assist the user in developing overall situation awareness. Whether these capabilities provide the ability to connect the dots, recommend possible situations occurring or simply identifying potential relevant events, they can have the potential to significantly reduce the amount of data needed to be analyzed by the user.

Specific areas of research for Situation Awareness within NCW are:
1. Intelligent collection/access of geographically disparate heterogeneous data sources, to include access methodologies, distributed data source integration, data cleansing and aliasing;
2. Services for interaction of heterogeneous modeling techniques (e.g., Bayesian Nets, Neural Networks, Fuzzy Maps, Markov models, etc.) to develop an overall picture of the situation. Services to include methods for the instantiation of models, their interaction and exchange of results (from both local and distributed fusion nodes).

PHASE I: Develop an innovative approach to Situation Awareness that directly supports improved information superiority.

PHASE II: Develop a NCW service based on the Phase I design. Demonstrate the developed capability to prove feasibility for Situation Awareness and improved information superiority as a service within a networked, distributed service-oriented environment.

DUAL USE COMMERCIALIZATION: There are many dual use applications of situation awareness techniques. For example in the law enforcement community, this research could be applied to counter narcotics arena. On the commercial side, this research is applicable to business intelligence, where companies attempt to determine what their competitors are doing by collecting and analyzing data available over the web or the manufacturing process to monitor and improve the overall efficiency and quality of production.

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[2] Network Centric Warfare: An Overview of Emerging Theory, John J. Garsika, Joint Staff Directorate for C4 Systems, http://www.mors.org/publications/phalanx/dec00/feature.htm

[3] War Isn't A Rational Business, Col T. X. Hammes, USMC, http://www.d-n-i.net/fcs/hammes_netwar.htm

KEYWORDS: Network Centric Warfare, Network Centric Operations, Situation Awareness, Threat Assessment.

AF05-115 TITLE: Tactical Air Controller Wargame

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Design and prototype a PC-based wargame with sufficient fidelity to enable mission training and rehearsal by Tactical Air Controller personnel.

DESCRIPTION: The mission of a Tactical Air Controller (TAC) is a complex hazardous mentally demanding mission where errors can waste precious support and kill friends. Maintaining situational awareness of both air and ground in a dynamic high stress environment, while providing clear concise direction is an essential requirement of this mission. A wargame that allows a TAC to practice his art in a simulated situation will allow his training to sustain his efficiency in the real event. The same wargame would allow others to better understand the difficulties of the TACs mission, and allow easier development of equipment and procedures to improve the effectiveness of that mission.

The TAC must have "eyes-on-target" and positive ID of the incoming airstrike, while operating in the environment of an engaged light infantry platoon. This requires a wargame with a "first-person-shooter" environment (similar to Doom, Halo, and Delta Force).

The TAC must verbally provide air traffic control and talk in airstrikes. This requires embedded voice recognition software.

The TAC coordinates his work with artillery and helicopter missions and supports the company commander. These tasks are often require the use of maps, satellite photos, note pads, and similar support; so a non-shooter environment must be available for the planning phase and accessible during the "in-contact" portions of the wargame.

The wargame should take the TAC from the company commander's five paragraph mission order through the after action debrief. Included in the mission prep should be the TACs load out of mission equipment (batteries, radios, rangefinders, designators, UAVs, …), personal weapons (used if the situation totally disintegrates), and a generic basic equipment loadout.

The challenge: integrating dynamic (real-time) voice recognition software providing high order control input and feedback with AI controlled agents (aircraft and unit commanders) and agencies (artillery and rotary wing units) inside a dynamic full dimensionality first person environment. All on that, on a PC.

PHASE I: Demonstrate the integration of dynamic (real-time) voice recognition software providing control input with agents (aircraft) inside an non-developmental first person shooter. Capture the process for a Tactical Air Controller-based operation, and design -- and if possible, develop a concept prototype of -- a computer wargame suitable for providing a mission rehearsal environment/scenario.

PHASE II: Using the design generated in Phase I, develop a computer-based wargame with sufficient fidelity to enable mission training and rehearsal by Tactical Air Controller personnel.

DUAL USE COMMERCIALIZATION: Opportunities exist for this project to become the common platform used by all US military educational institutions in support of mission rehearsal in a wide variety of operational disciplines; including Distributed Mission Operations, Search and Rescue and other Special Forces missions. Furthermore, commercial wargame sales are a substantial market.

REFERENCES:

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2. "Designing A System-On- System Wargame", David O. Ross, Proc. SPIE Vol. 5091, p. 149-153, Enabling Technologies for Simulation Science VII; Alex F. Sisti, Dawn A. Trevisani; Eds.

3. Abstracting The Warfighter, D. O. Ross, Proceedings of the 1998 Summer Computer Simulation Conference, Reno NV, Jul 98

KEYWORDS: Adjudication Engine, Wargames, Course of Action, Asymmetric Modeling, Tactical Air Controller, Mission Rehearsal

AF05-117 TITLE: Chemical/Biological (CB) Protected Mobile Maintenance Shelters

TECHNOLOGY AREAS: Chemical/Bio Defense, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop Chemical/Biological (CB) protected shelters for housing or interfacing to portions of fighter aircraft during maintenance operations.

DESCRIPTION: A threat of a chemical or biological attack on an airbase forces the ground crew to perform maintenance activities in bulky and often cumbersome individual protective equipment. This greatly reduces their performance and severely affects aircraft maintenance and servicing. The objective of this program is to develop and demonstrate technology that enables Air Force ground crews to service fighter aircraft in a mobile enclosure that can be quickly positioned over any portion of the aircraft while providing an environment that is protected from CB contamination. The unit must be capable of providing an internal environment that allows the ground crew to perform their work without the use of individual chemical protection. The unit must have its own filtration and air handling system, have the ability to be installed rapidly, and be highly adaptable to sealing against surfaces. Due to use of low observable composite materials in manufacturing of fighter aircraft, maintenance operations require a shelter for protecting composite materials from environmental exposures and provides for removal of emissions during maintenance operations. This solicitation seeks a comprehensive protective shelter that will:

· Provide CB protection within the shelters for workers without the use entire of individual protective ensemble (MOPP gear)
· Provide adaptive interface mechanisms that can effectively seal against a portion of the aircraft and pavement/floor
· Provide passive systems for removal of fugitive CB agents, toxic industrial material (TIM), decontamination products, and maintenance emissions from within the shelter
· Be able to erect and sustain shelter in austere environments, with minimal effort of personnel and time in individual protection gear
· Be able to withstand wind speeds of at least 20 knots
· Have a compact, mobile filtration and environmental control package
· Be able to service any part of the aircraft with the shelter systems
· Be able to ship on the standard military air cargo pallet

PHASE I: During phase I, contractor must demonstrate the feasibility of fabricating and incorporating CB-resistant shells and liner systems, closures, and adaptable aircraft interfacing mechanisms to 1.) sustain operations without exceeding exposure limits of 0.1mg/m3 of agent and 2.) assurance that no more than 1% of outside contamination with a challenge level of 5g/m2 penetrates the adaptive interface mechanisms seal.

PHASE II: During phase II, contractor must fabricate a prototype model and demonstrate a prototype for a CB protected interface mobile maintenance shelter which will be used for further evaluation and characterization. This is to include 1.) removal of more than 90% removal of fugitive CB agents, TIMs, decontamination products, and maintenance emissions within the shelter 2.) provide a compact deployable system that requires minimal logistical support and 3.) compliance with the description of requirements above. The shelter's effectiveness will be demonstrated in a field environment during the effort.

PHASE III: The contractor is expected to proceed with commercialization of the material or development of the shelter as a protective facility commercially accessible to DoD. Concurrent pursuit of civilian-market products or protection in local, state, or federal government industry is consistent with the aims of this procurement.

DUAL USE COMMERCIALIZATION: The principle commercial opportunity is in military applications homeland defense. With slight modification, the same technology may be adaptable to other categories of emergency responders to hazardous material spill sites and large-scale painting facilities.

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"Review of Acute of Acute Human-Toxicity Estimates for Selected Chemical-Warfare Agents" National Academy Press, Washington D.C. 1997

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http://www.e-publishing.af.mil/pubfiles/af/32/afman32-4017/afman32-4017.pdf covers NBC policies and processes for pre-, trans-, and post-attacks in an contaminated environment.

http://www.acq.osd.mil/cp/rdaplancbpointdecon_22apr02.pdf for the Integrated Chemical and Biological Defense Research, Development, and Acquisition Plan

http://hld.sbccom.army.mil/ip/bca_qr.htm for Biological and Chemical Agent Quick Reference Tables

http://www.dlaps.hq.dla.mil/dlar/r4151.15.htm outlines the requirements Military Airlift Management System

KEYWORDS: chemical/biological (CB)protection,maintenance, shelters

AF05-118 TITLE: Lightweight Durable Intumescent Paint

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a lightweight, durable intumescent paint for application to composite parts inside and outside fighter aircraft to improve the properties of ignition time and flame spread.

DESCRIPTION: Efforts to create a lighter, faster, more efficient aircraft have led to the increased use of composite structural and skin materials. Composites are 24 percent of the airframe for the next-generation aircraft. The limited fire data available on composites addresses only non-coated materials. No data exists on the flammability characteristics of composites with coatings. Samples tested to date, with the exception of phenolic resin, ignite in less than 1 minute. Test thermal insult is equivalent to a 3 gallon JP-8 spill fire on the ground under the fuselage. Composite materials begin to degrade structurally approximately 10 seconds after exposed to flame. With current standards, crash/fire vehicles may not arrive in time to prevent ignition of these materials. Composites continue to burn after the liquid fuel fire is extinguished. The continuing fire produces as much heat as pinewood when burning. Cone calorimeter testing of a variety of graphite, Kevlar, and polyethylene reinforced organic matrix composites have shown ignition times as low as 4 seconds when exposed to a radiant flux of 75 kw/m-sq. The mean heat release rate may be as high as 350 kw/m-sq.

PHASE I: Demonstrate the feasibility of intumescent paints applicable to a variety of graphite fiber/organic matrix composites. Recommend a candidate paint for the potential Phase II effort that will increase ignition time to 5 minutes when tested on the cone calorimeter at 75 kw/m-sq.

PHASE II: Demonstrate an intumescent paint with weight no greater than 0.5 ounce per square foot, durability equivalent to current aircraft paints, and compatibility with low observable coatings. The final paint must comply with all applicable environmental guidelines for application and residue. Deliver 3 gallons each of the finished paint in colors white, black, and red for evaluation by AF personnel.

DUAL USE COMMERCIALIZATION: This new, innovative intumescent paint will have applications in both aircraft and facility construction and other structural applications, but in this case will have immediate use in fire prevention in the Air Force, Army, Navy, and the commercial aircraft industries and operational agencies.

REFERENCES:
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2. Effect of Ignition Conditions on Upward Flame Spread on a Composite Material in a Corner Configuration. Materials and Process Challenges: Aging Systems, Affordability, Alternative Applications. SAMPE Symposium and Exhibition, 41st International Proceedings. Volume 41. Book 1. Society for the Advancement of Material and Process Engineering (SAMPE). March 24-28, 1996, Anaheim, CA, Schmitt, G.; Bauer, J.; Magnurany, C. J.; Hurley, C., Editors, pp. 734-747, 1998. Fire Safety Journal, Vol. 31, No. 4, 331-344, November 1998.

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4. Ohlemiller, T. J.; Shields, J. R. , Evaluation of Intumescent Body Panel Coatings in Simulated Post-Accident Vehicle Fires, NISTIR 6157; 38 p. April 1998.

KEYWORDS: intumescent paint, flame ignition time

AF05-119 TITLE: Fuel Processor Hardware Components For Deployable Fuel Cell Power Generation

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

OBJECTIVE: Develop a fuel cell power generation system that is capable of running on JP-8 fuel to power fighter aircraft and support maintenance operations.

DESCRIPTION: All electric aircraft concept and aircraft maintenance require reliable, compact, and efficient electric power sources. Fuel cell electric generator using JP-8 fuel is identified as the electric power source of choice. A major component of a JP8 fuel cell electric generator is the fuel processor that extracts clean hydrogen from JP8. For the fuel processor to work effectively several compact hardware components compatible with JP8/diesel need to be developed for the high temperature and pressure operating rages of up to 700C and 15 atmospheres. Hardware components for both steam reforming and Catalytic Partial Oxidation (CPOX) technologies in the range of up to 10kW are of interest. These hardware components include compact liquid level controllers compatible with distillate fuels at temperatures greater than 300oC, compact gas-liquid separators for fine mist elimination and separation of liquid fuel from non-condensable hydrocarbon gas streams, compact pumps capable of delivering up to 200 mL/min at pressures up to 200 psig, heat exchangers with fouling resistance, compact water recovery subsystems capable of condensing and separating greater than 90% of water vapor from a hydrogen-rich reformate gas stream, compact fuel atomizers capable of aerosolizing distillate fuels such as JP-8 in low-pressure blower air, and others. Innovative concepts are sought to develop hardware with emphases on compactness, efficiency, and compatibility with distillate fuels and operating parameters.

PHASE I: Design and test a viable unit to demonstrate the feasibility of the selected concept and identify technical deficiencies forl further investigation and improvement.

PHASE II: Design, build, test, and demonstrater a prototype fuel cell electric generator running on JP-8 fuel for fighter aircraft applications. The prototype is desired to be delivered to the AF at the end of the effort for further testing and characterization by the AF.

DUAL USE COMMERCIALIZATION: A successful, efficient, lightweight, small-size, and coke-free JP-8 fuel processor/fuel cell unit will have a multitude of commercial applications in addition to the deployable generator. Portable, backup, and auxiliary power units (APUs) are three potential applications.

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KEYWORDS: JP-8, diesel fuel reforming, hardware, auxiliary components, gas-liquid separator, fuel pump, water pump, fuel atomizer

AF05-120 TITLE: Advanced Shelter Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an innovative, rapidly deployed, and highly efficient shelter for housing fighter aircraft during maintenance operations.

DESCRIPTION: Currently deployable shelters for forward base operations are too heavy and bulky, require too much time and labor to set-up, and don't meet the needs of advanced weapon systems. To resolve this problem, a state-of–the-art shelter is required to support existing and future fighter aircraft. The desired solution is a shelter that would self deploy (i.e., airbeam shelter), would be very lightweight, and require very little, if any, maintenance once erected. Also, due to use of low observable (LO) composite materials in the manufacturing of fighter aircraft, maintenance operations require a shelter for protecting composite materials from the sun's ultra-violet exposures. The rapid evolution of rigidizing with lightweight impregnable material as a replacement for conventional steel beams in the construction of the bare base facilities has provided a gateway to more reliable structures for future deployments. New shelter technology that inflates at low pressure, is well insulated, and requires minimum manpower to setup a full-scale hangar-type facility will be the program goal. The ability to rigidize existing beam shelters in deployed airbase locations will greatly improve the time it takes to establish maintenance facilities after fighter aircraft reach their theater.

PHASE I: Demonstrate the feasibility of using chosen technology to rigidize or impregnate shelter structural support systems with advanced lightweight materials.

PHASE II: Design, fabricate, demonstrate, and test a prototype shelter with chosen rigidized or impregnated lightweight material in the structural support system.

DUAL USE COMMERCIALIZATION: A successful, lightweight, quick-setup, foam-filled beam shelter will have a multitude of commercial applications in addition to the deployed forces. Temporary hospitals and portable tents during natural disasters are two potential applications of this technology.

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KEYWORDS: air-beam shelters, deployable foam systems, low observable composite materials, aircraft hangar impregnated support systems

AF05-121 TITLE: Lightweight Environmental Control Unit (ECU)

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a compact (ECU) that uses hydrocarbon as refrigerant for heating and cooling of fighter aircraft maintenance hangars/shelters.

DESCRIPTION: Maintenance of aircraft in the hangar/shelter requires a powerful air conditioning system to remove heat generated by electronics within the aircraft hangar. Current systems use air cycle refrigeration systems that have low thermal efficiency. Through the use of hydrocarbon refrigerants, significant increase in refrigeration efficiency and reduction in ECU size can be realized, resulting in lower fuel consumption for these tests. Traditionally, flammable materials have not been used for refrigeration; however, by decreasing fuel consumption, the amount of flammable materials in the vicinity of the aircraft during maintenance can be reduced, since only a small amount is needed in the refrigeration system.

PHASE I: Develop an analytical model to evaluate performance of various hydrocarbon refrigerants and their mixtures. Select a hydrocarbon mixture refrigerant based on model predictions. Measure flammability issues and test the mixture performance. Demonstrate the feasibility of using the proposed mixture for a full-scale system.

PHASE II: Design, build, and test, a 5-ton prototype hydrocarbon refrigeration ECU. It is desired that this unit be delivered at the end of the Phase II effort for further evaluation and characterization. Eventual commercialization to DOD would occur via a potential Phase III contract pending peformance evaluation.

DUAL USE COMMERCIALIZATION: A successful, efficient, lightweight, and small-size ECU will have multitude of commercial applications. In addition to the deployed base application, residential, and commercial ECU are potential applications.

REFERENCES:
1. Eric Granryd, "Hydrocarbons as refrigerants - an overview," International Journal of Refrigeration Vol. 24, pp. 15-24, 2001.

2. I. L. Maclaine-cross E. Leonardi, "Comparative Performance of Hydrocarbon Refrigerants," I.I.F. - I.I.R. - Commissions E2, E1, B1, B2 -- Melbourne, Australia -- 1996, - 11th to 14th February.

3. Parmar, A. S., "Performance of Hydrocarbon Refrigerants in Motor Car Air-Conditioning," B.E. thesis, School of Mechanical and Manufacturing Engineering, The University of New South Wales, Sydney, 1995.

KEYWORDS: hydrocarbon refrigerants, compression cycle, heat pump, environmental control unit

AF05-122 TITLE: Efficient Superalloy Ingot Breakdown

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Explore and transition advanced software describing ingot breakdown in Ni-base superalloys to increase yield and improve properties.

DESCRIPTION: Nickel-based superalloys are widely used in the aerospace industry for gas turbine engine applications due to their attractive high temperature properties and durability in this demanding environment. Wrought products require secondary operations to refine the as-cast grain size and improve chemical homogeneity. The losses that occur during this primary ingot breakdown step represent a major cost factor for alloys used in advanced gas turbine engines. Application of phenomenological- and physics-based models incorporating the kinetics of chemical homogenization, dynamic recrystallization, static recrystallization, and grain growth and texture evolution as a function of initial ingot condition, hot working temperature, time at temperature, strain state, and strain rate could dramatically improve the efficiency of metal production. Effort should be made to limit the number of material-specific input parameters that require fitting. Data for a model alloy, e.g., alloys 718, IN-100, or U-720,

will be used to demonstrate the feasibility of the approach. Where input data are not available, appropriate experiments will be conducted to provide the parametric information. Models and the corresponding computer codes must be developed and validated to simultaneously solve these kinetic equations so that grain size distribution and grain size anomalies can be predicted. The final product should be compatible with existing software packages used by industry to model forming operations.

PHASE I: Define the basic set of models that must be included to define the simultaneous processes occurring in primary ingot breakdown and secondary billet production. Processes to be considered include upset forging and cogging and/or extrusion. Detailed plans will be drafted to complete the model in Phase II.

PHASE II: Fully develop the model and computer codes for the selected model alloy and interface with existing software packages. Material parameters needed in the model will be fully described, and methods for determination will be specified. Extension will be made to common mill operations and their serial combinations, for example, upset forging, side forging (cogging) and extrusion. The applicability of the model and code to the superalloy composition will be demonstrated. In all cases, confirmation of the predictions from the model will be corroborated with detailed microstructural characterization of appropriately scaled ingot/billet. A preliminary demonstration of the methodology, conducted in collaboration with an industrial mill product supplier, will be used as a measure of code maturity and utility.

DUAL USE COMMERCIALIZATION: The validated computer code will be fully integrated into, or made compatible with, existing software packages. It will be made available to the entire industry and will improve the yield for both civilian and military gas turbine hardware.

REFERENCES:
1. G. Shen, S.L. Semiatin, and R. Shivpuri, “Modeling Microstructural Development During the Forging of Waspaloy,” Metall. and Mater. Trans. A, Vol. 26A, p. 1795, 1995.

2. S.L. Semiatin, P.N. Fagin, M.G. Glavicic, and D. Raabe, “Deformation Behavior of Waspaloy at Hot-Working Temperatures,” Scripta Mater., Vol. 50, p. 625, 2004.

3. S.L. Semiatin, D.S. Weaver, P.N. Fagin, M.G. Glavicic, R.L. Goetz, N.D. Frey, R.C. Kramb, and M.M. Antony, “Deformation and Recrystallization Behavior during Hot Working of a Coarse-Grain, Nickel-Base Superalloy Ingot Material,” Metall. and Mater. Trans. A, Vol. 35A, 2004, in press.

KEYWORDS: nickel-base superalloys, ingot breakdown, hot working, mill product, manufacturing

AF05-123 TITLE: Decision Making Tool for Lean Aircraft Assembly Modernization

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop and demonstrate an analytical tool for quantifying the benefits and costs of moving and pulse line assembly strategies in lower rate aircraft manufacturing vs more traditional, fixed stations.

DESCRIPTION: A number of benefits have been identified with the application of moving/pulse line strategies to the assembly of large aircraft. These approaches to increase the flow of the assembly process have been widely used for other products with higher rate production. Recent developments have shown that benefits can be achieved with lower rate production as well. Boeing has reported benefits on the order of 30-50 percent improvements in cycle times and inventory levels for a number of its large commercial aircraft assembly lines. Moving lines allow everyone in the factory to immediately identify schedule status visually and promote more effective production planning and quicker resolution of problems. It also reduces the need for unique assembly tools and fixtures that are costly to build and maintain. There has been enough benchmarking that data is available now to develop the algorithms to evaluate the options for a given product scenario. This will help contractors to make effective decisions on the best assembly approach weighing investments against benefits, and in turn promote lower cost products for the government.

The purpose of this research is to develop and demonstrate a decision tool that will quickly, easily, and accurately quantify the benefits, costs, and limits associated with using a moving/pulse line in an aircraft assembly environment.

PHASE I: Determine costs and benefits of using a moving/pulse line in an aircraft assembly environment. Determine the algorithms required to perform an effective analysis. Investigate the feasibility and interest of potential customers for this type of product. Develop and demonstrate a prototype computer-based decision aid with notional data. This tool should be Microsoft Windows compatible, to keep future commercial applications in mind.

PHASE II: Gather actual data in order to verify the algorithms developed in Phase I. Refine the prototype tool and demonstrate its use on a wide variety of test cases. Develop, test, and deliver a prototype tool for evaluation by the Air Force, with future commercial applications in mind. Formal DOD commercialization would be accomplished via a Phase III contract.

DUAL USE COMMERCIALIZATION: This tool would be very valuable to AF weapon systems that have to make production decisions in often low rate conditions. It could also be adapted to industrial use to effectively analyze production scenarios.

REFERENCES:
1. Womack, James P., David T. Jones, and Daniel Roos, The Machine that Changed the World, New York: Rawson Associates, 1990.

2. Womack, James P. and David T. Jones, Lean Thinking: Banish Waste and Create Wealth in Your Corporation, New York: Simon & Schuster, 1996.

KEYWORDS: analysis tool, aircraft, assembly, modernization, lean manufacturing

AF05-124 TITLE: In situ Repair of Ti-6-2-4-2S Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a methodology to repair in situ hot structures comprised of Ti-6-2-4-2S alloy.

DESCRIPTION: The U.S. Air Force (AF) is interested in pursuing technologies that will enable the repair of hot metallic structures made of titanium alloy Ti-6-2-4-2S. The AF currently has applications of Ti-6-4-2S that are experiencing cracking problems. Being very labor intensive to repair and replace, these application would benefit tremendously from a repair that could be done in situ, with potentially millions of dollars in savings.

In particular, the AF is interested in repairs that would restore the original structure stiffness without degrading the original microstructure. A low-heat metal deposition process capable of repairing through cracking on a thin (~0.160 inch) Ti–6-2-4-2S panels without adversely affecting the material strength in the heat-affected zone, while providing metallurgical bond strength. Residual stresses and deformations due to the process must be minimized.

PHASE I: Demonstrate the feasibility of the technology with regard in situ repair of Ti-6-2-4-2S. Phase I would demonstrate that the process or procedure being used restores the specimen to its pre-cracked state with regard to stiffness, microstructure, and fatigue life, without introducing large residual stresses.

PHASE II: Develop a prototype system to repair a government-defined application. The end product of Phase II would be a prototype system that eliminates the current cracks in AF applications and restores the applications to original (pre-cracked) states without disassembly.

DUAL USE COMMERCIALIZATION: The process would have significant benefit to the AF since current applications are in need of such an in situ repair; however, the commercial aerospace industry would also benefit from such a process.

REFERENCES:
1. Kalpakjian, S. and Schmid, S., Manufacturing Engineering and Technology, Prentice-Hall, Inc., 2001.

KEYWORDS: laser added manufacturing, titanium alloy, in situ repair

AF05-125 TITLE: Composite-Bonded Joint Strength Evaluation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Demonstration of a production prototype for a device for determining proof load capabilities of composite-bonded joints.

DESCRIPTION: The evaluation of adhesive bonds to determine the strength of the joint is a critical need for the implementation of bonded primary structure. However, the evaluation of bond strength is considered the most difficult problem for nondestructive evaluation (NDE). Although progress has been made on a variety of techniques to increase sensitivity of NDE methods to bond line defects, no known nondestructive technique has the ability to provide a measure of bond strength. Proof testing remains the method that must be implemented when a determination of the minimum strength of a joint is required. Recently, studies of shock loading bonded joints have shown that under laboratory conditions this method can be tailored to provide a localized proof test of bonded joints to infer or to determine the minimum strengths of the joints. In these studies, the technique used for laser shock peening was used to load the joint with a proof load. If the laser fluence is increased in defined increments up to the point of failure, then the joint strength can be easily determined from either the response of the joint to the loading or from subsequent ultrasonic inspection of the joint for the induced delamination. Potential effects of the proof test on the structure are minimal. If the area of loading is kept small, then anomalies below allowable defect sizes may be created, well within the design and manufacturing tolerances of an engineering structure. Laser shock loading need not be the method proposed. However, in parallel studies of alternative shock loading methods, the laser shock approach provided the most reliable and repeatable data, as well as clearly interpretable physics. Development of an approach for thick (greater than 0.5 inch) bonded joints and multiple bonded joints is desired.

PHASE I: Design and demonstrate the feasibility a system with characteristics suitable for bond strength measurements inspection. A system design with minimum construction costs but with the capability for both thick and thin structure is desired. The delivery of the interrogating energy on the bonded joint is an important design constraint. For example, many times access to internal bonded structure is limited to relatively small openings, and the orientation of the bond of interest is frequently not optimal for normal incidence interrogation. Furthermore, there are numerous situations when the bond line of interest permits only single-sided access. Phase I must address these key boundary conditions for the proposed system. It is also desired that the systems be designed in such a way that derivative designs can be generated for a portable device.

PHASE II: Develop a production prototype. This effort will be the construction and demonstration of an innovative portable system with the desired characteristics. Such a system would be adaptable to a variety of delivery head scenarios outlined in the Phase I effort and demonstrated in the Phase II effort. It is desireable to have the prototype a deliverable of the Phase II effort for further evaluation and testing. Formal product delivery to the AF would be during Phase III utilizing non-SBIR funds pending performance evaluation.

DUAL USE COMMERCIALIZATION: The portable system can be utilized both on commercial and military composite aerospace components, armor systems, power generation systems, etc. to effectively verify bond strength on critical bonded composite components.

REFERENCES: 1. R. Bossi, K. Housen, and W. Shepherd, "Using shock Loads to Measure Bonded Joint Strength," Materials Evaluation, Vol. 60, No. 11, pp. 1333-1338, November 2002.

KEYWORDS: bonded joints, composite structures, bond strength, delamination, laser, proof test

AF05-126 TITLE: Quality Assurance of Composite Bonding Processes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Development of quantitative tools for the assessment of bond surface preparation quality.

DESCRIPTION: Bonding processes involve critical steps such as surface preparation, adhesive mixing, adhesive application, curing time, temperature, and pressure. Quantitative methods are sought that allow the inspection of the surface condition of the composite adherends before continued consolidation of the bonded joint. Methods are sought for characterizing the surface conditions, particularly any conditions that will not permit adhesion between the adherend and adhesive just prior to the bond consolidation operation.

Various techniques may be proposed for surface characterization based on surface energy. Key characteristics desired are: semi-quantitative output, portability, lightweight, and no requirement that operators have specialized technical knowledge. Concepts that may be considered include the use of contact angle measurements, fluids and tape peel testing, or any other concept that meets the desired criteria mentioned previously. ASTM-based standards related to surface measurements should be considered as the basis for the proposed approach, if feasible.

PHASE I: Demonstrate the feasibility of utilizing an innovative instrument/technique for repeatable quantitative information regarding pre-bond surface quality.

PHASE II: Develop and demonstrate a production prototype device and deliver a statistical database derived from manufacturing environment applications. Coordination with an airframe manufacturer is recommended but not required. It is desired that the Phase II prototype be a deliverable of the Phase II effort for further testing and evaluation. Formal product delivery to the AF would be during Phase III using non-SBIR funds pending performance evaluation and testing.

DUAL USE COMMERCIALIZATION: The surface charaterization tool would be applicable to both military and commercial aerospace systems where bond integrity is critical to structural component performance.

REFERENCES:
1. R. G. Dillingham, S. Conyne-Rapin, F. J. Boerio, R. H. Bossi, and R. Crane, "Surface Preparation of Composite Materials for Adhesive Bonding," Proc. of the 26th Annual Meeting of The Adhesion Society, Eds. J. T. Koberstein and G. L. Anderson, The Adhesion Society, Blacksburg, VA, 2003, p. 285

KEYWORDS: bonded joints, composite structures, surface preparation, contamination, quality assurance.

AF05-127 TITLE: Machining of Complex Integral Airframe Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop manufacturing equipment and processes for machining of complex integral aircraft airframe structures. Examples of these structures are complete wing skeletons and control surfaces.

DESCRIPTION: Practically all aluminum and many titanium aircraft structures are made by end milling out most (typically 90 to 95 %) of the material of plate stock. Resulting structures are light and stiff and they consist of open pockets with thin bottoms, each enclosed by walls of thin ribs perpendicular to the webs. In recent years the technique of high speed milling has become widely predominant in the manufacture of these parts.

However, new generations of wing skeletons, control surfaces and other major structure components are more complex in that they contain additional, integrated features. The ribs are shaped like I-beams and parts also contain complex, precise internal features. This project will target aluminum alloy parts with the following specific features of interest. These include 4 inch deep pockets that are 8 inches square. These pockets contain return flanges of 1.5 inches wide and corner radii of 0.25”. Overall part thickness should be between 0.04 to 0.06 inches. In service an actual part may also include a complex curvature. Current spindle, tooling and machining approaches prevent

efficient and practical milling of these structures. Complex features require small cuts with flexible tools and multiple set ups. Fabrication time of a complex part can be an order of magnitude larger than a simple part.

Complex designs are restricted by the bulkiness and small range of motion of current machines and tools. Complex, integral designs are often less weight efficient than built-up structure due to these equipment and process limitations. Multiple setups are required to manufacture complex features, producing tolerance losses and decreasing quality while increasing weight. The low productivity of current manufacturing processes for complex internal features significantly increases manufacturing time and cost. The Air Force is soliciting proposals to develop new higher productivity, higher accuracy equipment and process technologies for machining integral, complex aircraft airframe components cost effectively.

PHASE I. Design the equipment and hardware variants, in principle, and carry out basic computations to compare and choose the more promising variant. Select and design a pre-prototype and carry out all the necessary computations to be ready for a feasibility demonstration and recommendation to build the prototype for testing. Determine the characteristics so as to satisfy the use for several types and designs of parts to be chosen by the Air Force.

PHASE II. Build the pre-prototype equipment, subject it to measurements and non machining tests so as to prepare and carry out a program for machining tests to verify the parameters and decide the final prototype design. Build the prototype and test its performance of machining the required part features in aluminum. The report and the prototype will be offered to the Air Force for use and evaluation.

DUAL USE COMMERCIALIZATION:: The developed equipment and approach can be used 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.

KEYWORDS: aircraft machining, metals, affordability, alloys, spindles, machine tools, complex integrated structures, hi-temp material

AF05-128 TITLE: High-Performance Hybrid Electronic Enclosure

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop new affordable aircraft thermal management composite materials for innovative cooling concepts for high-performance, high-power electronic enclosed box applications.

DESCRIPTION: Hybrid graphitic fiber composite material electronic enclosed boxes with liquid-cooled heat sink panels attached to a motherboard are predicted to weigh 30 - 50 percent less than current state-of-the-art materials. Due to the electronic power chip junction temperature requirements, the cooling and power density are limited and can be sufficiently improved by composite material selection. This effort will focus on selecting HiK carbon fiber composite materials for a liquid-cooled heat sink with design and assembly of the thermal management, structural, and stiffness details of an enclosure, assuming electronic cards, up to total 80 W/card (VME, PCI architecture, etc.) assuming one side only or both sides of the card. The architecture will be examined to facilitate transporting an increased cooling load from the liquid cooling wall to the electronic card aluminum rail. Many enhanced material properties for the high-power electronic enclosure can be tailored by strategically locating newly qualified HiK graphitic fiber for the liquid-cooled heat exchanger wall and integrating structural polyacrylonitrile (PAN)/pitch fibers material and new tailored foam for the electronic enclosure and other hybrid materials for shielding. This includes using higher mechanical performance fiber chassis, utilizing joints, and modifying fabrication one-step processing approach to produce a lightweight composite component that addresses thermal management requirements.

PHASE I: Demonstrate the feasibility of the proposed liquid heat sink, cool wall assembly concept. Secondary will be a demonstration of an improved simple higher production rate, cost reduction, and process schedule of an electronic enclosure with electro magnetic interference (EMI) shielding. Proof-of-concept core subcomponents will

be fabricated and tested and should possess thermal and structural properties sufficient to show increased power density cooling, and reduced cost of assembly.

PHASE II: The concept(s) demonstration will be full scale as a liquid heat sink, coolwall, high-power electronic enclosed box, developed in detail and thermal and structural material performance tested for a typical fighter aircraft environment. The payoff and benefits of the technology will be demonstrated by the fabrication and testing of the unit.

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. A. Abusafieh and G. Tremblay, "Light Weight Electronic Enclosures Using Composites," SAMPE Journal, Vol. 38, No. 6, Nov-Dec 2002.

2. M. Fenske, J. Barth, J. Didion, and P. Mule, "The Development of Light Weight Enclosures for Space Applications," SAMPE Journal, Vol. 35, No. 5, 1995.

3. G. Tremblay and G. Krumweide, "Issues to Address in Use of Composite Materials for Electronic Packaging," DASA conference, Seattle, WA, October 1998.

4. Lawrence K. English, "Lighter Weight and Lower Cost with Foam-Core Composites," Materials Engineering-September, pp. 51-54, 1987.

KEYWORDS: electronics box, heat sinks, composites

AF05-129 TITLE: Fretting Wear Elimination in Gear Box Housings

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop surface treatments and/or coating technologies to eliminate fretting wear of bearing housings in gearboxes made of aluminum alloys.

DESCRIPTION: Gearbox mechanisms of AF fighter aircraft lift systems are subjected to adverse vibrations, loads, and temperature cycling. In housing gear mechanisms, aluminum cast alloys such as A357 are used because they provide an adequate combination of mechanical strength, thermal conductivity, and low density. However, bearing housings experience excessive fretting wear on the aluminum surface due to its comparatively low hardness and galling tendency. Fretting wear problems such as this are traditionally solved using steel inserts or bushings, which are press-fit into aluminum alloy casing, and interface with the bearings. To reduce gearbox weight and avoid unnecessary steel-aluminum couplings, a replacement of the steel inserts with surface treatments and/or coating technologies is sought to provide fretting resistance to the aluminum housing. Possible solutions may involve application of a local coating and/or treatment to the bearing housing. For instance, treatments include application of a thin coating/treatment as a final operation to a mechanically finished aluminum housing, or application of a thicker coating/treatment with a subsequent mechanical finishing prior the bearing insertion. Coating/treatment processes must not affect the bulk mechanical characteristics of the aluminum gearbox casing and should be resistant to fretting wear at temperatures between –60 to 300 degrees F. Project coordination with the lift system gear box manufacturer is recommended.

PHASE I: Demonstrate the feasibility of a coating/treatment to eliminate fretting at the surface of aluminum alloys in contact with steel for application to a bearing housing of the lift system gear box. Produce coating/treatment samples and demonstrate through appropriate testing that the process may provide fretting elimination in aluminum alloy housings.

PHASE II: Develop and validate a manufacturing process for surface modification of gearbox housings. Produce and test prototypes of new housings where surface modifications are used as a replacement of steel inserts. Assess the benefits of using these surface modification technologies for gearbox housings.

DUAL USE COMMERCIALIZATION: New fretting-eliminating surface modification technologies for aluminum alloys could have numerous mechanical applications for both military and commercial applications. These developments could be employed in almost any mechanical system where fretting wear of aluminum alloys is a limiting factor. Both aerospace and automotive industry will benefit from the new technology.

REFERENCES:
1. R. B. Waterhouse, "Fretting wear," Friction Lubrication and Wear Technology, ASM Handbook, Vol. 18, p. 242, 1992.

2. E. Sauger, S. Fouvry, L. Ponsonnet, P. Kapsa, J.M. Martin, and L. Vincent, "Tribologically transformed structure in fretting," Wear, Vol. 245, p. 39-52, 2000.

KEYWORDS: aluminum alloy, fretting wear, surface treatment, coating, gearbox

AF05-130 TITLE: Numerical Modeling Tools for Cold-Hearth Melting Processes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop numerical modeling tools for the electron-beam and plasma cold-hearth melting processes to aid in furnace design and optimization.

DESCRIPTION: Hearth melting is a critical process for producing rotor-grade titanium. Additionally, hearth melting is considered to hold great potential for producing aerospace-quality titanium in a single melting step. Hence, hearth-melting technology is critical to the quality and affordability of Air Force systems.

Unfortunately, complete process modeling tools do not exist for hearth-melting processes. Existing models do not predict vaporization of alloying elements or entrapment of inert gases and have not been completely validated on production systems, particularly with respect to the elimination of inclusions and hard alpha.

Hence, additional development is required to expand the capabilities of hearth-melting models to enable the optimization of present hearth-melting furnaces and the design of more robust and efficient hearth-melting furnaces.

PHASE I: Demonstrate the feasibility of the selected approach to model the elimination of inclusions and hard alpha, the vaporization of alloying elements, and the entrapment of helium (as well as the size and shape of the melt pool) during hearth melting of titanium. Proposals should demonstrate reasonable evidence that this proof of principle can be obtained within Phase I.

PHASE II: Develop and refine the model to the point where performance can be physically demonstrated for an industrially relevant geometry. The model shall provide quantitative information on the effects of changes in process parameters on chemical composition and melt pool characteristics to permit an evaluation of the ultimate application potential to meet Air Force needs. Provide a written report which illustrates the accuracy with which the model is able to predict the features of the electron beam and plasma cold-hearth melting processes.

DUAL USE COMMERCIALIZATION: The developed approaches will have broad commercial applicability due to the large number of commercial air, space, and engine systems that have affordability and quality requirements similar to those faced by DoD.

REFERENCES:
1. Yang, Lifang, “On the cold-hearth melting for titanium or other high temperature alloys,” Rare Metal Materials and Engineering, Vol. 23, No. 6, pp. 70-73, December 1994.

2. Choudhury, Alok and Hengsberger, Eckart, “Electron beam melting and refining of metals and alloys,” ISIJ International, Vol. 32, No. 5, pp. 673-681, 1992.

3. Bellot, J. P.; Hess, E.; and Ablitzer, D., “Aluminum volatilization and inclusion removal in the electron beam cold hearth melting of Ti alloys,” Metallurgical and Materials Transactions B: Process Metallurgy and Materials Processing Science, Vol. 31, No. 4, pp. 845-854, August 2000.

4. Akhonin, S. V.; Trigub, N. P.; Zamkov, V. N.; and Semiatin, S. L., “Mathematical modeling of aluminum evaporation during electron-beam cold-hearth melting of Ti-6Al-4V ingots,” Metallurgical and Materials Transactions B: Process Metallurgy and Materials Processing Science, Vol. 34, No. 4, pp. 447-454, August 2003.

KEYWORDS: titanium, cold-hearth melting, plasma arc melting (PAM), electron beam cold-hearth melting (EBCHM), process modeling

AF05-131 TITLE: Robust Solid Lubricant Coating for Gears of Cryogenic Fuel Turbopumps

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

OBJECTIVE: Develop solid lubricant coatings for turbopump gears operating at high contact pressures and speeds at cryogenic temperatures.

DESCRIPTION: Reliable performance of mechanical systems in evolved expendable launch vehicles is critical for the overall mission success. For liquid fuel rocket engines, e.g., RL10, the reliability of fuel pumps is especially challenging. In particular, gears of these pumps were identified as a potential source of pump unstable performance due to a nonuniform surface wear and an onset of undesirable vibrations at rocket launch. The gears are made of a carburized 9310 steel. They operate at sliding speeds in the range of 800-1200 fpm and contact pressures in the range of 90-190 ksi. The gear surface may be exposed to cryogenic hydrogen. The gears operate at extremely low temperatures, ranging from 100 to 300 R, and require solid lubrication to minimize friction losses and vibrations. Currently used solid lubricants have a high degree of nonuniformity in thickness and wear, resulting in a noisy operation which may cause pump failure by excessive vibrations. Advanced solid lubricant materials and application processes need to be developed to provide a thin and uniform lubricating coating on the surface of the fuel pump gears. This coating should lubricate pump gears at cryogenic temperatures for the entire launch period with a minimum friction and wear to provide a stable, low vibration performance of the turbo pump gearbox. Coordination of the development and test efforts with the fuel pump manufacturer is strongly recommended.

PHASE I: Suggest advanced solid lubricant coating materials and application technologies, which can be used to provide a uniform solid lubricant coatings on gear surfaces in contact with cryogenic hydrogen. Demonstrate feasibility of these advanced coatings by testing samples at loads, speeds, and temperature conditions similar to that of rocket fuel pump gears.

PHASE II: Develop gear coating technological process and produce prototype coatings on the gear surface. Perform tests of the coated gear performance across loads, speeds, and environments of the rocket fuel pumps. Optimize the coating application process and performance to provide the required reduction in gear surface wear and vibrations at the reduced coating cost.

DUAL USE COMMERCIALIZATION: Dual use applications include cryogenic fuel turbopumps for both military and commercial launches. The coated turbopump gears will be used in expendable propulsion systems to launch space weapon platforms and military satellites for intelligence, surveillance, reconnaissance, and telecommunication and/or for the deployment of commercial communication, positioning, mapping, research and other satellites. If Phase II technical exit criteria are met and commercial and/or government (non-SBIR) program funds are identified for Phase III, the contractor shall design, fabricate, integrate, and flight-test the new solid lubricant material.

REFERENCES:
1. J. L. Lince and P. D. Fleischauer, Solid Lubricants, in “Space Vehicle Mechanisms,” edited by P. L. Conley, J. Wiley & Sons, New York, p.153, 1998.

2. H. E. Sliney, Solid Lubricants, in “Friction, Lubrication and Wear Technology,” ASM Handbook, Vol. 18, ASM International, p. 113, 1992.

KEYWORDS: rocket engine,cryogenic fuel turbopump,gears,solid lubricant,coating,wear, reliability

AF05-132 TITLE: Thermal Response Modeling of Trajectory Shaping Vehicles (TSVs)

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Provide innovative algorithms for assessing and sizing the TSV thermal protection systems (TPS) and structural integrity.

DESCRIPTION: Reliable numerical tools were developed over the years for assessing ballistic reentry vehicle (RV) TPSs and structural load capabilities. Examples of those modeling and simulation tools are listed in references 1 through 3. Those codes are limited to one-dimensional transient thermal conduction formulation, and vehicles at small angles of attack. The heatshield materials’ thermal properties and surface ablation models are largely limited to graphite, and carbon phenolic materials. For future emerging mission needs, more advanced and unconventional heatshield material and complex body configuration are involved. The existing modeling and simulation tools used are inadequate to assess and to size future vehicle (e.g., the TSV) TPSs. For instance, the Systems Improved Numerical Differencing Analyzer (SINDA) and Abacus codes can predict three-dimensional thermal conduction, but they cannot handle TSV surface ablations and they cannot predict the hypersonic heating at angle of attack.

PHASE I: Develop multi-dimensional, fully coupled thermal response modeling of hypersonic RVs using composite heatshields and bonding materials on the reentry body (e.g., leading edge, control surfaces, etc.). The thermal protection materials can be a composite reusable TPS, or a sublimer, charring ablator, radiating surface, and melting ablators. The formulation includes the estimation of the hypersonic viscous heating (laminar, transitional, and turbulent flows) and wall pressure on a TSV body at angle of attack using engineering approximation methodologies, fluid and solid interaction, ablation, shape change, in-depth pyrolysis gas generation, and hot structure load bearing capability. Thermodynamic considerations due to catalytic wall effects must be included. The effects of thermal penetration upon the internal sensors and payloads should be accurately modeled. In Phase I, the analysis is focused on a blunt conic RV at zero angle of attack. Modeling should include the simulation of thermal histories of the internal components (e.g., inertial measurement unit (IMU), fuze, and global positioning system (GPS) receivers), warhead, graphite nose, carbon phenolic frustum, and elastomeric shielding material (ESM) base materials. Rigorous multi-dimensional internal thermal conduction and in-depth heatshield pyrolysis phenomena must be modeled appropriately.

PHASE II: Extend the Phase I effort to a TSV with non-circular cross section (e.g., high lift-to-drag (L/D) ratio vehicle). The computations should constitute the whole maneuvering trajectory starting at reentry (e.g., h ~ 300 kft altitude), and ending at impact. The heatshield will include but not be limited to the candidate materials now under development at Air Force material laboratories and their contractors. The detailed internal compartments (such as sensors, payloads, and fuze) must be simulated in the formulation, and the internal thermal radiation heat transfer among the various components will be properly modeled. The numerical results will be validated with government supplied test data. The numerical computation time on a representative trajectory will be limited to 20 hours on a relatively fast personal computer (PC) (2.5 GHz). At the end of Phase II, the delivered items include a final report, computer code user manual, sample cases, and the numerical software.

DUAL USE COMMERCIALIZATION: The proposed modeling and simulation effort will have benefits to space and commercial communities. Applications include general, multi-component body TPS, use of the numerical algorithms and flow field solver for other general problems of interest (e.g., commercial aircraft design).

REFERENCES:
1. King, H. H. C.; Muramoto, K. K.; Murray, A. L.; and Pronchick, S. W., “ABRES Shape Change Code (ASCC 86): Technical Report and User’s Manual,” Rept. FR-86-24/ATD, Acurex Corp., Mountain View, CA, December 1986.

2. Moyer, C. B. and Rindal, R. A., “Finite Difference Solution for the In-depth Response of Charring Materials Considering Surface Chemical and Energy Balance,” NASA-CR-1061, June 1968.

3. Squire, T. H. and Murray, A. L., “Maneuvering ABRES Shape Change Code (MASCC 88)," BSD-TR-89-11, August 1989.

KEYWORDS: thermal protection system, trajectory shaping vehicle, thermal sizing analysis, thermal conduction, thermal radiation, heatshield ablation, in-depth pyrolysis

AF05-133 TITLE: Multifunctional Aircraft Protective Coating

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Development of a non toxic, environmentally compliant aircraft protective coating capable of providing both active corrosion protection/inhibition and desired optical signature properties.

DESCRIPTION: Current military aircraft utilize a protective coating system that consists of separate primer and topcoat films, both individually applied. The primer coating (MIL-PRF-23377) is typically an epoxy resin pigmented with strontium chromate to satisfy the system function of corrosion protection. The topcoat is generally a polyurethane resin with appropriate pigmentation to provide the desired color, infrared properties, and gloss on the exterior surface. The Air Force would achieve a significant reduction in volatile organic content/hazardous air pollutant (VOC/HAP) emissions as well as labor costs via utilization of a single coating film that could provide all functions of both the current primer and topcoat. Recent developments in promising non-Cr(6+) corrosion inhibitors that are not intensely colored may offer the opportunity for developing such a multifunctional coating.

PHASE I: Demonstrate the feasibility of a prototype coating that utilizes proven effective non chromium-based active corrosion inhibitors. The coating shall be capable of meeting all or nearly all of the MIL-PRF-23377 primer requirements, particularly with respect to corrosion protection and adhesion. Additionally, the coating shall meet all or nearly all of the MIL-PRF-85285 topcoat requirements, particularly with respect to color (Fed. Std. 36375), gloss, and weathering durability. The coating shall be applied to AA2024-T3 substrates with conventional surface cleaning, preparation, and pre-treatment procedures. Accelerated test methods shall be employed to evaluate corrosion resistance and exterior durability. The coating shall be capable of curing to the extent that aircraft flight is permitted within 24 hours. A compatible nondestructive evaluation/inspection (NDE/I) technique for substrate corrosion protection shall be identified.

PHASE II: Optimization of prototype coating to satisfy all existing requirements of both primer and topcoat materials. Incorporation of testing on available non chrome surface treatments. Development of modifications to expand available federal standard color options. Utilize comprehensive accelerated performance testing to develop lifetime prediction of performance. Development and implementation of NDE/I techniques for monitoring coating performance. A 5-gallon sample of fully formulated coating capable of being applied by a third party for independent performance evaluation will be delivered at the end of the program.

DUAL USE COMMERCIALIZATION: Many military platforms can use such a coating system as an alternative to environmentally unfriendly processes currently used. Many similar commercial aerospace applications would exist. The system would be an affordable and environmentally friendly option versus current processes that produce significant volatile organic content and hazardous air pollutants.

REFERENCES:
1. MIL-PRF-23377.

2. MIL-PRF-85285.

3. Air Force Office of Scientific Research (1995) Air Force Blue Ribbon Advisory Panel on Aircraft Coatings, pp. 128. Air Force Materiel Command: Bolling AFB.

4. Koleske, J. V., “Aerospace and Aircraft Coatings,” Chapter 58, Paint and Coating Testing Manual, in ASTM Manual Series Vol. MNL 17, pp. 925. Ed. B. Gardner, ASTM: Philadelphia, PA, 1995.

KEYWORDS: aircraft coating, non chrome, corrosion inhibition, multi-functional, AA2024-T3, primer, topcoat

AF05-134 TITLE: Microelectronical Devices for the Health Monitoring of Nonstructural Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a microelectromechanical (MEMS) device-based sensor for the health monitoring of hydraulic fluids, liquid lubricants, tribological coatings, or corrosion-resistant coatings.

DESCRIPTION: Military aircraft and space systems utilize a variety of specialty nonstructural materials for actuation, lubrication, and corrosion control. These materials have been developed over several decades and their formulation and behavior are fairly well known. Replacement during service is typically based upon preprogrammed maintenance, not extinction of useful life of the material. Service life extension of hydraulic fluids and corrosion-resistant coatings would reduce hazardous materials wastes and labor costs. Extending the life of tribological coatings would increase the time between engine overhauls, also reducing costs. In addition, the ability to detect imminent failure of the protective nature of these materials would save orders of magnitudes in costs of failed components, not to mention aircraft and human life.

This program would identify a candidate class of nonstructural materials and determine the key material property parameters for in-service monitoring. Commercially available MEMS components would be modified to perform an in situ measurement of the key materials property that could be detected in real time.

PHASE I: Identify a single class of nonstructural materials and determine and identify the key material property parameters of this class of materials that are critical to their in-service deterioration before failure. Identify candidate MEMS devices that could be modified to construct a sensor that could perform an in-service measurement of one of these parameters.

PHASE II: Modify commercially available MEMS devices and perform laboratory experiments to demonstrate that a sensor based upon this device can measure the key property parameter. Develop installation and in situ measurement techniques for the acquisition of the key property parameters from the sensor based. Demonstrate the ability to remotely acquire data from the MEMS-based sensor in a laboratory experiment simulating actual use of the nonstructural material and MEMS-based sensor.

DUAL USE COMMERCIALIZATION: Commercial applications involve a multitude of similar applications such as hydraulic and lubrication monitoring of high value machinery, bearings and friction devices in electric power generation, and corrosion monitoring of buried pipelines.

REFERENCES:
1. Romig Jr, A.D.; Dugger, Michael T.; and McWhorter, Paul J., "Materials issues in microelectromechanical devices: science, engineering, manufacturability and reliability," Acta Materialia Vol. 51, Issue 19, pp. 5837-5866, November 25, 2003.

2. Starr, A.F.; Nemat-Nasser, S.; Smith,D.R.; Meyer, D.A.; "Development of Embedded Microelectronic Sensor Networks in Composite Materials," November 11, 2003. May be found at: http://mwww.mita.sd.keio.ac.jp/news/workshop/proceedings/Starr.pdf

KEYWORDS: coating, vehicle health monitoring, corrosion, lubricants, hydraulic systems, microelectromechanical devices

AF05-135 TITLE: Polymeric Nanophotonics: High-Index Polymeric Photonic Crystals for Optics

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop fabrication techniques for high quality, three-dimensional, high-index-contrast (index ratio > 1.4) photonic crystals with a functional polymer as one of the constituent materials.

DESCRIPTION: In recent years, there have been dramatic advances in the utility and functionality of polymers as a class of optical materials. Parallel to that development has been the great interest in photonic crystals as a way to manipulate light and engineer new material structures for various applications and optical interactions. The intersection of these two areas in photonics, combined with the engineered optical properties of photonic crystals, offers a rich variety of possibilities due to the great tailorability of the polymers. The number of potential applications is very large and this type of material may even enable new types of devices. Commercially, there is recognition of photonic crystals as a material that can enable many exciting applications in photonics while currently polymers are already utilized as a material in commercial photonic devices.

The fabrication technique must be versatile so that there is a large degree of design freedom. In addition, the manufacturing method should utilize the existing set of available polymer materials; the scope of this work does not include synthesis of new polymer systems in general. It is also preferred that the crystals produced are comprised of two optically lossless materials unless the absorption is part of the ultimate device function. Applications of such materials systems include, but are not limited to the following: beam steering and control (superprism effect for example or diffractionless beam propagation), enhanced nonlinear optical interactions such as electro-optic modulation which could perhaps be applied to reconfigurable optical materials, two-photon optical limiting, coupling, degenerate four-wave mixing for all-optical switching, frequency conversion, and other polymeric photo-interactions that could be enhanced or engineered by using photonic crystals.

PHASE I: Demonstrate the viability of the fabrication method with creation of at least one demonstration sample. In addition, the material should be sufficiently characterized to enable prediction of performance within a targeted application or device.

PHASE II: Refine, further develop, and scale up the method so that it becomes a tool for manufacturing large amounts of the material according to design input. Materials will be thoroughly characterized, and photonic devices will demonstrate the effectiveness of the manufactured materials.

DUAL USE COMMERCIALIZATION: The vast number of potential applications of this type of technology makes the commercial potential enormous and will grow as the photonics industry grows. Commercial application examples are integrated photonic devices and chips for communications and system control, optical switching networks, optical coatings, and a great number of other photonic devices for which this material could be the enabling technology.

REFERENCES:

1. T. Prasad, V. Colvin, and D. Mittleman , “Superprism phenomenon in three-dimensional macroporous polymer photonic crystals,” Phys. Rev. B 67, 165103, 2003.

2. Special Edition: Organic and Polymeric Nonlinear Optical Materials, JOSA B, Vol. 15, No. 1, 1998.

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4. K. Sakoda, Optical Properties of Photonic Crystals, (Springer Series in Optical Sciences, 80) Springer Verlag, 2001.

5. R. E. Slusher and B.J. Eggleton (eds.), Nonlinear Photonic Crystals, Spinger Series in Photonics, Vol. 10.

KEYWORDS: nanophotonic polymers, optical polymers, nonlinear optical nanocomposites, polymer photonic crystals, photonic crystals

AF05-136 TITLE: Technologies for In Situ Interrogation of Damage States in Structural Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop local and global in situ sensing technologies to interrogate material and damage states for engine, airframe, and/or hot structure components that operate in extreme or harsh environments.

DESCRIPTION: To satisfy increasingly difficult mission requirements, components in current and future military aerospace vehicles will be subjected to extreme environments, often at elevated temperature. The development of novel, innovative, reliable, and integrated materials state-awareness sensors and interrogation technology is needed to enable and enhance the prediction of remaining lifetime of components in a range of complex mechanical systems. In addition to the difficulties of detecting damage in harsh environments, state-awareness sensors are needed that can operate in confined locations on rotating components such as turbine engine compressor airfoils, disks, and bearing sumps. The aggressive environments may be oxidative and/or corrosive, high G loads may exist, and temperatures may exceed 700 degrees C, under some circumstances. In some instances, the sensors will need to be self-powered or have the ability to receive power and communicate their measurements in inaccessible areas. The technologies must map and trend actual material and failure damage of the in real or near-real time. A secondary need is the development of high-reliability, long-life sensors to measure local temperatures of rotating components under high G loading and transmit the measurements for real-time analysis.

PHASE I: Identify and/or develop appropriate and innovative low-power sensor technologies that will enable quantification of specific degradation states, failure modes, and usage conditions of structural components in a laboratory that simulates vehicle operating conditions. Define and describe approaches to process sensor signal output and obtain information on the physics of failure. Demonstrate the feasibility of using the proposed novel sensors to identify representative materials damage on laboratory coupons.

PHASE II: Develop and demonstrate innovative sensor technology tools to quantify damage in components under simulated engine, aircraft, or spacecraft operational conditions. Demonstrate sensor durability, low false-alarm rate, the ability to follow material and structural damage states. Delivery of a prototype system for further evaluation by the USAF is encouraged.

DUAL USE COMMERCIALIZATION: It is anticipated that the offeror will transition the developed sensor technology into structural-health and life-management practices. Commercial benefits include improved life management of turbine engine and/or airframe components for commercial aircraft.

REFERENCES:
1. Nondestructive evaluation and Health monitoring of Aerospace Materials and Composites II San Diego CA March 3-5 2003, Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 2003.

2.Structural Health Monitoring -Internal Workshop, 1991, 2001, 2003, Stanford University, Editor Fu-Kuo Chang.

KEYWORDS: material degradation, extreme/harsh environment, damage, diagnosis, prognosis, remaining life, turbine engine, aircraft, structure

AF05-137 TITLE: Development of Durable, Fiber-Reinforced Refractory Composites for Thermal Protection Systems (TPSs)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate impact-resistant, durable material solutions and design concepts for leading edge TPSs.

DESCRIPTION: TPSs on leading edges, control surfaces, and over large areas of the skin represent a crucial need for next-generation reentry and military space vehicles. The reusable TPS currently employed by NASA on the space shuttle requires rehabilitation after each mission, offers no multi-functionality, and is very susceptible to impact damage. The recent loss of the space shuttle Columbia emphasizes the need for more impact-resistant leading edge designs. The Air Force is currently developing durable leading edge concepts that will meet the quick turn-around requirements needed for military reusable launch systems. These designs employ carbon-carbon, carbon-silicon carbide, and/or silicon carbide-silicon-carbide aeroshells. The majority of the research to date has been on the integration of different materials to meet the aero-thermal and mechanical requirements. The purpose of this effort is to augment on-going leading edge development by evaluating the impact resistance of fiber-reinforced refractory composites and by developing novel fiber preforms, hybrid solutions, material stack-ups, and/or processing techniques that demonstrate notable improvement in impact over the baseline. Impact requirements will be provided by the Air Force. The results from this effort will be coordinated with and possibly integrated into other Air Force leading edge efforts. A government panel made up of representatives from the Air Force and NASA will assess the technical results and the military-commercial viability of the developments throughout the effort.

PHASE I: Demonstrate the feasibility of a leading edge thermal protection concept that addresses the reusable launch requirements described above. Propose viable methods (e.g., novel fiber preforms, hybrid solutions, material stack-ups, and/or processing techniques) that will enhance the survivability of thermal protection solutions against impact requirements for high and low velocity set forth by the Air Force. Novel solutions required to enhance the impact resistance shall be proposed and refined throughout Phase I. Claims to the effectiveness of solutions must be supported by analytical predictions. Integration of these material concepts with leading edge designs being pursued by the Air Force is highly desirable.

PHASE II: Focus efforts on implementing the novel material designs proposed in Phase I to a subscale demonstration component. Specific tasks include, but are not limited to, refinement of the material design, prediction of performance using analytical methods, fabrication of specimens, demonstration of enhanced performance, scale up of methods and processes for subscale demonstration and validation. A subcomponent demonstrating the enhanced durability will be delivered to the Air Force for evaluation and characterization. A final report summarizing the findings will be written and provided to the Air Force.

KEYWORDS: Composite, carbon-carbon, silicon-carbide, reentry vehicles, thermal protection, coatings, oxidation, impact durability, high velocity impact, low velocity impact

AF05-138 TITLE: High-Temperature Integral Tank Sealant

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a high-temperature integral fuel tank sealant that meets the requirements of current AF fighter aircraft.

DESCRIPTION: The Air Force requires an integral fuel tank sealant that can withstand long-term service in fuel at 250 ºF and 350 ºF in air (fuel tank ullage space). Current fluorosilicone sealants conforming to SAE AMS 3375 can meet the temperature requirements but lack the strength and toughness desired. Polythioether sealants conforming to SAE AMS 3277 have the desired strength and toughness but are limited to temperature below 320 ºF except for limited intermittent periods. A new sealant meeting the requirements of SAE AMS 3277 and capable of withstanding long-term service to 350 ºF is needed.

The Air Force is seeking a new high-temperature fuel tank sealant that meets current performance requirements and is compatible with other aircraft system materials. The material should be capable of being cured at room temperature and providing long-term service from –65 to +250 ºF in fuel and at 350 ºF in air and fuel vapors. The candidate sealants must demonstrate compatibility with SAE-AMS-C-27725 fuel tank coatings and other fuel tank materials. The candidate sealant must also demonstrate adhesion to AMS-C-27725 coatings, graphite/epoxy composites, titanium and steel.

PHASE I: Develop and demonstrate innovative material(s) capable of meeting the requirements of SAE AMS 3277 at temperatures of 250 ºF in fuel and 350 ºF in air.

PHASE II: Develop, test, and demonstrate the characteristics of the proposed materials to meet or exceed current system requirements. Validate material compatibility with a simulated fuel tank system. Deliverables will include a demonstration coupon and material samples.

DUAL USE COMMERCIALIZATION: Many AF systems would be able to utilize the improved fuel tank sealant and commercial aircraft would have the potential to benefit similar applications in their fuel tanks.

REFERENCES:
1. SAE AMS-C-27725, Coatings, Corrosion Preventive, Polyurethane for Use to 250 °F (121 °C).

2. SAE AMS-3277, Sealing Compound, Polythioether Rubber Fuel Resistant, Fast Curing Intermittent Use to 360 ºF (182 ºC).

3. SAE AMS-3375, Adhesive/Sealant, Fluorosilicone, Aromatic Fuel Resistant, One-Part Room Temperature Vulcanizing.

KEYWORDS: high temperature, fuel tank, sealants, materials

AF05-139 TITLE: High-Refractive-Index Polymer Fibers for Imaging Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and fabricate polymer fibers with high index of refraction for applications in imaging systems.

DESCRIPTION: Many Air Force helmet mounted devices, including Night Vision Goggles (NVGs) utilize fiber optic image inverters made out of glass. Typically these inverters are made out of glass fibers arranged into a fiber optic array. Similar fiber optic inverters made from polymers would have reduced weight and other potential advantages. The polymer fibers should be more amenable to doping with organic dyes that could be used for optimizing image clarity and resolution. In addition, these high index polymer fibers might find use in new imaging devices under development.

PHASE I: Design and fabricate polymer fibers with high index of refraction for applications in imaging systems. Demonstrate that the fibers can be arranged into a fiber optic array.

PHASE II: Design, fabricate, and deliver prototype polymer fiber optic arrays containing bundles of high index of refraction fibers for further evaluation and characterization. Demonstrate that the optical quality of these fiber optic arrays is comparable to that of glass fiber optic arrays. Demonstrate that the polymer fiber arrays can be twisted to make fiber optic inverters. Show evidence that the polymer fiber arrays can be incorporated into device architectures like the Night Vision Goggle. Deliverables will include data reports, material samples, and a prototype image inverter made of polymer fiber optic arrays for further testing and characterization.

PHASE III DUAL USE APPLICATIONS: These high refractive index polymer fibers and arrays could be used in a broad range of military and commercial applications where glass fiber optics and fiber arrays are currently utilized. In head mounted devices, these arrays could reduce weight on next generation NVGs and direct view devices.

REFERENCES:
(1) Peng G.D., Li A.D.Q. "Preparation of Polymer Optical Fibers Doped with Nonlinear Optical Active Chromophores" Journal of Polymer Science: Part B: Polymer Physics. 39, 2001, 1794-1801.

(2) H.S. Nalwa. "Polymer Optical Fibers" (American Scientific Publishing, 2004).

KEYWORDS: polymer fibers, high refractive index, fiber-optic arrays, image inverters.

AF05-140 TITLE: Replicated Hybrid/Composite Mirror Technologies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop engineered materials for a replicated hybrid/composite mirror that can operate in the visible optics range at ambient air or space condition and that has an areal density < 7 kg/m2.

DESCRIPTION: The next generation of defense missions will rely heavily on enhanced aerospace surveillance and reconnaissance, directed-energy systems, transformational communications, laser radar systems, and telescopes operating from the infrared through the X-ray frequency spectrum. All of these applications require low-cost, lightweight, high-precision mirrors produced in a timely fashion. The size, shape, operational environment, and configuration of these mirrors are mission specific and are often determined by the launch and flight payload constraints. The key system drivers in all of these applications are mass, cost, production schedule, robustness, and optical quality. Depending upon the application, size and quantity may also become very important.

The state-of-the-art material for aerospace mirrors is monolithic glass. It can be formed into complex shapes, ground to high precision, and polished to an Angstrom level surface finish. Unfortunately, this processing method span years, is limited in size, and cost millions of dollars per mirror. Additionally, glass is not a good structural material, having low elastic modulus, strength, and fracture toughness. Therefore, the amount of lightweighting of a glass mirror and its support structure is limited.

The next generation of mirror technologies will likely use replicated hybrid/composite mirror designs that replace glass as the mirror structural substrate, thereby reducing the areal density while improving the material robustness. To reduce the cost and schedule of producing a mirror, one would like to eliminate the rigorous grinding and polishing tasks by replication technology (either surface imprint or replicated nano-laminate/foil attachment). If foil replication is used then stable bonding agents with no shrinkage, out-gassing, or hydroscopic behavior must be developed.

To summarize, the combinations of materials (metallic, ceramic, or polymeric) used to produce a replicated hybrid/composite mirror must allow for (CTE) and modulus tailoring on the nanometer level, have low density, exhibit no out-gassing or hydroscopic behavior, and have high strength, stiffness, and toughness. These mirrors should have visible optics quality with figure distortion errors less than 63nm (RMS) and a surface roughness least than 2 nm RMS. These conditions must be maintainable through at least ambient atmospheric and space conditions. Additional value will be given to systems that can also handle either cryogenic condition and/or the anticipated thermal loads observed during high-energy laser (HEL) applications. Other goals of this program are to show that a half-meter-sized visible quality mirror can be produced with an areal density of less than 7 kg/m2, a fabrication time of months, and cost below $500 K/m.

PHASE I: Provide clear evidence and/or technically sound descriptions of their end-to-end manufacturing processes that illustrate why it will lead to a low areal density, low cost, short production time, and visible quality rigid mirror that is stable (structurally and environmentally) under at least ambient air and space conditions. Materials and process need to be clearly defined with technical names and referenced datasheets (trademark designations are usually not sufficient to judge material or process applicability). The offeror should also make some estimates of the time and cost of producing on-axis parabolic mirrors of 0.5 and 1 meter class and compare this to state-of-the-art glass mirrors of the similar prescription. In the Phase I effort, the offeror will be required to tests their methodologies on small coupons and to validate their whole approach by producing at least a 10-cm-diameter flat

replicated mirror with a visible quality of less than 63nm RMS surface figure error and a 2-nm RMS surface roughness. Mirror characterization should include figure and surface finish analysis over the anticipated thermal use range. Deliverables will be reports, data, test samples, and the 10 cm flat replicated mirror of visible quality.

PHASE II: Focus on scaling-up the process to at least a 0.5-m rigid mirror shaped to a parabolic form without increasing the visible optics figure and finish errors. Repeatability and reliability issues will need to be addressed through design modeling, process analysis, process control studies, and nondestructive evaluation (NDE). The mechanical limits where flexural distortion causes loss of optical quality need to be identified. This includes vibrational and/or actuation limits including overload and fatigue efforts. The offerors are encouraged to team with an optical testing facility or a system integrator in this phase so that a full optical and structural analysis of the mirror will be assured. This will also help in designing toward an end-user application of military relevancy. Application alignment may allow for a Phase II enhancement, a technology insertion program, or some co-funding toward a Phase III effort. The recommended deliverables for the Phase II effort will be reports, data, test samples and subscale components as well as the 0.5m parabolic replicated mirror of visible quality that will be used for subsequent testing and evaluation.

DUAL USE COMMERCIALIZATION: Due to the current high activity levels in both government and industry related to transformational communications, directed energy, and reconnaissance programs, there are many DoD opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DoD prime-contractors should be pursued toward the end of this program. Commercial, and civilian remote sensing applications, optical communications systems, ground-based telescope applications, printed circuit board photo-etching systems, automatic identification systems, scanning and dimensioning systems, environmental and gaseous emission testing systems, and inspection mirrors could also benefit from this technology.

REFERENCES:
1. Matthews, Gary, F.A. Carbone, P. Clark, and D.M. Mack, “Semi-rigid active mirror technology advancements,” Optical Manufacturing and Testing IV, Ed, H. Philip Stahl, SPIE Proc. Vol. 4451, pp. 51-57, 2001.

2. Chen, P. C. et al, "Advances in Very Lightweight Composite Mirror Technology," Opt. Eng., Vol. 39, pp. 2320-2329, 2000.

3. Catanzaro, B., et al, "C/SiC Advanced Mirror System Demonstrator Designs," UV, Optical, and IR Space Telescopes and Instruments, Eds. J. B. Breckenridge and P. J. Jakobsen, Proc. SPIE Vol. 4013, pp. 672-680, 2000.

4. Matson, L. E., 2003 IEEE Aerospace Conference Proceedings, Big Sky, Montana, March 8-15, 2003.

5. Barbee, T., 2003 IEEE Aerospace Conference Proceedings, Big Sky, Montana, March 8-15, 2003

KEYWORDS: lightweight optics, mirror fabrication, mirror construction, mirror replication, hybrid mirrors, optical foils, nano-laminate mirrors

AF05-141 TITLE: Improved Manufacturing Technologies for Aircraft Engines

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Explore and demonstrate innovative manufacturing technologies that enable advanced and affordable manufacture of aircraft engine components.

DESCRIPTION: Examine processes associated with the manufacture of engine components. The offeror shall select a process, e.g. drilling, electrochemical machining (ECM), surface treatments, casting, etc., and develop innovations that will make these better, faster, and/or cheaper. These innovations should be generic enough to be applicable to the greatest possible number of aerospace alloys of titanium and nickel, and to the greatest number of Air Force engines. These include but are not limited to: Integrally bladed Rotor (IBR) Repair, hole drilling, precision casting of structures and blades, advanced cooling techniques, affordable surface treatments, ceramic bearings, polymeric matrix composites, and advanced machining of titanium and nickel.

PHASE I: Select at least one manufacturing technique. The feasibility to produce economically and superior quality components is to be demonstrated. The offeror shall demonstrate the engineering, manufacturing and economic feasibility of the new process 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 new process to minimize or eliminate downstream operations. Resulting prototype structures shall be mechanically and microstructurally characterized. An economic model of the new manufacturing process shall be constructed to quantify potential savings and cost drivers and their respective influence on overall process economics. An initial commercialization plan shall be developed and a business case established to quantify future investments, including equipment changeover and qualification expenses. The offeror should consider the benefits of interacting with a component or engine manufacturer in Phase I.

PHASE II: The small business is encouraged to coordinate or team with a component or engine manufacturer for Phase II although it is not mandatory. The contractor will demonstrate that the full-scale process 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. Techniques eliminating or minimizing downstream operations shall be demonstrated and cost and cycle time reductions will be validated. Material property testing shall be conducted to obtain engineering data per standardized testing techniques to document acceptability for future industrial use. 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.

DUAL USE COMMERCIALIZATION: The developed technologies will have applications for both military and commercial engines.

REFERENCES:
1. Millitary Jet Engine Acquisition by O. Younossi, et al., ISBN 0-8330-3282-8 (pbk.)
2. Laser Drilling of Cooling Holes Through Plasma Sprayed Thermal Barrier Coatings by K. T. Voisey and T. W. Clyne. Surface and Coatings Technology 176 (2004) 296-306.
3. A Comprehensive Study of the Long Pulse ND-YAG Laser Drilling of Multi-Layer Carbon Fiber Composites by W. S. O. Rodden et al. Optics Communications 210 (2002) 319-328.
4. Laser Shock Peening For Fatigue Resistance by Allan H. Clauer. Surface Performance of Titanium, J. K. Gregory, H. J. Rack, and D. Eylon (eds.) TMS, Warrendale, PA. (1996) 217-230.

KEYWORDS: composite, manufacturing, machining, drilling, casting, ECM

AF05-142 TITLE: Compact Water Recovery Unit for Fuel Cell Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a compact water recovery unit capable of recovering water from the exhaust of either proton exchange membrane (PEM) fuel cells, or solid oxide fuel cells, or both.

DESCRIPTION: Fuel cells electrochemically convert hydrogen and oxygen to dc oxygen depleted air. In solid oxide fuel cells (SOFC), the anode exhaust consists of steam, hydrogen, carbon oxides, and possible light hydrocarbons gases. The rate of water generation is about 4 to 8 grams per minute per kilowatt. The military is developing logistic fuel processing technology to provide hydrogen to fuel cell power generators. Steam reforming is one technology to extract hydrogen. The recovered water can be used in drinking or recycled to provide steam for the steam reforming process. Innovative approaches are sought to develop compact and efficient water recovery units operating at fuel cell exhaust temperature range of 120 to 800 ºC and pressure range of 1 to 10 atmosphere. The developed unit shall be compact and recovers all water needed for the steam reforming of up to 4:1 steam-to-carbon ratio, with no water make-up is required.

PHASE I: Evaluate potential innovative water recovery methods. Down select to a particular technology that is most effective for fuel cell exhaust conditions. Design, build, and demonstrate a bench scale system to demonstrate the technical feasibility. Conduct a series of experiments to evaluate the system's performance.

PHASE II: Design, build, and test a prototype recovery unit that can recover water from fuel cell exhaust. Evaluate performance and make necessary modifications to achieve a high performance design. It is desired that the prototype unit will be a deliverable of the Phase II program for additional testing and evaluation.

DUAL USE COMMERCIALIZATION: A successful development of a compact and efficient water recovery unit will have a multitude of commercial applications in addition to Air Force operations. They can be used in recovering water from industrial applications, combustion processes, and ambient air.

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KEYWORDS: water recovery, fuel cell, gas water separation

AF05-143 TITLE: Innovative Thermal Protection Systems (TPSs) for Trajectory Shaping Vehicles (TSVs)

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Provide innovative thermal protection materials and concepts for a long-glide TSV.

DESCRIPTION: The TPS baseline for current high-speed, heat-soak trajectories is a derivative of the Space Shuttle design. The leading edge TPS for the Shuttle is a rayon-based carbon-carbon composition with a silicon-carbided oxidation protection layer. The Shuttle leading edge material system has been sufficient for the requirements defined by NASA, but do not meet the structural and thermal requirements of the Air Force. The Shuttle leading edge is restricted to a maximum temperature of ~3,000 K. Therefore, this approach is not suitable for nosetip or TSV’s leading edge design where the temperature would exceed this limit. Additionally, the Shuttle baseline composite TPS uses a non structural carbon-carbon, thereby requiring elaborate substructure to react combined aero thermal loads. The next-generation TPS must be multifunctional, managing both the thermal and structural loads. Solutions that satisfy requirements for both reusable and single-use TPS solutions are needed and are of interest.

PHASE I: Develop innovative designs and TPS candidate materials for a heat-soak trajectory (e.g., flight time longer than 30 minutes). It would minimize the TPS weight and, size, and have sufficient strength to sustain the reentry loads. The approach must be different from the existing design mentioned above. The proposed TPS design should have a compatible substructure, which can take axial and lateral loads. The new TPS systems must not only address the frustum heatshield, but must also satisfy the requirements for TSV nose and leading edge regions.

PHASE II: Detailed sizing analysis will be made on the Phase I concepts for use on a TSV mission. Assessments will be made on the advantage of using the new and innovative TPS systems. The concepts in Phase I will be optimized based on the results of the Phase II thermal-mechanical assessment, which include measurements of thermal and structural properties at elevated temperatures using either radiant or arc-jet facilities. Test coupons representative of the TPS will be fabricated and prepared for thermal-mechanical evaluations. After the ground tests and preliminary analysis, flight test plans will be proposed for promising designs. A representative TPS subscale component will be delivered to the Air Force at the end of the effort.

DUAL USE COMMERCIALIZATION: The proposed modeling and simulation effort will have benefits to space and commercial communities. Applications include general, multicomponent-body TPS, use of the numerical algorithms, and flow field solver for other general problems of interest, such as, launch vehicle, orbital reusable space vehicle, and commercial aircraft design.

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1. Rasky, D. J., H. K. Tran, and D. B. Leiser, "Thermal Protection Systems," Launchspace, pp. 49, June 1998.

KEYWORDS: thermal protection system, trajectory-shaping vehicle thermal sizing analysis, thermal conduction and radiation, and heatshield ablation, in-depth pyrolysis

AF05-145 TITLE: Insensitive Munitions Booster Explosives

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Develop an enhanced high output booster explosive to initiate extremely insensitive main fills.

DESCRIPTION: As the Air Force moves closer towards having weapons with extremely insensitive main fill explosives, it becomes increasingly more difficult and sometimes impossible to initiate these fills with typical inventory fuze configurations. For this reason, it is highly desirable to have an increased output booster explosive for initiation of extremely insensitive main charge fills that allows for an improved weapon hazard classification. A volumetric reduction with the same or greater output than PBXN-5 for use in miniature munition applications is also highly desirable. An increase in output pressure of 15% above PBXN-5 should be the goal for increased performance. The project should include CL-20 high explosive formulation with a polymeric binder system such as HyTemp 4454 binder system with DOA. Other binder systems with promising technological advantage will also be considered. The desired explosive should be easily pressed or cast to high a density, equal or greater than 1.78 g/cc, in production. The resulting product characteristics should maintain cook-off insensitivity similar to that of PBXN-7 and PBXN-9. The phase I program should include preliminary formulation development, output comparison with PBXN-5 using Dent Block Test and Detonation Velocity experiments. Additionally, preliminary sensitivity testing such as Impact, BAM friction, ESD, Variable Confinement Cook-off, Large Scale Gap Test (LSGT) are expected to be accomplished in the Phase I effort.

PHASE I: The phase I program should include preliminary formulation development, output comparison with PBXN-5 using Dent Block Test and Detonation Velocity experiments. Additionally, preliminary sensitivity testing such as Impact, BAM friction, ESD, Variable Confinement Cook-off, Large Scale Gap Test (LSGT) are expected to be accomplished in the Phase I effort.

PHASE II: In the Phase II effort the booster explosive formulation may be refined if necessary, scale up/processing considerations investigated, Wedge Test performed to obtain "Pop Plot," and further performance testing conducted.

DUAL USE COMMERCIALIZATION: An Increased Output Booster Explosive has potential military use in both Insensitive Munitions and Miniature Munitions. Additionally, there is potential in the commercial sectors of mining, oil drilling, and aerospace industry.

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KEYWORDS: Explosive, booster, fuze, insensitive fill, High Output, initiation, Cl-20

AF05-146 TITLE: Target Tagging By-products for Bomb Damage Information (BDI)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

OBJECTIVE: Identify a tracer material or passive/active target marking process for small munitions (2 to 20 pounds) that leaves a detectable and discernible residue on an engaged target.

DESCRIPTION: Revisiting a previously hit target wastes resources and needlessly jeopardizes the warfighter. A method of identifying previously engaged targets via distant airborne sensor platforms would help eliminate this problem. Examples of candidate technologies include using (1) stable - but non-prevalent - isotopes embedded in the munition's casing and/or explosive fill and using laser interrogation/spectroscopy for detection, or (2) embedded gamma-emitting isotopes in small quantities. Ideal candidate materials would not occur naturally (so they would be unique to the weapon), and would thus uniquely "paint" the target, marking it as having been previously engaged. These chemical or atomic "dyes" would retain their unique properties after impact, being subject to high temperatures and molecular recombinations from explosive events. The signature would be detectable in good weather from a platform high above the ground (~20,000 feet) and be resistant to duplication and countermeasures. A suitable target-tagging technology also would need to be generally compatible with modern air-delivered munitions, materials, aircraft and concepts of operation; the target-tagging material would have to be recognizable against a variety of background materials (sand, rock, pavement, etc.), and, if possible, through clutter (physically similar, yet un-engaged targets), and obstruction (trees, brush, airborne sand). Finally, these target-tagging materials would have to be safe considering: handling, storage, transport, deployment and long-term environmental impact.

PHASE I: Identify and select candidate materials and mechanisms for target tagging. Explain means of operation, physical/theoretical basis, sensitivity or signature level, and operational feasibility.

PHASE II: Demonstrate durability, dispersion, and coating properties of tagging substances during live explosive events. Demonstrate detection in live fire test using small-caliber ballistic munitions embedded with tagging material or mechanism. The government will allow and support range testing at Eglin AFB during Phase II at no cost to the contract.

DUAL USE COMMERCIALIZATION: Search-and-rescue (self tagging), law enforcement (prisoner tracking), environmental science (drainage mapping), recreational paintball, exercise/practice weaponry, inventory tracking/identification, on-the-road tracking/identification of hazardous materials. Military uses are target tagging of hit targets to prevent unnecessary repetitive engagements.

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4. Stable isotope tracers in the life sciences and medicine. Matwiyoff, N.A.; Ott, D.G. Source: Science; 21 Sept. 1973; vol.181, no.4105, p.1125-33.

KEYWORDS: target identification, target tagging, Bomb Damage Information (BDI), Bomb Damage Assessment (BDA), markers, spectrometry, laser identification, painting

AF05-147 TITLE: Multiaperture Optical Systems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop new innovative concepts in seeker/sensor architectures.

DESCRIPTION: Human engineered imaging optical systems typically are laid out like the 'camera eye' or vertebrate eye: a single imaging optic, and a focal plane where a fairly high-resolution image is formed. The 'camera eye' demands a fairly large volume for the incoming radiation to come to a focus in the focal plane. This architecture results from certain trades having been made, and the Air Force Research Laboratory Munitions Directorate Advanced Guidance Division (AFRL/MNG) is interested in exploring optical architectures resulting from different sets of trades and believes other designs to be possible. One obvious design would be motivated by the compound (or arthropod) eye, consisting of a large number of small, independent facets. In this design, resolution is sacrificed for the sake of the device's ability to conform to the aircraft surface (flexibility), and relaxing the requirement for a large volume for focusing. This would allow for new seeker/sensor designs that could be mounted "conformal" to the airframe. Such a sensor might be significantly less expensive than the 'camera' and there are applications that do not require extremely high angular resolution but instead require, for example, extremely wide field of view.

PHASE I: Determine the technological or scientific merit and the feasibility of the proposed innovative optics/seeker/sensor concept, and develop a design suitable for fabrication.

PHASE II: Produce a deliverable prototype with preliminary contractor testing, and be amenable to further in-depth government testing.

DUAL USE COMMERCIALIZATION: Examples of military applications include innovative seeker designs, fuze Target Detecting Devices (TDDs), surveillance devices and missile warning receivers. Examples for commercial applications include surveillance sensors, wide field of regard (FOR) motion detectors, security and imaging systems.

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4. M. Land and D. E. Nilsson, Animal Eyes, Oxford Press; (February 2002)

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KEYWORDS: Multiaperture, Optic, Sensor, Imaging, Compound Eye, Insect Vision

AF05-148 TITLE: Advanced NanoEnergetics and Electrical Conversion Processes

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

OBJECTIVE: Develop energetic materials, processes or nanoscale-systems with inherent energy-conversion mechanisms for use as primary or auxiliary electrical power sources for miniaturized smart weaponry.

DESCRIPTION: Energetic elements and materials provide rich energy storage mechanisms. However, converting this stored (chemical or atomic) energy into a useful electromotive force typically requires a separate process with additional hardware that greatly diminishes the simplicity and size of the original energy source. Furthermore, hindered by many fundamental physical limitations such as magnetic saturation, dielectric breakdown, and transport

phenomena, typical electrical conversion mechanisms can not readily accommodate the maximum reaction rate of the fuel that made it so attractive in the first place (as is the case with explosives). We require practical ideas for safe and controllable chemical, biological or atomic reactions with inherent nanoscale electrical conversion technologies that do not so drastically reduce the energy- and power-based performance metrics as compared to the fuel alone. The goal is to replace or supplement the conventional energy sources in miniaturized smart munitions that are responsible for powering guidance, navigation, and fuzing systems. Due to the various sizes and loads of these subsystems, it is also appropriate to determine the limitations of scale of the new nanoscale conversion material and mechanism all the while considering environmental and operational limitations such as temperature, shock, and long-term, dormant storage (shelf life).

PHASE I: Select energetic material and nanoscale energy conversion technique. Describe the energy conversion mechanism in detail, and from an analysis of first principles, calculate respective advantages over alternate technologies to include the expected maximum rate and efficiency of conversion to an electrical form.

PHASE II: Demonstrate electrical-energy conversion mechanism and experimentally quantify major electrical performance metrics (energy density, power density) versus temperature, shock and other environmental variables using suitable logistics (petroleum), environmental (biomass), explosive, or radioisotope fuel. Perform side-by-side comparative testing with typical military (thermal, liquid reserve) and commercial batteries.

DUAL USE COMMERCIALIZATION: Electrical power source for commercial batteries, autonomous electric transportation, electric propulsion for micro Air Vehicles (MAV), compact consumer electronics, and space exploration. Long-term Air Force applications are power for air/ground loitering, compact, and subterranean munitions. Immediate military applications include soldier power, battlefield sensors and more energetic replacements for thermal and reserve batteries.

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KEYWORDS: energetics, radioisotopes, battery, fuel cell, energy harvesting, biochemistry, biologically-inspired energy conversion

AF05-149 TITLE: Field Programmable Gate Array (FPGA) Defragmentation for Performance Sustainment Technology

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

OBJECTIVE: Develop robust defragmentation methodologies for Field Programmable Gate Array (FPGA) performance sustainment in applications that have high reconfiguration rate.

DESCRIPTION: The primary motivation for implementing systems for air munitions and vehicles based on FPGAs is the strong potential for the rapid fielding of systems, hardware miniaturization, and the significant decrease in parts obsolescence. In the past year, FPGAs have even been enhanced with embedded microprocessors that allow

more functionality, potentially for more advanced computational processing, to be derived by a single chip. An ongoing improvement is the growing number of reconfigurable logic elements, or density, that is being specified for recent designs of FPGAs. Due to this increasing level of density for FPGAs, now on the order of 6 to 8 million configurable logic blocks (CLB), the potential advantage for partial configuration, is much more foreseeable. Partial configuration is an approach that refers to an FPGA having the ability to store a variety of configurations while concurrently implementing the configuration of choice. Such configurations could include Miniature Munitions Store Interface (MMSI), MIL-STD-1760, datalink protocols, Bomb Impact Assessment (BIA) algorithms, or even wavelet compression schemes. The flexibility that is granted by this approach is not without trade-offs. Over time, as an FPGA loads and unloads configurations, the location of the unoccupied area on the array is likely to become fragmented, similar to what occurs in memory systems when random access memory (RAM) is allocated and de-allocated. This is very important when considering an expected 15- to 20-year shelf-life for this technology. There may be enough empty area on the FPGA to hold an incoming configuration, but it may be distributed throughout the array. A configuration normally requires a contiguous region of the chip, so it would have to overwrite a portion of a valid configuration in order to be placed onto the FPGA. A system that incorporates the ability to perform defragmentation of the FPGA's reconfigurable array, however, would be able to consolidate the unused area by moving valid configurations to new locations. This area can then be used by incoming configurations, potentially without overwriting any of the moved configurations. The use of a defragmentation application allows the performance and high flexibility of an FPGA to be maintained over the course of the system life, specifically for the anticipated need and active use of the partial configuration approach.

PHASE I: Investigate and define robust FPGA defragmentation methodologies for weapon system applications with high reconfiguration rates.

PHASE II: Develop and demonstrate methodologies defined in Phase I in a realistic application requiring a high frequency of configuration.

DUAL USE COMMERCIALIZATION: Successful demonstration of defragmentation of FPGAs will lead to applications of the technology in autonomous robots in space, real time medical imaging, airport security, and computer aided design software requiring finite element analysis. The DoD has many needs for high-performance real-time reconfigurable FPGAs, such as in the Unmanned Combat Aerial Vehicle (UCAV).

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KEYWORDS: Defragmentation Methodologies, Reconfiguration Rates, Performance Sustainment, FPGA Reconfiguration, Partial Configuration, Dynamic Reconfiguration

AF05-151 TITLE: Development of Multi-Hit Nonlinear Progressive Collapse Models for Fixed Targets

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

OBJECTIVE: Develop High-Fidelity Physics-Based Fast-Running Models for simulating nonlinear progressive collapse of aboveground fixed target structures damaged by multiple air-delivered conventional weapons.

DESCRIPTION: The Air Force Research Laboratory (AFRL) is developing a computer program that provides a computational environment and algorithms for assessing the survivability/vulnerability of aboveground fixed target structures subjected to any air-to-ground delivered conventional weapons (old and new, large and small). The program, named MEVA (for Modular Effectiveness Vulnerability Assessment), contains modules for weapon delivery, target model generation, weapon effects modeling, structural response analysis, and damage assessment. If a targeting objective is to collapse a particular building with minimum collateral damage, it may be advantageous to target the building with several smaller weapons rather than one large one. The selection and delivery of such weapons will involve the optimum selection of weapons, their delivery including sequencing and targeting accuracy, and the capability of the weapons to inflict the kind of damage sufficient to collapse the building with high probability. In general, multiple weapons may be targeted to strike the same location or strategically different locations on a building. Uncertainties inherent in the targeting, weapon effects, structural response and damageability must be taken into account in performing the optimization. Fast-running models (FRM) will be required to implement the analysis so that optimization can be carried out in a cost-effective manner. In addition to the new small weapons being developed through AFRL's Integrating Concepts process, the model must also handle the current larger weapons that may be delivered one at a time. The multi-hit nonlinear progressive collapse analysis model developed under this project must interface with MEVA's Smart Target Model Generator (STMG) used to generate models of multi-story building targets, MEVA's blast and fragment models, and MEVA's library of fast-running Structural Response component models for columns, beams, walls, slabs, etc., assembled to conduct vulnerability analysis. The finial FRM will need to have a short run-time and 80 percent statistical reliability. Potential offerors can receive a software developer's kit by contacting AFRL/MNAL, Norman Gagnon, norman.gagnon@eglin.af.mil, (850) 882-5767. The kit will contain the STMG, Blast and Fragment models, Structural Response component models, and MEVA interface information.

PHASE I: Demonstrate the feasibility of developing a High-Fidelity Physics-Based (HFPB) FRM that is capable of assembling damaged as well as undamaged structural components in a nonlinear progressive collapse analysis model. Also demonstrate the feasibility of providing optimized multi-hit targeting for building collapse weaponeering.

PHASE II: Develop, demonstrate and validate a HFPB FRM nonlinear progressive collapse module for MEVA capable of predicting and assessing the likelihood of structural collapse of multi-story buildings under damage inflicted by single or sequentially delivered large and small air-to-ground delivered conventional weapons.

DUAL USE COMMERCIALIZATION: Once the successful integration of this model into MEVA has been accomplished, the way is open to exploring the other similar codes that can benefit from the same technology. Most of these codes are developed and maintained by government agencies, such as the Technical Support Working Group (TSWG), Defense Threat Reduction Agency (DTRA), U.S. Army Engineer Research and Development Center (ERDC), U.S. Navy, and others. In addition, currently there are no computational capabilities for analyzing the progressive collapse of multi-story buildings except for nonlinear finite-element codes that require weeks or more to build a model, and possibly days to execute a problem, depending on the complexity of the structure, the extent of damage to the structure, and the available computational platform. Consequently, terrorist threats cannot be assessed for most multi-story buildings. Homeland security as well as the security of soft targets abroad would benefit from the type of capability described here.

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KEYWORDS: Nonlinear Progressive Building Collapse, Structural Response, Munition Effectiveness, Lethality & Vulnerability, High-Fidelity Physics-Based (HFPB), Fast Running Models (FRM), Modular Effectiveness/Vulnerability Assessment (MEVA), Masonry and Column/Girder Urban Construction.

AF05-152 TITLE: Development of HFPB Structural Response Models for Brick Masonry Construction

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

OBJECTIVE: Develop High-Fidelity Physics-Based Fast Running Models for simulating the structural response of brick/stone/tile masonry and other construction methods to air-delivered conventional weapons.

DESCRIPTION: The primary requirement is to determine if High-Fidelity Physics-Based (HFPB) models can be used to simulate the structural response of brick/stone/tile masonry, metal/wood stud, and earth/adobe wall construction methods to the blast and fragmentation effects of air-to-ground delivered conventional weapons. Currently, very little HFPB modeling in this area exists. The model must handle the new small weapons being developed through the Air Force Research laboratory (AFRL) Integrating Concepts process and the current larger weapons. From this HFPB model, Fast Running Models (FRM) are to be derived to supplement the other structural response models for Reinforced Concrete and Concrete Masonry Unit (CMU) currently found in Modular Effectiveness/Vulnerability Assessment (MEVA). These new models must also interface with the Smart Target Model Generator (STMG) (used to generate models of multi-story buildings i.e., targets) and the different blast and fragment models used in MEVA. MEVA is a lethality/vulnerability program developed by AFRL/MNAL. One of its capabilities is to assess the vulnerability of various fixed targets to conventional weapons. It consists of different modules that are linked as required to conduct the required analysis. Currently MEVA uses the pressure/impulse curves found in the Facility And Component Explosive Damage Assessment Program (FACEDAP) and DAHS manuals to calculate structural response for these fixed target types. The new models will replace those curves in MEVA. The finial FRM will need to have a short run time and an 80 percent statistical reliability. Potential offerors can receive a software developer's kit by contacting AFRL/MNAL, Norman Gagnon, norman.gagnon@eglin.af.mil, (850) 882-5767. The kit will contain the STMG, Blast and Fragment models, Structural Response component models, and MEVA interface information.

PHASE I: Provide proof of feasibility to determine if HFPB FRM models can simulate the structural response of brick/stone/tile masonry, metal/wood stud, and earth/adobe wall construction methods to air-to-ground delivered conventional weapons.

PHASE II: Develop, demonstrate and validate the accuracy of HFPB FRM models to simulate the structural response of brick/stone/tile masonry, metal/wood stud, and earth/adobe wall construction methods to air-to-ground delivered conventional weapons.

DUAL USE COMMERCIALIZATION: Once the successful integration of this model into MEVA has been accomplished, the way is open to exploring the other similar codes that can benefit from the same technology. Most of these codes are developed and maintained by government agencies, such as the Technical Support Working Group (TSWG), Defense Threat Reduction Agency (DTRA), U.S. Army Engineer Research and Development Center (ERDC), U.S. Navy, and others. However, a few (e.g., ERASDAC) are commercial codes developed and

marketed by contractors with licenses available for purchase. This will provide the ability to predict the structural response of civilian structures to conventional weapons or explosives and enable better design of future structures.

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KEYWORDS: Structural Response, High-Fidelity Physics-Based (HFPB), Fast Running Models (FRM), Munition Effectiveness, Lethality & Vulnerability, Modular Effectiveness/Vulnerability Assessment (MEVA), Facility And Component Explosive Damage Assessment Program (FACEDAP), Masonry Urban Construction.

AF05-153 TITLE: Methods to Direct and Focus Blast

TECHNOLOGY AREAS: Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop and test methods to direct and/or focus blast waves in volumetric explosives.

DESCRIPTION: Although long neglected, blast weapons are well suited for the defeat of high value targets such as soft structures (structural defeat), hard targets (functional defeat), and urban targets (where collateral damage concerns prevent the use of fragmentation weapons with their larger footprints). Volumetric explosives, which include fuel air explosives (FAE) and thermobarics (TBX), have the potential to be more effective than high explosives against these targets due to their greater energy density and improved target coupling (a volumetric source versus a point source). This topic calls for development of techniques to direct and/or focus blast. These directional blast warheads would be analogous to their mass-focusing counterparts--shaped charge jets (SCJ) and explosively-formed penetrators (EFP). The goals are to: (a) increase lethality by focusing more of the available energy on target; (b) decrease the collateral damage from blast (via directional blast versus omnidirectional blast); and (c) miniaturize the warhead (i.e., decrease the mass and volume) by exploiting the higher energy density of volumetric explosives and eliminating extraneous fuel mass.

PHASE I: Propose novel approaches to increasing blast effects on the target, and use (or, only if necessary, develop) physics-based models to evaluate concept(s). For example, these concepts might include: cloud shaping (through geometry or innovative dispersion methods) for directional blast control, or distributed/multi-point initiation of the cloud to focus blast. Small-scale testing to show proof-of-concept is highly desirable.

PHASE II: Design and test one or more concepts in medium- or large-scale experiments, and use the resulting experimental data to validate the models.

DUAL USE COMMERCIALIZATION: The military application is for a blast warhead, perhaps for military operations in urban terrain (MOUT). Possible commercial applications include: mining applications; control of vortex flows in internal combustion engines to increase efficiency; and pyrotechnics (fireworks) displays.

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KEYWORDS: Blast, Detonation, Deflagration, Combustion, Volumetric Explosive, Fuel-Air Explosive, Thermobaric, Military Operations in Urban Terrain (MOUT)

AF05-154 TITLE: Passive and Active Camouflage Techniques for Micro Vehicles

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

OBJECTIVE: Develop capability for micro air vehicle or microbot to use active/passive camouflage techniques.

DESCRIPTION: Micro air vehicles or micro robotic systems used for reconnaissance, surveillance, penetration, and functional defeat of deeply buried, hardened targets may be relatively easily detected if in close proximity with the target or other objective. There is a need for both passive and active camouflage techniques to reduce these systems' vulnerability. These small systems are highly sensitive to payload form, fit and weight; thus it is a technology challenge to incorporate a camouflaging scheme which may adapt to its environment, while adding little-to- no-additional weight to the carbon-composite airframe or micro robotic structure. This camouflaging scheme will decrease visibility and thus increase odds for survival and mission accomplishment.

PHASE I: Develop or select and characterize material(s) and/or technique(s) to actively or passively camouflage a micro air vehicle or micro robotic system, while adding little-to-no-weight to the system.

PHASE II: Fabricate and demonstrate the feasibility and functionality of a prototype design in a variety of controlled environments.

DUAL USE COMMERCIALIZATION: This technology may prove suitable to actively/adaptively camouflage aircraft, weaponry and other munitions. It may also apply commercially for concealing safes or other valuables in one's business, home or automobile.

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KEYWORDS: Active Camouflage, Passive Camouflage, Tunable Active Coating, Chiral Liquid Crystal Polymer Membranes, Micro Air Vehicles, Micro Robotic Systems, Survivability, Multifunctional Composite Structures

AF05-155 TITLE: Statistical Modeling of Obscured Targets with Environmental Returns (SMOTER)

TECHNOLOGY AREAS: Information Systems, Weapons

OBJECTIVE: Develop a first-principles, statistics-based model for the sensor signatures of various targets (low-observable, air, surface) in a variety of obscuring environments (weather, ground cover, terrain).

DESCRIPTION: Current fuze sensors operating at RF frequencies are “trained” using a discretized (facet-based) computer model to generate a “scene” from which a radar return is predicted using empirical data. This is

problematic in the computational time required to generate a scene, as well as the lengthy training process (requiring many scenes for the system to learn to find what it is looking for).

This topic seeks groups who would develop a different paradigm for both the simulation and real-time processing of sensor returns in real-world situations, where targets of interest are hidden or obscured by environmental factors. The only information required for such a model is restricted to statistical information on the background (e.g., readily obtained probability distributions for the ambient materials and returns) and the target(s). Nominally, the mathematical models developed using this approach should be 1) reduced-order (i.e., not based on pixel-by-pixel analysis), 2) based on physical principles (e.g., the scattering cross-section from a suspension of water in air), and 3) not based on empirical data.

The model and processing algorithms would be experimentally validated on targets in representative obscuring environments.

PHASE I: 1) Define and develop a statistics-based, reduced-order method for detecting various targets (low-observable, air, surface, etc.) obscured by the environment, including biological (trees, grasses), meteorological (fog, rain), and geological (rivers, rocks) features that are modeled using first-principle calculations. 2) Demonstrate the feasibility of the approach using simulations of selected targets obscured by a set of environmental factors.

PHASE II: 1) Demonstrate in laboratory and limited field tests the validity of the approach on a series of test targets that match Phase I simulations. 2) Implement and validate real-time processing capability based on the reduced-order model.

DUAL USE COMMERCIALIZATION: The validated model and processing capabilities developed for the U. S. Air Force will be equally applicable to civilian applications such as remote sensing and search-and-rescue.

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KEYWORDS: radar frequency (RF) sensor, RF model, fuze sensor, obscured targets, search and rescue, foliage penetrating (FOPEN) radar, targets under trees (TUT)

AF05-156 TITLE: Transport, Compartmentalization, and Effects of Nanoparticles in the Environment

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Assess how nanoparticles move through aquatic/terrestrial environments and how they affect flora and fauna.

DESCRIPTION: As weapons containing nanoparticle-based materials are being developed, it is imperative that the DOD understands the effects of releasing these particles into the environment. Given recent controversy over weapon constituents like lead and perchlorates, the DOD is under closer scrutiny to develop munitions that have a

lesser likelihood of causing harm to the environment. Such knowledge is important to allow for the development of pollution prevention or environmental mitigation measures once nanoparticle constituents are weaponized and released. Nanoparticles/nanomaterials represent the ?cutting edge? of materials research. Their market is fast approaching the $1 billion dollar mark in the US alone. There are several military and commercial applications for nanoparticles, which underlines the urgent need to characterize their behavior in the environment: Automotive catalyst supports, biodiagnostics, chemical-mechanical polishing (CMP) slurries for silicon wafer polishing, magnetic recording tapes, optical fibers, sunscreens, photocatalysts, orthopedic products, optical devices, enhanced LCD screens, polymer composites, batteries, solar cells etc. We propose that an academic entity devise an innovative and creative approach to determine the influence of nanoparticles from an ecological perspective. Phase I efforts would include: characterizing the behavior of nanoparticles when released in different atmospheric conditions (excess heat, humidity, precipitation, etc.), performing soil mobility tests to ascertain if nanoparticles remain stationary or quickly move through the soil column, and evaluating any chemical change in the nanoparticle that would enhance or decrease its bioavailability. Aquatic tests would evaluate what characteristic changes nanoparticles go through due to pH and if they settle or stay suspended in a water column. Subsequent analysis would evaluate the pervasiveness of the nanoparticles in the food web. This research effort would evaluate nanoparticle uptake into terrestrial and aquatic flora and would also include bioassays on terrestrial and aquatic fauna. An assessment of lower organisms would be used to predict the bioaccumulation potential of these particles. The results of such experimentation would be delivered in the form of a technical report.

PHASE I: A research effort characterizing the following: behavior of nanoparticles when released in different atmospheric conditions (excess heat, humidity, precipitation, etc.), soil mobility test to see if nanoparticles remain stationary or quickly move through the soil column, investigation of any nanoparticle chemical changes that would enhance or decrease bioavailability, and aquatic tests to evaluate what characteristic changes particles go through due to pH and if they settle or stay suspended in a water column.

PHASE II: An evaluation of the pervasiveness of nanoparticles in the food web. This research would evaluate material uptake into terrestrial and aquatic plants and would include bioassays on terrestrial and aquatic fauna. The bioaccumulation potential of nanoparticles will also be assessed.

DUAL USE COMMERCIALIZATION: Nanoparticles/nanomaterials represent the “cutting edge” of materials research. Their market is fast approaching the $1 billion dollar mark in the US alone. There are several military and non-military applications for nanoparticles, which underlines the urgent need to characterize their behavior in the environment:
Automotive catalyst supports, biodiagnostics, chemical-mechanical polishing (CMP) slurries for silicon wafer polishing, magnetic recording tapes, optical fibers, sunscreens, photocatalysts, orthopedic products, optical devices, enhanced LCD screens, polymer composites, etc.

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KEYWORDS: Nanoparticles, nanomaterials, environment, nanoparticle bioaccumulation, nanoparticle mobility, nanoparticle toxicity

AF05-157 TITLE: Shock Hardening of Fuzing Optoelectronics/Communication Devices

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

OBJECTIVE: Investigate mechanisms that negatively affect electromagnetic properties of microscale devices under shock loading.

DESCRIPTION: The extreme shock loading of hard-target penetrating munitions necessitates giving special consideration to event-survivability of electronics and other devices within the munition casing. Novel shock-survivable sensor concepts based on optical and optoelectronic devices are being explored, but there is currently little understanding of the effects of shock loading on the electromagnetic properties of these devices. This topic seeks groups who would identify mechanisms that negatively affect the electromagnetic properties of microscale devices (e.g., off-the-shelf laser diodes, VCSELS, waveguides, and MOEMS) under shock loading, quantify these phenomena as a function of shock magnitude and pulse shape, and identify solutions for mitigating these effects.

PHASE I: Identify mechanisms that negatively affect the electromagnetic properties of commercial off-the-shelf (COTS) microscale optoelectronics and optics devices under shock loading, both theoretically and experimentally. Quantify the effect of shock loading on these microscale devices as a function of shock magnitude and pulse shape. Select and characterize materials, processes, or packaging techniques for shock hardening of sensitive fuzing components.

PHASE II: Propose a solution or set of potential solutions for mitigating these negative effects. Manufacture shock-hardened prototypes to demonstrate technology. Test the validity of the proposed solution(s) using the same quantifiable shock load testing that was performed on the COTS devices of Phase I. Quantify the effects of shock loading on these shock-hardened microscale devices, and compare these results with those of the Phase I task to demonstrate the validity of the solution(s).

DUAL USE COMMERCIALIZATION: Transition the shock-hardened solution to commercial applications, such as consumer electronics, commercial aviation diagnostics, automotive electronics, and military laser designators.
A material that can withstand and mitigate the shock loads encountered in penetrating weapons could be useful in automotive bumpers and structural components to decrease injury to occupants during an accident.

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KEYWORDS: shock-hardened, electromagnetic properties, optoelectronics devices, communication devices, shock absorption, fuzes

AF05-159 TITLE: Guidance Research

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes, Sensors, Electronics, Weapons

OBJECTIVE: Develop innovative concepts in guidance technologies for air deliverable autonomous munitions.

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Munitions Directorate seeks new and innovative ideas/concepts in areas related to precision guidance and autonomous target acquisition and classification. Topics of interest related to seekers include Flash Ladar and Synthetic Aperture Radar (SAR) seeker technology and related components including signal processing used by such seekers for autonomously acquiring and classifying targets. For Ladar seekers, this includes, but is not limited to, short pulse laser sources, focal plane array detectors, read out integrated circuits, non-mechanical beam steering technology, and detection schemes designed to exploit target characteristics other than 3D shapes. For SAR seekers, this includes, but is not limited to, RF sources, electronically steered antennas (ESA), polarization-sensing systems, modulators (both single element and pixilated), SAR processing techniques and processing systems, algorithms for autonomous target acquisition (ATA) and classification (ATC). Topics in the Image Processing area include: innovative signal and image processing algorithms related to synthetic aperture radar (SAR) and laser radar (LADAR), needed to autonomously detect and recognize signatures of targets embedded in backgrounds; operations/functions associated with the ATA process involving noise elimination, detection, segmentation, feature extraction, classification (e.g., truck vs. tank), and identification (e.g., tank A vs. tank B). Key research areas include signal and image processing, pattern recognition/classification, image understanding, computational super-resolution, knowledge- and model-based vision, optic flow/structure from motion, and data fusion. Topics of interest in guidance technology include innovative approaches for integrating the guidance law, target state estimation, and autopilot functions. Of particular interest are cutting edge methods for the design of closed loop guidance and control systems for munitions with numerous Micro-Electromechanical Systems (MEMS)-based sensors and control actuators; both biomimetic and mathematics-based approaches are of interest. Topics of interest related to modeling and evaluation include synthetic target signature generation and scene projection technology for hardware-in-the-loop applications. For all applications, biologically-motivated innovations are of particular interest.

PHASE I: Determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: Produce and demonstrate a well-defined deliverable product.

DUAL USE COMMERCIALIZATION: Concepts must have a good dual use/commercialization potential. Anticipated dual use would include medical imaging/diagnostic applications, geolocation technology, surveillance applications, and pattern recognition applications.

REFERENCES: 1. http://www.mn.afrl.af.mil

KEYWORDS: Ladar, SAR, Electronically Steered Antennas, Jam-Resistant GPS, Biomimetic, Autonomous Munitions Guidance, Algorithms for Autonomous Target Acquisition and Classification (ATA), MEMS Devices

AF05-160 TITLE: Ordnance Research

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

OBJECTIVE: Identify, develop, and demonstrate commercial components/technologies having application to air deliverable munitions.

DESCRIPTION: New and innovative ideas/concepts are needed in the area of air delivered, non-nuclear munitions that have a dual use/commercialization potential. Military products include warheads; penetrators; submunitions; fuzes (including safe and arm devices); explosives/energetic materials; polymer binders for shock survivable explosives; solid state inertial components; test technology; modeling and simulation resources and techniques; and conventional weapon environmental demilitarization and disposal techniques. Examples of desired research are shock hardened fuze sensors ; warhead initiation; self-forging fragment warheads; shaped charges; reactive fragment warheads; hard-target weapon/penetration technology; and low velocity deep earth penetrators. Rapid solid-state reaction, combustion and detonation process models for metallic particle systems are of interest. These models should include energy extraction rate, theoretical descriptions of initiation, and kinetics of reaction. Process models should also account for the physical processes unique to metallic particle energetic systems. Metallic particle sizes of interest are 10-100 nanometers. Models developed should provide insight into the impact of parameterization of particle size, surface area, and heat conduction rate as related to initiation and reaction behavior. In the area of ordnance fuzing, desired research includes highly reliable, miniaturized fuze components to include: capacitors (1uF, rated at >1kV) that can be micro-fabricated on a substrate; mechanical shock harvesting and conversion mechanisms for initiation electrical power; high power RF circuits and components for through media telemetry; and novel initiation circuits including methods to reversibly convert explosives from low to high sensitivity. Application of fabrication processes producing desirable material properties (strength, toughness, ductility, plasticity, uniformity, etc.) for severe loading environments are of interest. Materials of application include composites, alloys, and elements. Processes of interest should be economical for producing large quantities but include nano-level control. Highly lethal micro sized (cm3) damage mechanisms are of interest and are not limited to energetic materials. Modeling is necessary for design of micro-warheads to include mirco-detonics. Novel mechanisms for delivering lethal energy into deeply buried hardened targets are of interest. This includes unique application of existing materials, novel materials development, unique application of physical phenomena, unusual susceptibilities of hard target support systems, and exploitation of revolutionary technologies.

PHASE I: Determine the scientific or technological merit and feasibility of the innovative concept. Merit and feasibility must be clearly demonstrated during this phase. A technical evaluation of the concept or methodology, a demonstration of proof of principle, or a thorough description of the technical approach, alternative approaches, and risk factors may be appropriate.

PHASE II: Produce well defined deliverable technology demonstrator hardware or simulation/model capability.

DUAL USE COMMERCIALIZATION: A wide range of commercial products could be produced from this research. Typical products include propellants, initiators, gas generators, high strength and high strain rate materials, low cost sensors/detectors, and environmentally compatible recycling processes for energetic materials.

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3. http://www.mn.afrl.af.mil

KEYWORDS: Fuzes, Warheads, Explosives, Hard Target Defeat, Hardened electronics, Micro-damage mechanisms

AF05-161 TITLE: IR Algorithms for Video-Aided Navigation

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

OBJECTIVE: Develop real-time algorithms for infared (IR) video processing to enable robust day and night video-aided navigation for autonomous air vehicles

DESCRIPTION: While GPS has provided a solution for precision navigation in many defense settings, novel ideas for autonomous agent (micro air vehicles [MAV], robots, munitions, etc…) missions require a robust navigation capability without reliance on GPS. Advanced IR cameras – particularly small, uncooled systems, meet the size and power constraints for use on MAVs and small robots. While enabling 24 hour surveillance, these IR cameras could also be used to provide robust 24 hour navigation – especially in settings where GPS coverage cannot be guaranteed.

The idea of video-aided navigation is not new, but it has been explored primarily using visible imagery – limiting its applicability to daylight operations. Common algorithm paradigms for motion estimation include optic flow, feature tracking, and image registration. This SBIR seeks to establish equivalent techniques appropriate to IR imagery and determine bounds on motion estimation performance for various terrain types, weather, and lighting conditions. Research should also determine algorithm performance differences between long-wave and mid-wave IR.

PHASE I: Develop IR applicable image processing algorithms to support day/night video-aided navigation. Potential algorithms include, but are not limited to, optic flow, feature detection and tracking, and fast image registration algorithms. Test the IR algorithms to determine trade-offs between computational complexity, camera resolution, frame rate, and motion estimation error using government provided simulated and real IR imagery. Document motion estimation performance for various terrain types, lighting conditions, and IR bands.

PHASE II: Demonstrate a real-time capability to process IR imagery from a simulated or real source to support video-aided navigation. Integrate the IR processing into a government defined navigation system simulation and conduct performance analysis for various mission types.

DUAL USE COMMERCIALIZATION: The IR algorithms would be of great interest to the UAV community to enable 24 hour robust navigation, particularly in urban "canyons" where GPS signal coverage can be lost. The technology could also be applied to ground-based robots for tunnel defeat or indoor surveillance. Robust indoor, low/no-light navigation would also benefit research programs developing rescue robots for response to natural disasters or terrorist attack response.

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KEYWORDS: Video-Aided Navigation, egomotion estimation, optical flow, feature tracking, geolocation, infared (IR) algorithms

AF05-162 TITLE: Real-time Video Stabilization for Micro-air Vehicles

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop real-time algorithms to stabilize electro-optical (EO) and laser radar (LADAR) video from micro-air vehicles (MAV).

DESCRIPTION: The proliferation of unmanned aerial vehicles (UAV) and micro-air vehicles (MAV) for defense purposes gives the warfighter unprecedented access to real-time video imagery. Unfortunately in the MAV case, the imagery can be difficult to exploit due to poorly constrained platform motion. Visual quality often suffers from moderate to extreme jitter in roll, pitch, and yaw – increasing the time required to detect and identify threats. Given that resolution is poor and field-of-view is often small for MAV cameras, target detection time can often exceed the time a threat is in view.

Ideally, a video stabilization algorithm would compensate for high frequency camera motion while preserving the overall motion due to camera translation, thus improving an operator's ability to exploit the imagery. Depending on computational requirements, the algorithm could reside on the MAV or at the user station. Generally, it should be assumed that platform motion data is either non-existent or of limited quality. Reasonable motion data, when available, would include non-differential GPS at 1Hz and micro-electromechanical systems (MEM) inertial measuring unit (IMU) data for Roll/Pitch/Yaw and accelerations at 10Hz.

This form of video stabilization is also of interest for foveated cameras, cameras that have a reconfigurable, multi-resolution focal plain plane used to increase FOV while minimizing bandwidth. Here, the algorithm would be used to stabilize high-resolution sub-windows of the focal plain plane against high-frequency platform jitter. Finally, "Flash" LADAR sensors are under development, which will provide a 3D equivalent to EO video, at similar frame rates. Once again, removal of high-frequency camera motion will improve exploitability of the sensor data.

PHASE I: Develop a video stabilization algorithm appropriate for EO video cameras on MAVs. Determine hardware requirements for real-time implementation using a personal computer (PC) or embedded system. Detail trade-offs in performance and computational complexity given various levels of motion truth.

PHASE II: Extend the Phase I algorithm to support Flash LADAR and foveated cameras and outline real-time hardware requirements. At a minimum, demonstrate a real-time capability to stabilize EO video on a MAV. Preferably, demonstrate real-time capability for EO, LADAR, and foveated sensors.

DUAL USE COMMERCIALIZATION: A successful Phase II demonstration should position the contractor to transition the video stabilization algorithms to active DOD UAV programs. The algorithms are appropriate for inclusion on new systems and could also be used as upgrades to existing platforms as they will not require changes in flight hardware. This work would also see strong interest from the civilian law enforcement and security community.

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KEYWORDS: Video stabilization, motion compensation, BIA, sensor exploitation, video algorithms, electronic image motion compensation

AF05-164 TITLE: Micro Air Deployed Munition for Cluttered Urban Environment

TECHNOLOGY AREAS:

OBJECTIVE: Investigate enabling technologies to develop and design a micro air platform for Bomb Impact Assessment (BIA) and reconnaissance in a cluttered urban environment.

DESCRIPTION: Current concepts for micro air platforms for BIA and reconnaissance missions operate above the level of buildings and other urban structures. The cluttered urban environment presents unique challenges for small air platforms performing BIA and reconnaissance due to the restricted air space for maneuvering. Buildings and other obstructions often limit the air platform's line of sight, and can also hinder other required functions such as visual assessments. A small air vehicle is required that can operate in this cluttered urban environment and provide

robust environmental assessments. Innovative research to develop technologies for urban BIA and reconnaissance micro air vehicles could include platform functionality, vision based guidance and collision avoidance, sensors, multi-function structures, power systems, and data link/communication systems. The micro air platform must be released from an existing munition platform, and then have the capability to operate in a low level (minimum of 1 story) urban environment to assess the impact effects of the release munition, or to collect required reconnaissance information. The platform's projected area must have a maximum dimension of 10 inches, and the platform must have a maximum weight of 200 grams including supporting subsystems.

PHASE I: Define the proposed concept, identify key technologies, and predict the performance of the proposed design concept of a micro air platform for BIA and reconnaissance using modeling and simulation techniques. Identification of critical parameters and concept application to Concept of Employment (CONEMP) are key.

PHASE II: Finalize the design concept of the micro air platform for BIA and reconnaissance. Develop an operable prototype or suitable platform that demonstrates the intended technological concept in a cluttered urban environment. Final report should highlight prototype concept development and design, how CONEMPS are supported, and how the prototype concept takes into account the system integration process of additional required technologies to meet the defined CONEMPS.

DUAL USE COMMERCIALIZATION: Law enforcement has expressed interest in small vehicles for reconnaissance. Micro air vehicles are being considered for use in the toy industry as an alternative to conventional model aircraft.

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1. AFRL/MN Home Page: http://www.mn.afrl.af.mil

2. Micro Air Vehicles-Towards a New Dimension In Flight: http://darpa.mil/tto/man/man_auvsi.html

3. UAV Vehicle Overview: http://www.uavforum.com

KEYWORDS: Micro Air Vehicle (MAV), Munition Deployed Subsystems, Bomb Impact Assessment, MAV reconnaissance

AF05-165 TITLE: Mid Air Refueling of Powered Weapons

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

OBJECTIVE: Demonstrate the feasibility of one or more aspects of an enhanced endurance weapon concept to meet the requirement for persistent and sustained air operations over the battlefield. (Twenty fours per day, seven days a week (24/7) for up to 50 days)

DESCRIPTION: The Air Force Research Laboratory (AFRL) Munitions Directorate (MN) is conducting research on enhanced endurance weapon concepts to address the requirement for persistent and sustained air operations over the battlefield. The emerging requirements include network centric sustained and persistent combat operations, near continuous (24/7) intelligence, surveillance, and reconnaissance (ISR) using long loitering platforms with integrated sensor and munitions, and operating capability in areas inaccessible by manned aircraft.

AFRL is researching enhanced endurance weapon concepts, such as Area Dominator, to meet the emerging persistent attack requirements. Enhanced endurance requires increasing the combat loitering capability of future weapon concepts. One key area of research will clearly depend on significant increases in the propulsive components of the concept. AFRL/MN is looking to enhance the endurance of future powered weapons by a factor of 10 to 100. Areas of interest include the entire spectrum of enhanced endurance approaches. Specific technology solutions such as, enhanced high energy density fuels and solar power and expanded concept of operations (CONOPs) approaches such as, mid-air refueling/re-energizing of powered weapons, and lurk and loiter (fly-sit-fly) concepts are examples of acceptable approaches. Additional approaches include diesel/gas electric hybrid engines, advanced battery/electric engines and hyper-energetic approaches (e.g. hafnium, antimatter etc.). Downsizing of

existing technologies to be suitable for small unmanned weapons (<100 pounds) can be a significant technical challenge requiring new technology and will be considered. The purpose of this topic is to conduct research on one or more aspects of an enhanced endurance weapon concept that would permit persistent and sustained air operations for powered weapons for periods of 5 to 50 days.

PHASE I: Define an enhanced endurance weapon concept. Perform preliminary design and analysis to show that the approach is feasible. Identify one or more critical enhanced endurance technologies and the associated prototype hardware/software. Develop a research approach that includes a feasibility demonstration(s) of the associated prototype hardware/software necessary to prove of the concept's ability to meet the persistence requirements listed above. Identification of the critical technology demonstration(s) may include defining test objectives, method of test, performance requirements (i.e. success criterion), data requirements, and instrumentation requirements. Other logical step- by-step approaches are acceptable. Examples of critical technology experiments are characterization /performance tests of new high energy density fuels, solar cell performance testing, hybrid engine performance testing, flight demonstration of mid air refueling/re-energizing of powered weapons and vertical take off and landing demonstrations of lurk and loiter concepts. (These examples do not limit what concept or experiments the offeror may propose.)

PHASE II: Conduct one or more of the feasibility demonstrations of prototype hardware/software identified in Phase I. The demonstration(s) should demonstrate some key aspect of the concept and establish the feasibility and practicality of the proposed solution(s). Examples of feasibility demonstration(s) are compounding and testing new fuels, demonstration of advanced mid air docking maneuver software, conducting engine performance tests, and fabrication/ assembly of prototype hardware, and ground and/or flight testing. High fidelity simulations are acceptable proofs of appropriate technologies. (These examples do not limit what concept or experiments the offeror may propose.)

DUAL USE COMMERCIALIZATION: Demonstration of the feasibility of a concept to enable persistent and sustained operations over a battlefield will allow the warfighter to conduct continuous (24/7) search, destroy and damage assessment operations. The commander will have constellations of weapons in the battlespace providing continuous situational awareness and the ability to conduct continuous warfare. Persistent air vehicles will have enormous commercial application. Persistent air vehicles will be excellent platforms for communications e.g.. mobile cell phone towers. Additionally, persistent air vehicles could perform security, agricultural, forestry, weather, sporting event and news surveillance. The commercial possibilities are varied and economically significant.

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KEYWORDS: Enhanced endurance powered wepons, long loiter powered weapons,
Mid air refueling of powered weapons, solar powered weapons, high energy density fuels

AF05-166 TITLE: Jerk Reduction Technology (JRT)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

OBJECTIVE: Develop, test, and implement a novel mounting scheme to reduce the jerk experienced by a munition fuze.

DESCRIPTION: Considerable effort has been expended on trying to develop fuze instruments (such as accelerometers and other electronics) that can withstand the severe mechanical shock loads that occur in attacking

hardened, deeply-buried targets (HDBT). The magnitude of the acceleration experienced by fuze electronics in this mission varies but is invariably extremely large, many tens-of-thousands times the acceleration of gravity. However, the magnitude is not the only consideration: the acceleration occurs over very short time periods (sub-millisecond). The sudden, step-like nature of these impulses has an important implication: the spectral content of such a pulse is theoretically unbounded, creating large amplitude accelerations at very high frequencies. The spectral content of these accelerations can induce even high frequency resonant modes within the fuze that may lead to failure.

This SBIR seeks to identify novel concepts to reduce the "jerk", i.e., the time rate of change of the acceleration, in fuzes and/or fuze components (such as electronics) via a novel mounting scheme. This scheme should utilize novel materials, physical mechanisms (such as plastic mechanical deformation, etc.), or geometry/packaging to "flatten" the acceleration profile experienced by either 1) a full-scale fuze or 2) the critical electronics subsystems of a fuze.

The Phase I effort involves identifying several candidate schemes and using a first-principles approach to evaluate the efficacy in each. This will involve significant modeling of the proposed systems under realistic acceleration profiles. The modeling results will then be used to select the most promising design.

PHASE I: Design and model a mounting scheme that provides reduction of the jerk (i.e., rate of change of acceleration) in a fuze.

PHASE II: 1) Fabricate and test a prototype under shock loading. 2) Characterize the mechanical response of mounted fuzes under repetitive shock loads of varying magnitude, pulse shape, and duration.

DUAL USE COMMERCIALIZATION: A successful demonstration of this technology will lead to application of the mounting scheme in a wide variety of munitions platforms that experience a high-shock environment, such as air-delivered penetrating bombs and gun-launched munitions (such as land- and sea-based artillery shells). Some of the developed mounting schemes might find niche dual-use applications in crash-survivable instrumentation (i.e., "black boxes") and improving the survivability of systems in crash environments (such as automotive "crumple zones").

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KEYWORDS: Fuze, shock reduction, survivability, hard target, penetration, acceleration, deceleration, high-g, fuzewell

AF05-167 TITLE: Development of HFPB Structural Response Models for Steel Column/Girder Construction

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

OBJECTIVE: Develop High-Fidelity Physics-Based Fast Running Models for simulating the structural response of steel column/girder construction methods to air-delivered conventional weapons.

DESCRIPTION: The primary requirement is to determine if High-Fidelity Physics-Based (HFPB) models can be used to simulate the structural response of steel column and girder construction methods to the blast and fragmentation effects of air-to-ground delivered conventional weapons. Currently, the existing models do not handle the connections very well, which is an integral part of the problem. The model must handle the new small weapons being developed through the Air Force Research Laboratory Integrating Concepts process and the current larger weapons. From this HFPB model, fast running models (FRM) are to be derived to supplement the other structural response models for reinforced concrete and brick/stone/tile Concrete Masonry Unit (CMU) masonry currently found in Modular Effectiveness/Vulnerability Assessment (MEVA). These new models must also interface with the Smart Target Model Generator (STMG) (used to generate models of multi-story buildings i.e., targets) and the

different blast and fragment models used in MEVA. MEVA is a lethality/vulnerability program developed by AFRL/MNAL. One of its capabilities is to assess the vulnerability of various fixed targets to conventional weapons. It consists of different modules that are linked as required to conduct the required analysis. Currently, MEVA uses the pressure/impulse curves found in the Facility And Component Explosive Damage Assessment Program (FACEDAP) and DAHS manuals to calculate structural response for these fixed target types. The new models will replace those curves in MEVA. The finial FRM will need to have a short run time and an 80 percent statistical reliability. Potential offerors can receive a software developer's kit by contacting AFRL/MNAL, Norman Gagnon, norman.gagnon@eglin.af.mil, (850) 882-5767. The kit will contain the STMG, Blast and Fragment models, Structural Response component models, and MEVA interface information.

PHASE I: Provide proof of feasibility to determine if HFPB FRMs can simulate the structural response of steel column and girder construction methods (including connections) to air-to-ground delivered conventional weapons.

PHASE II: Develop, demonstrate and validate the accuracy of a HFPB FRM that can simulate the structural response of steel column and girder construction methods (including connections) to air-to-ground delivered conventional weapons.

DUAL USE COMMERCIALIZATION: Once the successful integration of this model into MEVA has been accomplished, the way is open to exploring the other similar codes that can benefit from the same technology. Most of these codes are developed and maintained by government agencies, such as the Technical Support Working Group (TSWG), Defense Threat Reduction Agency (DTRA), U.S. Army Engineer Research and Development Center (ERDC), U.S. Navy, and others. However, a few (e.g., ERASDAC) are commercial codes developed and marketed by contractors with licenses available for purchase. This will provide the ability to predict the Structural Response of civilian structures to conventional weapons or explosives and enable the better design of future structures.

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KEYWORDS: Structural Response, High-Fidelity Physics-Based (HFPB), Fast Running Models (FRM), Munition Effectiveness, Lethality & Vulnerability, Modular Effectiveness/Vulnerability Assessment (MEVA), Facility And Component Explosive Damage Assessment Program (FACEDAP), Steel Column and Girder Urban Construction.

AF05-168 TITLE: Novel 3D Shape Representations

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

OBJECTIVE: Identify and implement novel, real-time 3D shape representations for measured point-cloud data maximizing exploitation while minimizing computational complexity and bandwidth.

DESCRIPTION: The Interest in the use of 3D sensors for munitions autonomous agent applications is continually increasing. Common data sources include Laser Radar (LADAR), calibrated stereo cameras, and video utilizing structure from motion (SFM) algorithms. For each source, the sensor output is a range image combined with information on the sensor pointing direction and location at each frame. To emphasize the 3D structure and shape information, range images are normally transformed into a XYZ point cloud referenced to world or local coordinates.

While point cloud representations are easily extracted from range imagery, they have various shortcomings for both supervised and autonomous target acquisition and recognition applications. Foremost, individual points in the data have no explicit connectivity with other points to help define surfaces and objects which are building blocks of human perception and Automatic Target Acquisition/Automatic Target Recognition (ATA/ATR) algorithms. This motivates a change in shape representation in most applications - either to facilitate human reasoning over the 3D data or enable robust autonomous information extraction. Depending on the specific application, representations might include, but are not limited to faceted surfaces, spin images, spherical harmonics, geons, or abstract feature vectors.

Given that 3D representations are an active area of research, this SBIR effort seeks to develop solutions relevant to munitions and autonomous agents such as micro air vehicles. In this context, candidate representations must be compact, i.e., appropriate for transmission over low-bandwidth networks. They must also be computationally simple, as the processing must be done on vehicle, likely with limited processing resources.

PHASE I: Identify and implement candidate 3D shape representations using government provided synthetic and measured 3D data. In general, real and synthetic data will represent LADAR imagery with range and spatial sampling resolutions from 3cm - 24cm. The synthetic data will also contain various measurement noise levels. Data formats will be a combination of ASCII and binary data representing 3D points in XYZ coordinates and sensor meta data. Targets will be drawn from common military and civilian vehicles. To facilitate use of the data, the government will provide file specifications, data structures, and in some cases, helper applications in C or Matlab for each source of 3D data. This effort should include a performance analysis detailing each representation's computational complexity, bandwidth requirements, and accuracy compared to the point cloud data. Quantitative measures of shape reconstruction will need to be investigated in this phase.

PHASE II: Provide a real-time demonstration of shape representation and transmission over a low-bandwidth network. Source data will be obtained using a government provided LADAR or via simulation. Wherever possible, COTS hardware should be used to conduct the experiment. During this phase, the contractor should also consider how to fuse additional "meta data" to the 3D representation – an example being the average intensity return over a given surface patch.

DUAL USE COMMERCIALIZATION: With Phase II terminating with a successful demonstration, the contractor will be well positioned to transition the technology to an active acquisition program. The capabilities would be well suited to the surveillance UAV market and also for cooperative LADAR munitions. The civilian market for low-cost 3D sensors already exists. The technologies developed under this effort could reduce the cost of future industrial systems. The ability to apply meta data to 3D representations could be attractive in manufacturing settings where there is a desire to construct 3D models of parts with addition information on material or other properties.

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KEYWORDS: 3D Shape Representations, 3D Surface Reconstruction, LADAR, Structure From Motion, Stereo Vision

AF05-169 TITLE: High Resolution Urban & Natural Background Scene Generation For Small Cooperative Weapons

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Weapons

OBJECTIVE: Create a database of high-fidelity resolution 3-D backgrounds in multiple infrared wavebands for use in analyzing cooperative weapons in urban and mountainous environments.

DESCRIPTION: The Air Force Research Laboratory Munitions Directorate(AFRL/MN) is interested in advancing the current state-of-the-art infrared scene generation of 3-D urban and natural backgrounds to support algorithm development and testing. Scene generation requires accurate simulation of all aspects of the backgrounds including the temperature, emissivity, reflectivity, absorptivity, and geometric structure of realistic 3-D urban and natural environments. The goal of this effort is to create simulated visual and infrared databases of real world urban and mountainous environments that can be verified analytically from physics based radiative transfer calculations. The creation of the databases should be in a specified format. The databases should include the capability to vary the polygon count of the objects (buildings / mountains / valleys) or across the entire database. The polygons shall have surface normals with specified temperatures, emissivity, reflectivity, and absorptivity. The emissivity, reflectivity, and absorptivity will be based upon industry standard material typing data for urban and natural terrain. The temperatures shall be variable to account for time of day and time of year. The databases should be large enough to cover a 2Pi steradian field from a viewing sensor at altitudes from 0 – 10 km out to the horizon. The database development would evolve into an automated environment to develop 3-D databases based upon user specified parameters, to create nominal and stressing urban and mountainous databases that may include the capability to vary the street sizes, building sizes, building densities, roads, mountain peaks, trees, valleys, ridges, lakes, and rivers.

PHASE I: Develop a methodology for generation of the high-fidelity 3-D scenes for urban and natural terrain. Demonstrate the capability of generating realistic high-fidelity visual and infrared urban and mountainous terrain databases from 3-D wireframe files, including the temperatures, emissivity, reflectivity, absorptivity of given. Verify the simulation-generated scenes with analytically calculated results and report. Develop a prototype database viewer to display user-specified scene region (sub-regions) and scene components.

PHASE II: Detailed design and development of an automated high- fidelity infrared 3-D urban and natural scene generation environment. In addition, generate a finite number of varying urban and mountain scenes based upon real-world data and verify the simulated results with analytical calculations. The 3-D urban and mountain scene generation environments will be used to generate a TBD set of simulated 3-D urban and mountain databases. The 3-D urban and mountain scene generator shall be driven by a GUI and will provide full graphical display of the user-specified components of the generated scenes.

DUAL USE COMMERCIALIZATION: The generation of realistic 3-D urban and mountainous databases will be utilized by the PIOS program, for Optical Flow algorithm development/testing, and for other urban combat weapon sensor and signal processing design and development efforts. The 3-D urban and mountain scene generator will be integrated with representative codes such as Irma, CHAMP, real-Time CHAMP, FLITES, and BEST to support development and testing of sensors and algorithms in government, contractor research, and test facilities.

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KEYWORDS: Scene Generation, 3-D Urban/Terrain Database, Urban Combat, Low Altitude Air-To-Air Missile Engagements, Multi-Spectral, Natural Backgrounds

AF05-170 TITLE: Material Bonding For Lethal Air-to-Air Warheads

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Development of a Tantalum-Zirconium bonding technique suitable for munitions applications.

DESCRIPTION: Penetration performance is a function of density and strength of materials. But the effectiveness of a metal as a contributor to the lethal mechanisms can rely on other attributes such as chemical energy release. In the reaction of metals with oxygen the by-product of the chemical process is heat. From a weapons effectiveness perspective, this reaction is observed as a fire start mechanism, or depending on the nature of the reaction, overpressure effect. Both enhance the lethal damage a warhead can have on a target structure. The nature of the reaction is a fundamental property of materials depending on their affinity to react with oxygen, under various environmental conditions, typically oxygen atmosphere with elevated temperature and/or pressure. Since penetration is enhanced by increased density, it would seem prudent to bond a highly reactive metal, such as zirconium, to a high-density metal, such as tantalum. Possible processing techniques would be explosive driven bonding and electro-chemical deposition techniques. Whatever technique is utilized the figure of merit for success, as an initial concept phase, is to create a bond that can survive the initial shock loads during the acceleration of fragmenting warheads. These shock loads can produce extremely intense local tensile stress across the bond interface that could cause material separation, and therefore, negate the effectiveness of the material combination on the destruction of the target.

PHASE I: Demonstrate the processing technique, identify critical processing parameters, and conduct initial characterization of the bond interface.

PHASE II: Extend development of process parameters, scale-up process size sufficient for prototype warhead demonstration. Deliverables would include parts for proof of principle testing.

DUAL USE COMMERCIALIZATION: Phase III results can lead to the utilization of the bonding technology in the development of air-to-air warheads. The proper combination of materials with an effective bonding technique will increase the lethal performance of air-to-air warheads. Commercial applications for the bonding technology exist in the automotive and the aerospace industry. Primary commercial applications would be where unique properties of materials can be effectively combined to enhance product performance, or to reduce cost.

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KEYWORDS: Explosive Bonding, Explosive Welding, Material Processing, Tantalum, Zirconium, Warhead, Lethality

AF05-173 TITLE: Cryogenic Temperature Material Processing for Warhead Effectiveness

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a technique to process metals at cryogenic temperatures to enhance the mechanical properties for warhead applications.

DESCRIPTION: The engineering model for penetration developed by A. Tate (1967), see References 1-2, identifies the density and strength of a penetrator material as first order parameters. By changing the penetrator density and/or strength the effectiveness of a weapon as a penetrator can be influenced. For applications in chemical energy warheads (shape charges and explosively formed projectiles) other factors, like ductility and chemical energy release, are also important material characteristics of effective weapons. The material science community has aggressively pursued the development of Severe Plastic Deformation (SPD) to enhance the property of metal ductility. These advances are useful in design and manufacturing processes. For example, they can be exploited by reducing the tonnage to fabricate parts, and therefore, extend tooling life cycle and to allow the material to fill more intricate tooling geometries.

One example of SPD that has been successfully utilized is Equal Channel Angular Pressing (ECAP). By subjecting material to shear deformation, under confining pressure, metals can be processed to ultra-fine grain structure that can be exploited for enhanced material properties. An additional variable that can further enhance the outcome of SPD is the temperature of the material when processed. At low temperatures, (i.e., liguid nitrogen) the defect structure development is aided by the slower annilation rate. The manipulation of the metal defect structure by low temperature processing in combination with subsequent heat treatment will provide mechanical property characteristics of strength and ductility, see Reference 3, that can be exploited in warhead applications. Materials of interest to the Air Force include copper, tantalum and zirconium.

PHASE I: Demonstrate proof of principle processing technique at a pilot scale level. Conduct material characterization study of initial and final properties to demonstrate the benefit of severe plastic deformation at cryogenic temperature.

PHASE II: Scale processing to size suitable for processing material for warhead applications. Deliverable would include parts for proof of principle testing.

DUAL USE COMMERCIALIZATION: Phase III results can lead to the utilization of the metals processing technology in the development of chemical energy warheads. The enhanced strength provided by cryogenic material processing can be exploited for increase lethal performance of warheads. Commercial applications for the material processing technology include automotive and aerospace industry where increased strength of materials can reduce the cost to manufacture or material weight required for a specific engineering design.

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KEYWORDS: Cryogenic Temperature, Material Processing, Warhead, Lethality, SPD, Ductility

AF05-174 TITLE: Creative Mobile Terrain Sensing Multi-Valued Behavior Robots

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Weapons

OBJECTIVE: Develop creative terrain sensing and multi-valued behavior fusion algorithms for mobile autonomous robots.

DESCRIPTION: Due to the highly uncertain complex battlefield environments, autonomous mobile robots will have to employ creative behaviors to accomplish their objectives. Autonomous robot navigation in different terrains will require a variety of locomotion techniques. Robots may encounter grassy, sandy, rocky, wet and or snowy terrain during night or daytime operation. Using onboard sensors and sensing algorithms the robot must be able automatically detect the type of terrain and adjust its locomotion techniques accordingly in various levels of illumination. Autonomous robots must be capable of sensing and avoiding certain types of terrain (i.e. water puddles, ditches, mud etc…) depending on its locomotive capability. Innovative and flexible solutions are desired. Mobile robotics with creative terrain sensing and sensor fusion capabilities, maybe a good way to approach this problem. Recent advances in creative, self-training, artificial neural network object technology has paved the way for developing creative terrain sensing and multi-valued behavior fusion algorithms for autonomous mobile robots. In Phase I, alternative creative terrain sensing and multi-valued behavior fusion algorithms for autonomous mobile robots should be investigated and defined. The creative behavior algorithms approaches should allow for maximum levels of autonomy. Investigations of algorithms applicable to walking, crawling, and wheel based autonomous robots is desirable. Current approaches are primarily limited to illuminated homogenous terrain. Algorithms should be able to differentiate between a variety of terrains and use multi-valued behaviors to avoid and/or overcome obstacles in real-time. The algorithmic approach should allow the robot(s) to have the ability to continue learning during autonomous operations. The computational requirements of the new algorithms should be addressed in the investigation. Since performance will be a factor, alternative computing architectures may need to be investigated. Recent technology advances have resulted in several new computing architectures with increased computational capacity. Technical hurdles associated with developing and implementing the algorithms should be identified. In Phase II, Investigators should consider leveraging existing robotic platforms as well as developing new platforms for demonstrating the new algorithms. There are several commercial of the shelf mobile robotic platform that maybe suitable for use. The chosen platform should have maximum flexibility for implementing and demonstrating the newly developed algorithms. The chosen platform and computing architecture must be capable of demonstrating the algorithms in real-time.

PHASE I: Investigated and defined alternative creative terrain sensing and multi-valued behavior fusion algorithms for autonomous mobile robots. Establish computational performance goals for the alternative algorithmic approaches.

PHASE II: Implement the best approach from Phase I into hardware and software. Demonstrate the algorithms in a walking, crawling or wheel based autonomous robots in a variety of types of terrain with numerous obstacles in the pathway.

DUAL USE COMMERCIALIZATION: Technology developed on this program will have application for commercial and military robots and consumer toys. The technology could be used for Homeland Defense where autonomous multi-behavior robots protect power plants.

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KEYWORDS: autonomous mobile robots, multivalued behavior system, Self-learning, creative robots, sensor fusion, terrain sensing

AF05-178 TITLE: Development of Acoustic Models for High-Performance Combustors

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms

OBJECTIVE: Develop a computational approach to simulate the effect of interactions between turbulent fluctuations and kinetics on acoustic loads at high fuel-air ratios.

DESCRIPTION: To achieve significant improvement in determining/predicting the life of combustor liners in applications ranging from gas turbines to waste incineration, better design tools based on computational fluid dynamics (CFD) are needed. Accurate numerical simulation of combustion under turbulent flow conditions has to overcome a number of challenges in the area of fuel-air mixing, unsteady phenomena such as ignition and extinction, flame holding, interaction between turbulent fluctuations, and chemical kinetics. The turbulence/chemistry interactions can result in severe acoustic loads leading to resonance and failure of the liner material. In particular, the emphasis should be on high-pressure combustion of liquid fuels to address turbulence/chemistry-induced acoustic effects. Some of the desirable features of the acoustic models are 1) anisotropy, 2) freedom from topological constraints, 3) time-scale reliability, and 4) good performance for configurations with adverse pressure gradients and increased geometrical complexity. The acoustic model must feature 1) turbulence augmentation due to chemical heat release, 2) strong temperature dependence of the model to account for ignition and extinction 3) the ability to treat both fast and slow combustion kinetics well, and 4) applicable at high fuel-air ratio operation. Turbulence/chemistry interaction effects and modification in level of turbulence due to instantaneous heat release are the main acoustic drivers.

PHASE I: Develop the framework for unsteady turbulence/chemistry acoustics model and establish the feasibility of the model by presenting an example of the enhancement over the current models in predictive capability applied to available published acoustic data for gas turbine combustors.

PHASE II: Extend the model for high fuel-air ratio operation, validate the model with benchmark experiments, and implement the validated model as modules with the CFD capability. Demonstrate the capability for a typical high-performance combustor liner configuration.

DUAL USE COMMERCIALIZATION: High-speed versions of the acoustic models will have applications in advanced scramjet engines structural integrity, which have the potential to impact the payload capability of space boosters and transatmospheric vehicles using a single stage. Liner acoustic loads estimation for the land-based turbine engine combustors is a needed technology. The developed technology will be applicable in augmentor design and analysis. This technology will be equally important for ground-based gas turbine engines for power generation in the commercial environment.

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KEYWORDS: chemical kinetics, turbulence models, interactions, time scales, pressure fluctuations, high fuel-air ratio, acoustic loads, material failure, resonance, rigs, bench mark experiments, combustor liners

AF05-179 TITLE: Thermal Barrier Coating Life Determination

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an analytical model that will turn quantitative nondestructive inspection (NDI) data into remaining durability life measures for thermal barrier coated turbine engine components.

DESCRIPTION: Just as low-cost NDI methods are needed to determine the turbine barrier coating (TBC) structural integrity of both as fabricated and fielded engine components, analytical models are needed to turn the NDI data into meaningful remaining durability life measures that can be used to make keep/refurbish/scrap decisions. There are three areas in which such a model may be applied: 1) Maintenance inspection, 2) Screening method for new coating systems, and 3) Quality assurance. Premature failure of thermal protective coatings is a significant contributor to the high cost of maintaining turbine engines. The ability to predict such failures would enable the maintainer to remove components for cause rather than as a precaution. In recent years, efforts to improve coating durability have been hampered by the inability to objectively compare the relative merits of competing coating systems. Developing more reliable materials screening methods would enable the developer to rank order potential coating systems more efficiently. Lastly, the quality of the applied TBC is critical to the durability and life of the coated turbine engine part. Applying the thermal protective coatings uniformly over complex turbine airfoil shapes can be quite a challenging task. Variations in the thickness, tightness of the bonding to the substrate, etc., can have a major impact on coating durability. Therefore, the goal of this effort is to develop an NDI-based analytical model that will enable the user to make objective keep/refurbish/scrap decisions concerning both as-fabricated and fielded thermal barrier coated components. As a secondary goal, this model must be put into a user-friendly form that is compatible with the information systems that are currently being used by the fabricators/repairers/maintainers to track engine hardware.

PHASE I: Develop a PC-compatible prototype software package and a user’s manual for the analysis and modeling of test results from one or more selected nondestructive inspection method(s) for thermal barrier coated turbine airfoils.

PHASE II: Validate the analytical model using both as-fabricated and exposed coated engine components, and produce a user-friendly software package, a searchable user’s manual, and a training plan for fabricators and maintainers of coated engine components.

DUAL USE COMMERCIALIZATION: The potential military applications for this technology include maintenance depot tracking of coated parts in existing and advanced fighter, bomber, and helicopter engines. The potential commercial applications include manufacturing quality assurance inspections and end-user maintenance inspections and tracking of coated parts in commercial aircraft and ground-based power generators.

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KEYWORDS: NDI, nondestructive inspection, thermal barrier coating, TBC, life determination, NDI-based life determination, life prediction models, engine component maintenance, engine component tracking systems

AF05-180 TITLE: Advanced Redundancy Management Strategies for Engine/Aircraft Control

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop compact, efficient redundancy management architectures for electronic engine control and aerospace controls.

DESCRIPTION: Greater processing power and increasing control capability of electronics is directly attributable to use of semiconductor components (integrated circuits) with higher density and speed. New aircraft engines will employ controls with higher throughput Central Processing Units (CPUs) due to increased number of control loops and additional diagnostic/prognostic functions. Over the next ten years, a majority of engine systems will be upgrading their full authority digital engine controls (FADECs) for improved performance, reduced maintainability and reduced cost. However, the rising maturity of more electric systems will impose a significantly increased requirement for controls and semiconductor devices on engines and aircraft. Electronics capability (submicron IC technologies), mostly trouble free in commercial applications, are vulnerable to several effects imposed by the aerospace environment. High temperature, vibration, and radiation (neutrons, alpha, etc) at altitude are now becoming significant risk drivers for new designs (single-event upset and reduced temperature cycles to failure are examples). Operation in this environment directly leads to more electronic failures and higher error rates. State-of-the-art methods to control the effects of errors are well documented. Universally accepted approaches use redundant circuits and error correcting techniques such as parity, polynomial Cyclic Redundancy Checks (CRCs), and Hamming codes. These methods, though effective, impose a large penalty on the application in terms of circuit board space and processing power. An example is correcting a one bit error in an eight bit system. Parity imposes a 25-percent penalty, while the overhead for compact disk (CDR 8-14 coder) error correction is close to 50-percent. The cost in terms of board space and throughput on engine FADECs is equally high. To make a significant improvement in current engine control capability, technologies that implement error accommodation, prediction, and graceful degradation without significant hardware and speed overhead are required. Although mechanical and all biological systems often have graceful failure modes, it is the exception in electronic systems. Therefore, the topic goal is to extend these characteristics to electronic engine control systems. Suitable research activities include: electronic circuit life modeling (on-board), sensor modeling, circuit component integrated models, reconfigurable hardware and software architectures as well as information communication models. Research into distributed software control as well as reconfigurable control is appropriate. An additional goal of the research is to develop a conceptual design of a controller system that implements redundancy and fault accommodation through architecture rather than employing multiple copies of hardware and software that can be turned on or off as failures occur. The conceptual design will minimize hardware compared with state-of-the-art redundant (multiple) designs. Demonstration of the results will be shown through simulation.

PHASE I: Investigate and develop conceptual designs for advanced controllers implementing novel redundancy management architectures. Determine technical feasibility of the concept through simulation and appropriate analytical models.

PHASE II: Design and fabricate prototype hardware, based on the conceptual design work accomplished under the Phase I program. This hardware will be evaluated and used to demonstrate the feasibility of the technology for advanced turbine engines.

DUAL USE COMMERCIALIZATION: Commerical and military engines and aircraft will primarily benefit from the technology. Benefits include increased safety, weight savings, and improved mission success rates.

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3. Walker, I.D., “Dynamic Fault Reconfigurable Intelligent Control Architectures for Robotics," 1993 Fifth American Nuclear Society, Knoxville, TN, 1993, pp. 305-312.

KEYWORDS: engine controls, fault tolerance, reconfigurable controls, learning algorithms, upset avoidance, fault accommodating controls, redundant computing

AF05-181 TITLE: Coatings and Surface Treatment for Bearing Wear and Corrosion Prevention in Advanced Gas Turbine Engines

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop and demonstrate bearing coatings and/or surface treatments for advanced gas turbine engine applications.

DESCRIPTION: Bearings for advanced gas turbine engines for fighter aircraft and the Versatile Affordable Advanced Turbine Engines (VAATE) programs will experience increased DN (bearing speed parameter calculated by multiplying the bearing bore in millimeters by the bearing speed in revolutions per minute), increased load and high temperatures resulting in boundary lubrication, increased metal to metal contact and increased wear and corrosion. State-of-the-art (SOA) materials such as Pyrowear 675, CSS-42L and silicon nitride, to name a few, are potential candidates being considered to meet these demanding requirements. Coatings and surface modifications for these materials are also being considered in order to increase fatigue life, reduce wear, increase corrosion resistance, and provide a good thermal barrier. Coatings are considered to be one approach for improving the material properties of these advanced bearing materials while providing durability to the bearing/lubrication system with acceptable friction and corrosion resistance over a wide range of temperatures and engine duty cycles. Tribological films commonly experience poor adhesion when used with these advanced materials. Coatings have the potential of providing significant improvements in mechanical systems performance, satisfying many goals for advanced gas turbine engines bearings. Laser surface texturing and other surface modification techniques have also been investigated as a method to improve the tribological performance of bearing materials. Investigating the tribological properties of any bearing material with coating or surface modifications should be viewed as a system. Investigations are enhanced with the use of modeling and bench top screening tests. Criteria for testing include, but are not limited to, wear reduction, increased corrosion resistance, fatigue life enhancement, improved thermal properties, and compatibility with current and advanced materials.

PHASE I: Identify potential performance enhancements and limitations for SOA materials for use with advanced lubricants in VAATE main shaft bearings. Enhancements should meet or exceed performance of current M-50 bearings. Surface modifications should be reproducible, easy to apply and affordable.

PHASE II: Test, evaluate, and optimize the most promising bearing surface treatments identified in Phase I. Optimized surface modifications shall be demonstrated on full-scale bearing tests with co-operation and/or participation of a major gas turbine manufacturer.

DUAL USE COMMERCIALIZATION: Improved coating modeling and coatings demonstrations will greatly benefit the military's ability to maintain fleet readiness, improve commercial airlines engine reliability and maintainability, extend maintenance on ship power generators and ground based power generator turbines.

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1. Grant, D. H., Chin, H. A., Klenke, C., Galbato, A. T., Ragen, M. A., and Spitzer, R. F., “High Temperature Aircraft Turbine Engine Bearing and Lubrication System Development”, Bearing Steels: Into the 21st Century, ASTM STP 1327, J. J. C. Hoo and W. B. Green, Eds., American Society for Testing Materials, West Conshohocken, PA, 1998.

2. Chen, Y. H., Polonsky, I. A., Chun, Y. W., and Keer, L. M., “Tribological Properties and Rolling-Contact Fatigue Lives of TiN/SiNx Multilayer Coatings," Surface and Coatings Technology 154, pp. 152-161, 2002.

3. Erdemir, A., Eryilmaz, O. L., Nilufer, I. B., and Fenske, G. R., “Synthesis of Superlow-Friction Carbon Films From Highly Hydrogenated Methane Plasmas," Surface & Coatings Technology 133-134, pp. 448-454, 2000.

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5. Middleton, R. M., Huang, P. J., Wells, M. G. H. and Kant, R. A., “Effect of Coatings on Rolling Contact Fatigue Behavior of M50 Bearing Steel,” Surface Engineering, Vol. 7, No. 4, 1991.

KEYWORDS: turbine engines, bearings, surface modification, coatings, modeling, tribological film

AF05-182 TITLE: Innovative Combustor Concepts for Advanced High-Performance Military Gas Turbine Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a technology base for high-heat release, low-emissions innovative combustor concepts, aiming at improved performance with affordability as a design parameter with experimental proof.

DESCRIPTION: To meet the gas turbine engine propulsion requirements of future advanced military aircrafts, the engine components must be developed to operate at conditions well beyond the current technology. This includes design considerations of weight savings, improved operating characteristics, and efficient integration and packaging to meet the performance goals. Combustor components should be designed to deliver the maximum amount of heat release, with fuel economy, while providing low pollutant emissions. Conventional combustion systems have inlet guide vanes, diffuser, an array of fuel injectors, cooling circuits, heat exchangers, and exit guide vanes. To realize performance gains of increasing the thrust-to-weight ratio and affordability with increased cost savings, advanced gas turbine combustors needed to be evaluated in parallel with advanced fuel injection, improved fuel-air mixing technologies, and efficient front end design of the combustors. The ease of adapting these changes, without unduly altering the current fighter engine flow path is desired. Therefore, the purpose of this effort is twofold: (1) Identify combustion system improvements based on existing and revolutionary hybrid combustor concepts that can include traditional and nontraditional technologies, and (2) Apply analysis methodology for the suggested concepts to assess in-depth performance gains or losses and from a perspective of overall engine performance.

PHASE I: Develop novel concepts and verify their functionality, including flame stability and operational characteristics by applying suitable analysis methods, and suggest affordability and performance improvements of such concepts compared to conventional combustors.

PHASE II: Down-select the most promising concept and utilize detailed analysis methods and experimental programs to verify the performance, affordability, mechanical complexity, ease of integration and packaging, structural integrity, and demonstrate the concept for realistic conditions of interest.

DUAL USE COMMERCIALIZATION: The developed technology will be useful in both military and commercial industries that use gas turbines. It would also offer enhanced performance combustors for aero propulsion and reusable launch vehicles.

REFERENCES:
1. Norris, Guy, “Propelling Changes," Flight International, 5 November 1997, Vol. 152, No. 4599, pp. 35-37.

2. Koop, William E., “The Integrated High Performance Turbine Engine Technology (IHPTET) program,” AIAA, International Society for Air Breathing Engines, AAAF, et al., International Symposium on Air Breathing Engines, 13th, Chattanooga, TN, 7-12 September 1997, Report No. ISABE-97-7175.

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KEYWORDS: advanced combustor system, conventional and unconventional combustion systems, affordable future concepts, high-performance military gas turbine combustors, combined cycle combustors, high temperature, JP-8 fuel, novel flame holding techniques, advanced materials, lower emissions, weight savings, enhanced thrust

AF05-183 TITLE: Field Mistuning Inspection Tool

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop an automatic laser measurement device that can rapidly gather geometry data of turbine engine blisks and process the data for field mistuning inspections.

DESCRIPTION: Blade to blade variations in turbine engine rotors lead to the well-documented phenomenon of mistuning. Mistuning can cause an amplification of resonant response by up to 400 percent. Mistuning has been identified as a primary factor in high cycle fatigue (HCF) failures. To improve robustness in future designs, these components will need to be inspected for their mistuning characteristics. High-response rotors will be identified for refurbishment. This leads to a need for a rapid mistuning evaluation. Further, when components are in the field, usage may change the blade to blade characteristics of the rotor, requiring additional mistuning evaluation. This topic is focused on this need and its objective is to build an automated inspection tool that measures rotor geometry and automatically performs a bench-level test of mistuning.

Currently, turbine engine manufacturers are able to measure geometry data of turbine engine components using coordinate measurement machines (CMM). However, this data is of extremely low resolution and is only supportive of quality control purposes. The capability to gather data using a laser measurement device currently exists and has been used to measure single turbine engine blades. Measurement of a single turbine engine blade using a laser line scanner demonstrated that, from setup to completion, 13,300 points were gathered every minute. With the speed and high degree of resolution that laser measurement provides, the benefits of quality control, reverse engineering, finite element analysis (FEA), and probabilistic design now become possible.

Recent research has shown that by implementing a forced response experiment using a traveling wave excitation system and a laser vibrometer for velocity measurement, the amount of mistuning present in that component can be calculated.

Innovative ideas to incorporate the use of laser measurement devices (geometry and vibration) into a package that will allow for the complete three dimensional measurement of bladed disks is being sought. These measurement devices will be combined with computational FEA and mistuning prediction codes to determine the serviceability of an inspected component. If determined suitable for repair, recommendations to return the component to its tuned or lowest forced response configuration would be made. After repair, the component could then be reinspected to ensure that the necessary repairs had been conducted.

PHASE I: Develop and demonstrate a process that will update/develop an FEA model from geometric measurements or implement mistuning identification algorithms from forced response data to determine the amount of mistuning present in a rotor.

PHASE II: Automate 3-D geometric and/or vibration measurements with variable engine order excitation into a timely and seamless process. Automatic calculation of analytical and experimental mistuning is required.

DUAL USE COMMERCIALIZATION: Land-based turbines and marine-based turbines for military and commercial aircraft, automotive, all industries that are involved with part inspection, reverse engineering, FEA, and probabilistic design.

REFERENCES:
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2. Brown, J.M., "Probabilistic Analysis of Geometric Uncertainty Effects on Blade Modal Response," Proceedings of IGTI 2003: 2003 ASME Turbo Expo, 13-16 June 2002. Paper No. GT2003-38557 (2002).

KEYWORDS: laser measurement, laser scanning, CMM, reverse engineering, finite element analysis, FEA, probabilistic design

AF05-184 TITLE: Passive Thermal Management System for High-Temperature Military Aircraft Actuation System

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop a passive thermal management system for next-generation, high-temperature, fighter-type military aircraft flight control electronics and electrical actuation systems.

DESCRIPTION: Development of high-temperature, high-efficiency, and high-density power electronic component technologies, part of the more electric aircraft (MEA) effort, offers opportunities for passive, compact, and lightweight thermal management systems for aircraft actuation systems. The next-generation power electronics would operate at a cold plate temperature of 200 °C, making it possible to reject its heat through the structure to the ambient environment without active cooling. This development program is a passive cooling system for military aircraft electrical flight control actuation systems operating at altitudes up to and above 40 k ft at supersonic speeds. This cooling system has to perform under variable body force (up to 9 g) due to aircraft maneuvering, under transient heat load, extreme temperature environments (-55 to 200 °C), and vibration. Specifically, the system has to be able to acquire heat at 200 °C, 500 watts (~3 W/cm2) continuously and 5,000 watts (~30 W/cm2) transient (less than 1 second), and reject heat to ambient of -55 °C to 140 °C. A thermal energy storage approach is strongly encouraged for transient heat loads to average out the high heat flux, allowing more compact and lightweight final heat rejection. Phase change material (PCM) has a very large theoretical capacity to absorb and reject heat at near constant temperature without significant volume change, ideal for thermal energy storage. However, without enhancement, PCMs has very low thermal conductivity, typically 0.2 to 0.3 W/mK. There have been many efforts to enhance the thermal conductivity of PCMs to enable their use in thermal management systems. High-thermal-conductivity foam filled with a PCM is one example in which thermal conductivity as high as 200 W/mK was reported. This program seeks novel approaches and technologies to enhance the heat transfer rate of PCMs and their interface for heat absorption and rejection, and to yield an overall lightweight and compact system.

PHASE I: Determine the technical feasibility of the proposed innovation, including analysis, design, and experimental approach for demonstration of the concept of heat acquisition, storage, transportation, and rejection.

PHASE II: Perform detailed analysis, design, fabrication, and testing of the proposed passive thermal management system demonstrator for the fighter-type military aircraft flight control actuation system. Validate models for the design using data from appropriate diagnostics. Assess performance of the design in simulated or actual application environments.

DUAL USE COMMERCIALIZATION: Perform integration and packaging of the passive cooling system into aircraft actuation systems for civilian and military applications, such as military and commercial aircraft and unmanned air vehicles.

REFERENCES:
1. D. L. Vrable and K. L. Yerkes, "A thermal management concept for more electric aircraft power system application," SAE 1998 TRANSACTIONS, Journal of Aerospace, Section 1, Vol 107, pp. 181-187.

2. S. K. Thomas and K. L. Yerkes, “Quasi-Steady-State performance of a Heat Pipe Subjected to Transient Acceleration Loadings,” Journal of Thermophysics and Heat Transfer, Vol. 11, No. 2, pp. 306-309, 1996.

KEYWORDS: heat transfer, thermal management, electrical actuation, high-temperature electronics, thermal energy storage, phase change material

AF05-185 TITLE: Integration of Engine Failure and Trending Data to Support Reliability Centered Maintenance

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Develop a methodology to integrate disparate engine data systems to support full implementation of a Reliability Centered Maintenance (RCM) concept.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Knowledge based system tools for propulsion managers that enable full implementation of Reliability Centered Maintenance (RCM) concepts do not exist. The primary barrier to RCM tool development is that propulsion data is distributed across multiple information systems (i.e. Reliability and Maintainability Information System (REMIS), Comprehensive Engine Management System (CEMS), Comprehensive Engine Trending and Diagnostic System (CETADS), Joint Oil Analysis Program (JOAP), Interactive Electronic Technical Manuals (IETMS)). Extracting and integrating data from relevant systems presents a significant challenge. Given the data, fusion techniques are required to enable further development of RCM algorithms and tools.

PHASE I: Evaluate current and proposed information system data content collected in the support of various propulsion management activities. Develop a data fusion methodology that will support RCM tool development and program goals.

PHASE II: Demonstrate the Phase 1 data fusion methodology and provide a representative RCM tool that can perform a life prediction.

DUAL USE COMMERCIALIZATION: Commercial aircraft equipment management systems could potentially benefit from this technology. The military aircraft management systems that could potentially benefit from this technology are the Autonomic Logistics Information System (ALIS), the Air Force Enterprise Knowledge Service (AFKS, aka Enterprise Data Warehouse (EDW)) and ASC/AA Enterprise Knowledge Management (EKM) in support of legacy propulsion management concepts.

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3. Putting CBM and EHM in Perspective, by Dr. Link Jaw, Scientific Monitoring, Inc, Maintenance Technology Magazine, November 2001, http://www.mt-online.com/articles/1101_cbmehm.cfm.

KEYWORDS: data warehousing, diagnostics, prognostics, reliability-centered maintenance, engine health management, conditioned based maintenance, data integration

AF05-186 TITLE: Maintenance Cost Model for Advanced Propulsion Technologies

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a system for projecting mature maintenance costs from prototype design data for advanced propulsion system materials and components.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Reliability centered maintenance (RCM) practices attempt to optimize engine maintenance costs per flight hour. To correctly make RCM decisions, two estimates must be accurate: expected time on wing, and component costs. Expected time on wing estimates are accomplished by field data and Weibull distributions. The cost estimation presents a more significant problem. A given component may survive for several engine maintenance removals, so the component maintenance costs should be prorated. The relevant issue is allocating costs without knowing how many engine builds the component will last. This topic asks for an innovative solution to use reliability data and established cost estimates to determine a statistically rigorous method to allocate maintenance costs in the RCM decision making process. The solution must be compatible with current RCM tools and reduce variance in the cost per flight hour metric due to incorrect cost allocation over the life of an engine.

PHASE I: Formulate a methodology that extends the state of the art for projecting maintenance costs for gas turbine components across several engine builds, compatible with current RCM tools.

PHASE II: Produce a reliable, documented software tool, applicable to engine parts, grounded in actual data, to predict mature maintenance costs.

DUAL USE COMMERCIALIZATION: Maintenance cost projections are important for all industries, particularly aerospace, for assessing the maintenance decisions for commercial or military applications.

REFERENCES:
1. Defense Manufacturing Conference '01, Proceedings of Technical Presentations, Volumes I and II, "A Manufacturing Odyssey", 26-28 Nov 2001, Las Vegas, NV.

KEYWORDS: gas turbine engines, reparability, repair processes, maintenance cost estimation, cost analysis, cost modeling

AF05-187 TITLE: Gear Material and Lubrication for Advanced Gas Turbine Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop gear materials, surface technology, and compatibility with advanced lubricants to enable a large step improvement in gear performance and durability.

DESCRIPTION: Mechanical components for advanced gas turbine engines require significantly greater durability to accommodate the required loads, speeds, temperatures, and life cycle costs. Advances in gear materials and lubrication have not kept pace with advances in bearings.

Trends in main shaft bearings are toward advanced fracture-tough, corrosion-resistant materials. To satisfy total propulsion system performance, gear auxiliary drive systems require new generation materials and engineered surfaces. There is a significant cost impact due to rejection of expensive gears at overhaul due to corrosion. Technology from corrosion resistant and fracture-tough bearing materials can be transferred to gear systems by tailoring tribology-controlling attributes to maximize gear performance capabilities such as scuffing resistance at high sliding velocity. Surface durability can be enhanced with surface processing techniques to improve microstructure, hardness, compressive stresses, surface texture/topography, and surface chemistry. Surface chemistry must be compatible with advanced engine or gearbox oils. For special cases, new oil base stocks and chemical additives may be required to satisfy gear systems with unconventional materials.

Advancing gear technology requires a total material, manufacturing, environmental, and tribology systems approach for technology design and testing. A systematic development approach is needed to satisfy all requirements for tooth strength, toughness, corrosion resistance, abrasive/adhesive wear, surface pitting/frosting, and spalling. Special considerations must be given for oil-off operation and heat conduction from the surface.

Various tribological mechanisms must function effectively and interactively as a system over a wide range of performance and adverse conditions to maximize gear system performance.

Tests are required to map tribological performance at all engine-relevant conditions across the tooth face, particularly for spiral bevel gears. This mapping must cover the conditions across the face when gears are exposed to all of the environmental conditions imposed on operating gears, including extreme/adverse conditions.

Test parameters are needed to link contact operating conditions in service to performance parameters for design. Cost-effective test methodologies are needed to provide guidance for material development and advanced surface technologies. Empirical test data and associated predictive models are required for future virtual engine design software. The capability to develop and test durability attributes should be one of the primary goals of this effort.

This effort should develop one or more test machines and associated cost-effective test methodologies encompassing engine-relevant conditions for evaluating the capability of candidate gear materials. Such test data, in combination with currently available tests, should be able to screen candidate gear material systems, and minimize the need for full-scale gear testing. The effort should also provide empirical data and identify parameters for design and modeling.

Recommendations for useful modeling opportunities are encouraged. Some modeling work may be a part of this effort. The empirical data should include evaluation of the capability of as many advanced candidate gear material systems as may be available for testing as well as baseline gear material systems.

PHASE I: Based on an assessment of real-world gear operating conditions and gear materials, develop innovative machine design concepts for gear materials testing and evaluation. Identify and define test and design parameters for machine operation that would correlate with actual engine operation. Define the gear material system testing needs and design one or more machines to meet the needs. Identify and define test and design parameters.

PHASE II: Complete test machine fabrication and test methodology and automation. Evaluate as many candidate gear material systems as possible. Complete modeling and design parameter guidance packages. Provide recommendations for future gear capability improvement opportunities.

DUAL USE COMMERCIALIZATION: Military applications include aircraft gear systems and ground-based systems. Commercial applications include aircraft systems and industrial gear systems.

REFERENCES:
1. Johnson, Michael et al., “Thin Dense Chrome Bearing Insertion Program; Pyrowear 675 and Cronidur Wear Testing," AFRL-PR-WP-TR-1998-2110 (AD No. ADA361451).

2. Townsend, Dennis P. and Bamberger, Eric N., “Surface Fatigue Life of M50NIL and AISI 9310 Gears and Rolling-Contact Bars,” J. Propulsion, Vol. 7, No. 4, p. 642.

KEYWORDS: gear material, tribology, gears, lubrication, material science, chemistry, testing, test methods, modeling, metallurgy

AF05-188 TITLE: Methodology for the Real-Time Management of Aero Gas Turbine Engine Usage Data

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a novel methodology for the real-time management of aero gas turbine engine life and usage data.

DESCRIPTION: The monitoring of gas turbine component life and usage is becoming increasingly complex and is generating greater orders of magnitude of data that require processing, storage, and almost certainly retrieval and re-processing.

The issue can be illustrated through the example of the low cycle fatigue life of critical components. For older engines, this is specified simply in terms of a number of cycles. These may be defined for the whole component, or for specific high-stress features of that component. The consumption, or usage, of these cycles must then be calculated, monitored, and managed for a fleet of engines as the engines are flown and run. The early method of doing this was to estimate the mean number of cycles that would be consumed each flying hour, and then allocate a flying hour life. Subsequent methods included installing devices on aircraft to count and sum major and minor cycles. The most recent thinking has been for the installation of much more precise (but complex) on-board algorithms to calculate cycle consumption in real time as a function of spool speeds, temperatures, and their rates of change; these provide either for the download of processed data or raw data (for off-board processing). All of these methods have disadvantages. The early models are oversimplified and therefore, conservative and wasteful of potential component usage. The later ones are complex, processor intensive, and lead to significant data management problems (particularly when data must be maintained against individual components, through several overhauls, throughout the component's life). For example, one advanced engine has on-board algorithms for real-time usage calculation for over 120 critical areas that are then managed off-board.

This topic is searching for a novel methodology for managing gas turbine life and usage data in real time that is data efficient, manageable, effective, and safe. It is not looking for an Information Technology (IT) system architecture, but the methodology to be used on one. The methodology should be flexible enough to allow for re-assessment of consumption where subsequent knowledge provides a revised understanding of the way the damage is accrued. The solution might involve the recognition of different regimes of damage accrual (including transients) that could be summed, or feature extraction, but should reflect the physics of the damage being imparted to the component and not be just a data reduction or compression method. An analogy might be the algorithms developed for sound, pictures, and video developed by the JPEG and MPEG groups.

PHASE I: Develop a novel conceptual methodology for the management of gas turbine life and usage data that is data efficient, manageable, effective, safe, and flexible.

PHASE II: Develop algorithms that are compatible with industry standards to represent the on-board and off-board elements of a representative gas turbine life and usage data management system and to demonstrate its functionality.

DUAL USE COMMERCIALIZATION: Commercial applications include aircraft and power generation gas turbines. Military applications include aircraft, ship, and ground vehicle gas turbines.

REFERENCES:
1. E. L. Suarez, J. Hansen, M. Duffy, and P. Gatlin, AIAA 97-2900, New Approach to Tracking Engine Life, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, July 1997, Seattle, Washington.

2. E. L. Suarez, M. J. Duffy, D. Seto, and S. M. Cote, AIAA 2003-4985, Advanced Life Prediction Systems for Gas Turbine Engines, 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, July 2003, Huntsville, Alabama.

KEYWORDS: usage, damage, life, consumption, monitoring, data, management, Low Cycle Fatigue (LCF)

AF05-189 TITLE: Bayesian Engine Reliability Development Tool

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a tool that will enhance the industry capability to meet Engine Structural Integrity Program (ENSIP) failure probabilistic design systems.

DESCRIPTION: Predicting engine reliability is critical for both new engine development programs and existing engine fleets. In part, to support these needs, prime contractors have been developing probabilistic design systems for both blade high-cycle fatigue (HCF) and disk low-cycle fatigue (LCF). In current research efforts being conducted under the National HCF program in the area of probabilistic design, several enhancements to probabilistic design have been identified. These enhancements include: the ability to track reliability throughout the development process and operation; the ability to maximize the effectiveness of available information such as expert opinion, analysis, and test data; determination early in the development of critical design parameters so that test programs can be structured to maximize uncertainty reduction; model the reliability at the system level; and the capability to assign a confidence on the reliability calculation that accounts for lack of data, modeling error, and usage uncertainty. The reliability-based development will be applied to a fighter aircraft demonstrator engine and a to-be-determined fielded engine. The reliability-based development relies on technologies such as Bayesian analysis, multiple-loop probabilistic calculations, expert-elicitation, and uncertainty quantification. These approaches are currently being implemented with a collection of statistical shareware and hand-coded algorithms, and in some cases, advanced methods are not applied when code is not available.

There is a strong need for a development tool that incorporates existing capabilities in reliability calculations and develops new capabilities that are specific to the turbine engine development process. A criteria for the tool is for it to simplify the creation of a system-level reliability model. The model development will be “graphically assisted.” The graphically-assisted modeling tool would allow a “drag-and-drop” approach to building a logic diagram that defines model parameters and their interaction with physical models. The payoff for this tool will be: more accurate reliability calculations; capability to integrate information from experts, analysis and test; focus test program resources to improve reliability; determine system level effects; and to give engine program offices a reliability calculation with upper and lower confidence bounds.

PHASE I: Incorporate existing reliability prediction capabilities and incorporate them into a graphically assisted modeling tool. This tool at this stage will incorporate Bayesian analysis capabilities, definition of multiple Monte Carlo loops, and the ability to interface with finite element software codes.

PHASE II: Conduct research on new reliability prediction capabilities that are specific to turbine engines and incorporate these into the tool. The research to be conducted will include optimization of test resources, advanced approaches for quantifying uncertainty in analysis and test, and advanced methods for quantifying expert opinions.

DUAL USE COMMERCIALIZATION: The military applications, for this technology, include fighter aircraft and fighter engines. The commercial applications include aircraft, land-based turbines, automotive, and all industries that require reliability calculations of designs.

REFERENCES:
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2. Robert, C., The Bayesian Choice. Springer texts in statistics. Springer, New York, 1994.

KEYWORDS: reliability, probabilistics, Bayesian, uncertainty, confidence, development process

AF05-190 TITLE: High-Temperature Wiring for Engine Bays

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop high-temperature wiring for engine bays.

DESCRIPTION: Develop wiring and/or a fiber optics suite capable of sustaining high temperatures in engine bays. Advances in on-board engine measurement devices are enabling more sophisticated methods of monitoring engine condition. Control systems are being designed that directly manage more engine components than before. At the same time, gas turbine engines are being designed to run at sustained higher temperature conditions. In many cases, the limiting factor to the implementation of these new controls and diagnostic capabilities are not the devices themselves, but the temperature capability of the associated wiring. There is interest in developing economical but durable high-temperature wiring that can replace existing wiring harnesses being utilized on the hot sections of the engine, as well as allow introduction of electronics into areas of the engine that were previously considered too hot for electronics.

As an example, there is interest in locating measurement devices in the engine bearings in order to be closer to the sources of engine vibration, thereby minimizing the mechanical transmission path to the sensor, enabling a more detailed analysis of the bearing condition. Sensors exist which are capable of operating in the environment of the bearing, but no viable means to transmit the signal from the sensor to the engine control through the hot engine environment by wire has been identified.

To ensure the integrity of the wiring system, the solution should also include some predictive capability as to the health of the wiring harness and forecast when the wiring harness will need to be repaired or replaced. Sensor connections, sensor integration, prognostics and materials technology are critical elements to the reliability and survivability in a high-temperature environment. Achieving the upper limits of the temperature in the turbine section can be incrementally matched to the sensor system being used for demonstration. Changes in the characteristics of the wiring and sensor signals should be monitored and appropriate diagnostics, prognostics, and health management capabilities should be demonstrated in a realistic engine system environment.

PHASE I: Evaluate the suitability of electrical, mechanical and heat-resistant properties of materials for packaging wire and/or fiber for a high-temperature environment. Development of a conceptual system design, fabrication and testing of prototype hardware and software for a wiring solution in the range of engine bay temperatures (550 to 1300 Degrees F). Include acquisition and/or development of connectors that can be used at the sensor interface with the ability for the connectors to reliably sustain temperatures.

PHASE II: Design, fabricate, and test the wiring system based on the results of Phase I. Integrate the system with a developing sensor system for the turbine section and testing in an engine system environment. Demonstrate the suitability of the wiring system in a high-temperature environment.

DUAL USE COMMERCIALIZATION: Military applications include legacy and future propulsion developments for fighter aircraft. Commercial applications include aircraft, ground-based turbines, and critical commercial wiring systems that experience high-temperature environments.

REFERENCES:
1. G. Smith, J.B. Schroeder, K. Blemel, R. McMahon, "Prognostics for Wiring: Managing the Health of Aging Wiring Systems," Proc. of the Aging Aircraft Conference, September 1999.

2. G. Smith, J.B. Schroeder, R. McMahon, R. Beach, "Organized Wiring: 21st Century Aircraft Infrastructure Backbone (in 20th Century Aircraft)" Proc. Of the Aging Aircraft Conference, May 2000.

KEYWORDS: wiring, fiber optics, prognostics, high-temperature sensing, high-temperature connectors, fiber optic connectors

AF05-191 TITLE: Lithium Batteries for Strategic Missile Flight Testing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms

OBJECTIVE: Advance the state of the art for lithium batteries for strategic weapons applications that require dependable onboard power.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Some strategic weapons, developed over 40 years ago, still use silver zinc reserve batteries for flight testing. Building these batteries is becoming increasingly problematic as material reserves are depleted and personnel are lost. Meanwhile, lithium technology has surged and offers many potential advantages over the old battery technology. This topic seeks two different batteries for weapons flight testing. One battery will be required to generate a voltage of 34.0 to 25.0 volts and have a capacity of 2.7 amp-hours minimum. The battery must weigh less than 5.4 kilograms, and must produce 10.9 amps at a maximum. The second desired battery must generate 34 to 21 volts, have a capacity of 1.4 amp-hours minimum, weigh 2.0 kilograms at a maximum, and generate 10.0 amps at a maximum. The battery should be safe, dependable, and relatively inexpensive. Expended batteries should be relatively easy to dispose of with minimal lasting effects to the environment. There will be tradeoffs as certain performance parameters are optimized and challenges associated with developing a suitable package. Either primary or secondary batteries will be considered. Batteries should be capable of a 6-hour wetstand and should withstand hangfire without catastrophic failure.

PHASE I: Develop battery designs and hardware that can meet the desired energy and power requirements in a package compatible with the platform.

PHASE II: Demonstrate a manufacturable device, component, or system that results in improved existing technology whether through exceptional performance, significantly reduced price, significantly increase shelf life, or improved robustness. Develop and test prototypes.

DUAL USE COMMERCIALIZATION: Commercial applications include providing emergency power for commercial aircraft, and hospital intensive care units or operating rooms. Military applications include emergency power for aircraft and onboard power for weapons.

REFERENCES:
1. Linden, David, ed.,"Handbook of Batteries," 2nd Edition, New York, McGraw-Hill, 1995.

2. Surampudi, S., Marsh, R.A., Ogumi, Z., and Prakash, J., eds., "Lithium Batteries," Proceedings Volume 99-25, Pennington, NJ, The Electrochemical Society, Inc., 2000.

KEYWORDS: lithium, batteries, strategic missile, thermal batteries, flight test, missile

AF05-192 TITLE: Aeropropulsion and Power Technology

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

OBJECTIVE: Develop innovative technologies which provide major improvements in gas turbine engines, advanced propulsion systems, electrical power systems, and advanced fuels

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

The Propulsion Directorate aggressively pursues and solicits innovative ideas offering major performance advances in all areas of air-breathing propulsion, including turbine engines, advanced and combined cycle engines, fuels, and electrical power. Payoffs include increased aircraft and weapon system effectiveness, survivability, reliability, and affordability. Turbine engine technology development is focused on delivering higher thrust-to-weight ratios, reduced cost, improved efficiency, and increased reliability. Advanced and combined cycle engine efforts are focused on developing innovative and high-Mach air-breathing engines for future manned and unmanned applications. Fuel technologies are currently focused on improving the performance (thermal stability, low temperature properties, etc.) of JP-8 through the use of additives. Finally, electrical power efforts (nonpropulsive) are focused on advanced techniques for power generation, energy storage, and power management and distribution for aircraft, spacecraft, and weapons with a particular emphasis on directed-energy weapons. Subsets of these technologies include innovative combustion measurement techniques, diagnostics, control techniques, microelectromechanical machines (MEMS), and engine-related materials technologies. Emphasis is on developing high-speed components to transition into military aircraft and spacecraft for operations/missions and high-speed global reach missions, resulting in high readiness and increased safety and performance for the military warfighter. To attract industry, the technologies must provide low-risk technology transfer, advanced aircraft superiority, lower maintenance costs, increased performance, and increased affordability. The end result is developing satellite, spacecraft, aircraft, air-launch-missile, legacy fighter and bomber propulsion and power technology for the military war-fighter.

Offerors are strongly encouraged to establish relationships with suppliers of the aerospace systems relevant to their research in order to facilitate technology transition. Proposed efforts shall emphasize dual-use technologies that clearly offer commercial as well as military applications. Proposals emphasizing spin-on technology transfer from the commercial sector to military applications are also encouraged.

PHASE I: Develop the concept and perform analyses and subscale testing to demonstrate the feasibility of the proposed technology. Modeling and simulation is encouraged to guide the research.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

DUAL USE COMMERCIALIZATION: New and innovative propulsion and power technology is equally applicable to both military and commercial aircraft engines and power generation and distribution systems.

REFERENCES:
1. Turbine engine affordability (fighter-aircraft engines), Stricker, Jeffrey, USAF, Research Laboratory, Wright-Patterson AFB, OH [Stricker], 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002, Reston, VA: American Institute of Aeronautics and Astronautics, Inc.

2. Air Force programs to reduce particulate matter emissions from aircraft, Corporan, Edwin; Roquemore, Mel; Harrison, William; Jacobson, Andy; and Phelps, Donald, USAF, Research Laboratory, Wright-Patterson AFB, OH [Corporan], 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002, AIAA Paper 2002-3722, Reston, VA: American Institute of Aeronautics and Astronautics, Inc.

3. Ultra-compact combustion technology using high swirl for enhanced burning rate, Zelina, Joseph; Ehret, Jeffrey; Hancock, Robert; Roquemore, W; Shouse, Dale; and Sturgess, Geoffrey, USAF, Wright-Patterson AFB, OH [Zelina], 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002, AIAA Paper 2002-3725, Reston, VA: American Institute of Aeronautics and Astronautics, Inc.

4. Propellant requirements for future aerospace propulsion systems AU: Author, Edwards, Tim and Meyer, Michael L, USAF, Research Laboratory, Wright-Patterson AFB, OH [Edwards], 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002, AIAA Paper 2002-3870, Reston, VA: American Institute of Aeronautics and Astronautics, Inc.

5. Optical diagnostics for characterizing advanced combustors and pulsed-detonation engines, Gord, J R, Brown, M S, and Meyer, T R, USAF, Research Laboratory, Wright-Patterson AFB, OH [Gord], 22nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference, Saint Louis, MO, June 24-26, 2002, AIAA Paper 2002-3039, Reston, VA: American Institute of Aeronautics and Astronautics, Inc.

KEYWORDS: turbine engines, high-speed propulsion, scramjets, fuels, lubrication, electrical power systems

AF05-193 TITLE: Performance-Based Inspection Techniques for Turbine Engine Blades and Rotors

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Process geometric inspection data of turbine engine blades into structural and fluid dynamic analysis models.

DESCRIPTION: High cycle fatigue (HCF) of turbine engine components has come to the forefront of safety. HCF is caused when a component is excited by vibration at its resonant frequencies. While all objects have several natural frequencies at which they resonate, these frequencies can be discovered relatively easily through a variety of analytical test methods. Then, if designers or operators wish to avoid those resonant frequencies, they establish criteria at which the component and their higher level "system" of components will not operate. A gas turbine engine is composed of several disks of different sizes, and each containing its own set of blades. While each set of blades is designed to close tolerance dimensions, the thickness, length, and width will vary slightly from blade to blade. Because the blades will not all resonate at the exact same frequency, the rpm range associated with a resonant mode for the disk assembly is broadened beyond the predicted nominal response. This translates to an operational limitation in that the narrow rpm resonant bands (first bend, first torsion, etc.) are now larger, which directly correlates to a significant increase in the probability of HCF failure. To obtain these resonant ranges, which are strongly dependent on dimensional variations between individual blades, the exact dimensional properties of the individual blades must be determined and incorporated into a design analysis.

Benefits - This technology represents the ability to decrease process inspection time and increase inspection fidelity. This program would allow both manufacturers and repair facilities to analytically quantify the effects that manufacturing and operation do to structural and aeronautical performance. The potential for reduced life cycle cost and avoidance of HCF are of great interest.

Obstacles – Implementation of automation to a large sample of complex geometric structures (blades) is the largest obstacle to this program. In addition, computational requirements for the complex analyses may be difficult to overcome. The implementation of statistical methods to determine the proper number of analyses to perform will be critical to quantify the effects that geometric variations induce.

PHASE I: Focus on highly automated methods for the translation of documented geometric variations of a small sample of blades from coordinate measurement machines using touch probes, single-point lasers, and line scanning lasers into CAD geometry. This geometry will then be used to create structural finite element analysis (FEA) elements and computational fluid dynamics (CFD) grids. These newly formed models will be compared to the nominal design for statistical characterization of the geometric variations. The specific component for inspection of this will be from one of the first seven stages of the compressor from a low bypass military turbine engine. Structural analysis capabilities will include, but not be limited to, the ability to perform modal analysis, forced response, mistuning, sensitivity analysis, and damage tolerance. Aeronautical requirements will include, but not be limited to, the ability to perform both steady and unsteady aero calculations.

PHASE II: Implement Phase I calculations to statistically quantify the effects of blade variation on a large sample of blades. In addition, Phase I methodologies will be applied to a fully bladed rotor for 360-degree calculations.

DUAL USE COMMERCIALIZATION: Dual use applications are directly related to all military engines and their commercial counterparts. Success in this technology lends itself to large scale implementation.

REFERENCES:
1. O'Hara, Ryan P., "Rapid Process for Accurate as Manufactured Finite Element Model Building Using 3D Laser Scanner Technology," Proceedings of NAFEMS World Congress, 2003.

2. Brown, J.M., "Probabilistic Analysis of Geometric Uncertainty Effects on Blade Modal Response," Proceedings of IGTI ’03: 2003 ASME Turbo Expo, 13-16 June 2002. Paper No. GT2003-38557 (2002).

KEYWORDS: laser scanning, coordinate measurement machine, performance-based inspection, probabilistic design, modal analysis, FEA, CFD

AF05-194 TITLE: Improved Modeling Tools for High Speed Reacting Flows

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop improved modeling tools for computational fluid dynamic (CFD) analysis of high-speed reacting flows.

DESCRIPTION: More efficient and accurate analysis of high-speed reacting flow is desired. Examples of research areas are given below.

a) Linking object-oriented modeling to grid generation: A current weakness of the CFD process is that new grids need to be manually created for any change in geometry. Providing an automated knowledge-based process (such as ModelCenter, AML, or SIDE) linking the physical geometry with grid-generation codes to create meshes could greatly increase the speed of numerical analyses.

b) Multi-element-type grid generation: Newer CFD codes can solve on unstructured grids made up of multiple element types. A grid generator or grid adapter that takes advantage of the available element types is needed. Grids with predominantly hexahedral elements are attractive for numerical efficiency; other element types can be used to maintain consistent grid resolution where physical features would distort hexahedral elements.

c) Seamless integration of various CFD and analytical tools for full vehicle, engine, and structural analysis: Analytical and simulation methods of varying fidelity are used to develop complex air platform components.

Computer hardware advances make possible integration of these methods for full vehicle simulation. Analytical methods to accomplish such integration are required.

d) Curve fit kinetics generator: A methodology that converts detailed combustion kinetics models into practical quasi-global combustion models has been partially developed. A new model is currently required when the oxidizer or fuel is changed, or when the combustor conditions deviate substantially from the calibration data. A code that further automates the model generation is desired. The code should take a detailed kinetics model or combustion data and generate combustion model input data for Computational Fluid Dynamics codes.

e) Improved modeling of turbulent diffusion: The Reynolds-averaged Navier Stokes equations (RANS) for multicomponent flows contain the Reynolds stresses, and turbulent heat and mass flux terms. Traditionally, the turbulent stresses are evaluated with an eddy viscosity turbulence model; turbulent heat flux and turbulent mass flux are evaluated using gradient hypothesis models and are related to the eddy viscosity by turbulent Prandtl and Schmidt numbers. Thus, the (constant) turbulent Schmidt and Prandtl numbers control the modeled turbulent transport of mass and energy. Models that account for variations in the turbulent Schmidt and Prandtl numbers or that dispense with the underlying gradient diffusion assumption are desired to improve both the accuracy and generality of the RANS solver methodology.

f) Simulation of multispeed flows: Multispeed flows involve both low and high Mach number speed regimes within the same flow field. In addition to the speed range, other attendant complexities include mixing, fuel injection and large heat release due to chemical reaction or volumetric heat addition. Current simulation capabilities are tailored to meet the requirements of single-speed problem classes. New and innovative computational methodology is required for the effective simulation of multispeed flows in a manner that does not lose fidelity to the physics across the multispeed range, is optimized for each speed regime as well as the whole, and that blends well among the speed regimes without ad-hoc procedures or user knowledge/intervention.

PHASE I: Goals are dependent on the area(s) selected for research. Application of relevant technology should be demonstrated on a small model problem, with consideration of how the technique scales to larger problems.

PHASE II: Develop, demonstrate, and validate the enhanced computational tool applying it to an appropriate high-speed propulsion system. Significant improvement in the accuracy and/or computational efficiency must be demonstrated.

DUAL USE COMMERCIALIZATION: Several of the proposed research areas (items a-d in Description) provide significant benefit to the design and analysis of a myriad of fluid-dynamic systems (high-speed and low-speed, military and commercial). Some research areas may be applicable to a narrower range of systems. Examples of commercial applications of this technology include design of high-efficiency vehicles, advanced propulsion systems,and multidisciplinary design optimization. An example of unique military applications of this technology includes integration of weapons on flight vehicles.

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1. Monell, D., et.al, “Multi-Disciplinary Analysis for Future Launch Systems Using NASA's Advanced Engineering Environment” AIAA 2003-3428.

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

3. Chidambaram, N., Dash, S., and Kenzakowski, D., “Scalar Variance Transport in the Turbulence Modeling of Propulsive Jets,” Journal of Propulsion and Power, Vol. 17, No. 1, 2001, pp. 79-84.

4. Baurle, R., and Eklund, D., “Analysis of Dual-Mode Hydrocarbon Scramjet Operation at Mach 4-6.5,” Journal of Propulsion and Power, Vol. 18, No. 5, 2002, pp. 990-1002.

5. Sturgess, G., and McManus, K., “Calculations of Turbulent Mass Transport in a Bluff-Body Diffusion-Flame Combustor,” AIAA Paper 84-0372, 1984.

KEYWORDS: computational fluid dynamics, CFD, grid generation, chemical kinetics, turbulence, multi-disciplinary design optimization

AF05-195 TITLE: Innovative Heat Management Schemes for Hypersonic Aircraft

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop innovative cooling strategies for hypersonic flight systems.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Managing the heat load to critical engine components remains a significant challenge in the design and operation of a hydrocarbon-fueled hypersonic vehicle. Passive and active methods can be used for heat-load management. One method for active cooling is to flow the hydrocarbon fuel through critical areas of the engine structure using its heat capacity to provide the necessary cooling. In principle, the fuel can be used over a wide range of flight conditions if it has sufficient cooling properties (presumably this will require an endothermic fuel like JP-7). In this scenario, the fuel that is heated by the engine structure is then burned in the combustor to produce propulsive thrust. For a closed-loop system, this requires that the flow rate of fuel necessary for propulsion must be exactly equal to the required cooling flow rate for all portions of the flight envelope. In practice, this balance may be difficult to maintain. It is possible that cooling of certain critical areas in the engine may elevate the flow rate requirement above that of the propulsion system, thereby resulting in the need to dump fuel overboard during certain parts of the mission. Using the fuel to cool the engine will also require the combustor to be either insensitive to fuel-state transitions (liquid to gas to endothermically cracked mixture) or be controlled to effectively manage these changes. If the fuel were not needed as the only coolant, greater latitude would be given to fuel choice, as it would not necessarily need to have substantial endothermic properties (for example, JP10 might be selected based on its higher volumetric energy density). Alternate innovative technologies/schemes are therefore desired for the whole vehicle, which provide both 1) adequate vehicle cooling and 2) vaporization of the fuel in a timely manner. These might include (but are not limited to) the use of transpiration cooling methods or the use a separate cooling fluid (apart from the fuel).

PHASE I: Produce a design concept (including in-depth analysis) for keeping the structure in thermal balance, discharging heat to the fuel, controlling independently composition, and phase changes within the fuel, and negating the need for overboarding fuel. Variables for the design should be flight Mach number, thermal load, dynamic pressure, fuel flow rate, and flight time/duration.

PHASE II: Develop a test article to demonstrate its use in a robust hypersonic flight environment.

DUAL USE COMMERCIALIZATION: Thermal management technologies have wide and varied applications in all industries. Specific military and commercial applications include aircraft gas-turbine engines. Demonstrated technologies should be fairly simple to translate to any application where high-temperature operations are involved.

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2. Sillence, M. A., "Hydrocarbon Scramjet Engine Technology Flowpath Component Development," AIAA Paper 2002-5158, Presented at the 11th AIAA/AAAF Conference on Space Planes and Hypersonic Systems and Technologies, September 2002.

KEYWORDS: hypersonic vehicle cooling, scramjet vehicle cooling, scramjet heat management, hypersonic flight cooling systems, endothermic fuels, endothermic hydrocarbon fuels, endothermic fuels for hypersonic vehicles, fuel cooling for hypersonic vehicles

AF05-196 TITLE: Device Technologies for Photonic Electrical Power Systems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop required power switches for next generation Fly-By-Light (FBL) technologies.

DESCRIPTION: Research has shown significant weight, volume and cost reductions are possible through an application of emerging photonic technologies throughout the vehicle management system. This next-generation FBL architecture concept involves centralized computing with distributed passive sensing and optical communication/control. While feasibility of the conceptual architecture has been shown, several technologies require a more complete understanding of various interactions and limitations so key components can be designed appropriately to function in the highly dynamic, multistress environment of aircraft operations. This topic is intended to address the existing optically controlled power switch technological deficiencies which currently exist and limit the integration of optically controlled power utilization and control equipment. The technical challenges considered are the absence of 600-1200 volt, 10-100 amp power devices, with high temperature operating capability, which can be efficiently switched optically and utilized in electrical power converters, motor drives, or power supply applications. Critical to the consideration of optically triggered switch candidates are the wavelength of operation, electrical gain, and high-temperature operability. Short wavelength (< 400 nm) requirements, necessary for wide-band gap high-temperature semiconductor materials, are highly incompatible with fiber optic distribution of control signals due to strong absorption and dispersion losses. Device gain translates directly to optical power requirements and optical source volume and weight. These considerations significantly impact the suitability of a switch to satisfy the FBL architecture currently being considered for flight control and vehicle management systems under development.

The technical challenges for airframe electrical power equipment is the development of optically controlled power switches. Power switching devices capable of high temperature operation have the additional complexities of short wavelength signal distribution and optical power requirement minimization. Power devices are not required to be constrained to the 850 nm signal level control bus wavelength.

PHASE I: Investigate and demonstrate new and innovative technologies that can resolve one or more of the technical challenges discussed in this topic. Modeling, simulation, or breadboard quality components are desirable to demonstrate feasibility.

PHASE II: Develop prototype demonstration devices for the approach described. This requires the development of hardware components consistent with form, fit, and function requirements for application to aerospace vehicle electrical power systems. The hardware should also be capable of operating within the aircraft environment (i.e., temperature, vibration, g-shock, EMI, humidity, volume, weight, etc.).

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 nonaerospace applications include automotive drive-by-light, industrial automation, fiber-to-the-office/home computing, dense computing, and all-optical computing.

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1. Weaver, T.L. and Smith, R.H., “Photonic Vehicle Management”, 20th Digital Avionics Systems Conference, Daytona Beach, FL, October 2001.

2. Sellers, Gregory J. and Roth, Richard F., "Multi-fiber optic connectors for aircraft applications", SPIE Proceedings, Fly-By-Light: Technology Transfer, Orlando, Florida, Vol. 2467, pp. 87, April 1995.

3. Booth, B.L., Marchegiano, J.E., Chang, C.T., Furmanak, R.J., Graham, D.M., Wagner, R.G., "Polyguide™ Polymeric Technology for Optical Interconnect Circuits and Components" SPIE 1997. (http://www.opticalcrosslinks.com/pdf/photonics97.pdf)

KEYWORDS: second generation Fly-By-Light, photonic vehicle management system, high density fiber optic connectors, multifiber cable plant, fiber-optic breakout/fanout box, multifiber splice

AF05-197 TITLE: Power Manager for Special Operations Portable Power Applications

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a power harvester/manager device which will accept multiple power generator/energy storage inputs, regulate the output to various energy-consuming devices, and communicate to the user the status of power generation/energy storage units.

DESCRIPTION: The special operations soldier is the principal means for precision targeting and target designation. To support their mission, these war fighters must carry as much as 75 pounds of equipment through extreme conditions and rugged terrain. Because all of these devices must be operated autonomously, as much as 25 pounds of various batteries must be carried. Advanced power generation technologies are under development that could significantly lighten the battery load. However, to further decrease weight and increase efficiency of operations, a device is needed that can perform several functions.

The first function will be to harvest/manage energy from several different sources to provide background current during operation of host equipment and charge current to the secondary power source during low power operation of host equipment. These sources include batteries of various chemistries and states of charge, fuel cells, photovoltaic cells, and typical battery chargers. It should accept voltages from 6-32 volts, and provide outputs from 10-15 V and 24-30 V. It should be able to handle up to 15 amps input. The device will manage the flow of power within the hybrid battery system as well as between the hybrid system and the host equipment. The power manager should be able to optimize the current flow based on the source/battery chemistry characteristics.

The second function will be to provide outputs at several different voltage and current specifications as determined by the host equipment. The power manager will need to efficiently convert the power as needed. Output connections should be easily accessible by the user to power the host equipment.

The third function will be to relay pertinent information back to the user. Required information will include the usage rate and estimated time based on historical averages. The device should allow the user to select high efficiency or high rate modes which will enable different battery charging routines. Warning and course-of-action should also be communicated when a component is performing substandard or the system experiences deleterious conditions which could reduce component lifetime.

The goal of the power management device is to use multiple power sources in as efficient a manner as possible, having a net effect of decreasing the overall weight of power sources that must be carried to accomplish a specific mission. To achieve this goal, the power manager must consume as little energy as possible in its own operation and be designed in as light a package as possible. Judicious design tradeoffs may have to be made between efficient operation and the weight of the power manager.

PHASE I: Develop a suitable methodology for power management to achieve optimal performance. A suitable communication system should be thoroughly considered during this phase. Modeling and/or prototype testing should be used to show the necessary requirements can be met.

PHASE II: Produce a power harvester/manager prototype which meets the required specifications. Demonstrate the device's manufacturability and sturdiness for soldier use.

DUAL USE COMMERCIALIZATION: Military applications include power management for the special operations war fighter. Commercial applications include power managers for remote repair crews, emergency responders, field researchers, and backcountry camping and travel aides.

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KEYWORDS: smart battery charger, PMAD, dismounted soldier power, hybrid power, power manager, power harvester

AF05-198 TITLE: Plasma Switches for High-Repetition, High-Power Applications

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop advanced plasma switch design suitable for high currents and fast rise time capability for use in robust, pulsed power applications which require high duty cycles and long lifetimes.

DESCRIPTION: Plasma switches are devices designed to supplement various energy storage systems in the switching or delivery of very high current pulses. A plasma opening switch, in addition to being able to close to a highly conductive state, has the ability to rapidly open to a highly resistive state. These devices typically contain a sample of plasma that acts as a conductor for a brief period of time (approximately 100 ns to a few us) and by some means can be rapidly changed to a highly resistive (open) state. The rise time to open is typically 10 percent or less of the time in the closed state. The rapid opening and closing of the switch allows efficient energy storage (inductive or capacitive) schemes to be applied to pulse power applications.

Since plasma switches are able to operate at a much higher energy density than traditional switched capacitor banks as well as handle much higher currents (typically in the mega amperes range), these switches are particularly well suited for pulsed power applications like the Pulsed High Power Microwave initiative and other directed energy weaponry in which quick rise times (ns or us scale) and large voltage/power delivery are crucial.

A present limitation on the implementation of open plasma switches into related technologies is the relatively short lifespan (approximately 1E4 cycles) and low operational frequency at which these devices must operate. It does not appear that this limitation is fundamental to the nature of these devices, but rather technological. Research into enhancing the maximum duty cycle lifetime of plasma switches is crucial to transitioning this technology to the warfighter.

PHASE I: Identify and determine the limiting factors to high repetition rates and long duty lifetimes in present plasma switch designs. Focus should be on switch closing to permit high repetition rates (>1 kHz) by auxiliary methods to increase electron attachment rates in the plasma or other material by an alternate fluid control approach. Develop an approach for significantly enhancing the lifetime of existing switches or submit a design and/or prototype of a long-life, high-repetition plasma switching unit.

PHASE II: Construct a robust, high-cycle-rate plasma switching unit for use with a generator or capacitor bank (mega-ampere current scales).

DUAL USE COMMERCIALIZATION: The development of a high voltage, pulsed power circuit is a critical technical challenge for the development of an airborne high power microwave (HPM) power system. The high power burst-mode operation of a pulsed HPM necessitates repetitive storage and switching of electrical energy, for

which pulsed plasma switching may be uniquely suited. Commercial applications include communications, industrial production (generation of shock waves, cleaning, magnetic shaping), as well as civilian scientific research (inertial confinement fusion, particle accelerators).

REFERENCES:
1. Bochkov V. D. et al., "Sealed-off pseudospark switches for pulsed power applications (current status and prospects)" IEEE Trans. Plasma Sci., Vol. 29(5), pp. 1531-1537 (2001).

2. Ottinger et al., "Theoretical modeling of the plasma erosion opening switch for inductive storage applications," Journal of Applied Physics, Vol. 56(3), pp. 774-784 (1984).

3. Lisitsyn et al., "Improved operation of microsecond plasma opening switch by plasma source modification," Physics of Plasmas, Vol. 6(8) pp. 3416-3421 (1999).

KEYWORDS: plasma switch, pseudospark, mega ampere switching, pulsed power, opening switch, closing switch

AF05-200 TITLE: Mitigating Electric Propulsion Impact on Laser Communications for Transformational Communications

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop/validate active or passive methods of decreasing contamination of spacecraft surfaces by on-board electric propulsion thrusters.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

There has been little or no effort to determine whether or not the plumes of electric propulsion (EP) devices, which consist primarily of charged particles, would have an impact on laser communication systems. Impacts may include detrimental effects to laser communications components or interference with the propagation of laser communications signals. Evaluate the impact of EP plumes, particularly from Hall thrusters and ion engines, on satellite laser communications systems in GEO (geosynchronous earth orbit). Approaches may investigate impacts to the hardware, impacts to signal propagation, or both. If the system is impacted, concepts for mitigating impact should be proposed and validated. Proposed concepts should trade well on a system level.

PHASE I: Determine the impact of electric propulsion plumes on satellite laser communications systems in GEO.

PHASE II: Design, fabricate, validate, and optimize a prototype system to mitigate the impact, if any, of electric propulsion thrusters on laser communications systems. The design process is expected to be iterative.

DUAL USE COMMERCIALIZATION: Development of a system to mitigate the impact of electric propulsion thrusters on satellite laser communications could be applied to any spacecraft (military or commercial) using electric propulsion and laser communications, thereby increasing mission capability and profitability. Thus, the outlook for commercialization appears strong.

REFERENCES:
1. Jaworske, D., "Hall Effect Thruster Plume Contamination and Erosion Study," NASA Technical Memorandum, NASA/TM-2000-210204, 2000.

2. Fife, J. M., et al., "Spacecraft Interaction Test Results of the High Performance Hall System SPT-140," AIAA-2000-3521, 36th Joint Propulsion Conference, Huntsville, Alabama, 2000.

KEYWORDS: electric propulsion; contamination; laser communications; Hall thrusters; ion engines; transformational communications

AF05-201 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Establish progressing concepts, operating systems, and combine technical methods that will significantly enhance rocket propulsion for the next ten years.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Present bold concepts to modify current abilities that will advance rocket propulsion for Air Force needs and facilitate technology transfer to commercial applications. These fresh concepts will be the foundation for research in the future. Base thoughts on legitimate mathematical, aeronautical, astronautical, and chemical principles. Use indicators of excellence to raise the outcome of laboratory achievements and diminish the costs of operations. The new approaches are beneficial to all areas of the military community. If the new approaches incorporate existing technologies from the civilian community – this is considered to be ‘a plus.’ The program's main aspiration is to raise the specific impulse and mass fraction for propulsion while reducing the stage failure rate. Reduction of program costs through significant halving in the area of production and hardware manufacture is encouraged. Increase thrust-to-weight ratio for liquid rocket engines whenever possible. Increase the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems for all systems. Double the effectiveness of density impulse of monopropellants for satellite propulsion systems. An advance in technical contribution that is environmentally friendly is most advantageous to the military community. Create advancements in the daily maintenance of rocket systems, lower hours for preparation, and diminish expenses for preparation. Enhance the delivered energy of tactical missile propulsion systems. Limit additional environmental hazards or constraints caused by new propellant materials or manufacture of rocket motors while exceeding the existing propulsion efficiency for all systems. Enhance daily tasking and sustainability of cost-effective space launch applications. This new development should withstand the thermal and aerodynamic stresses encountered during flight into space. The fabrication of the design can encompass lightweight ceramic and composite materials. These materials are incorporated into the conception and establishment of the design. This system is dependable and maintained at a high level of operation. Many applications of technical processes increase the operability of sensors, displays of exhaust plume radiation, combustion identification, propellant, and service life indicators. Use state-of-the-art concepts that embody topics of advanced fuels and oxidizers, nuclear isomers, nanotechnology innovations, and applications for beamed energy propulsion. Opportunities for research in highly developed propulsion topics are included and framed to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technology applications for prospective investigators.

PHASE I: Continue research and form the thought process demanded to conduct measurements for certain methods and to form the opportunity of the hypothesized methods. Modeling and simulation are needed to monitor the measurements of equivalents.

PHASE II: Finalize the design from Phase I and generate technologies for a demonstrator or prototype that will give indicators and demonstrate that the measurements are valid. Garner a technology improvement method for operations in the future that may also be applicable to commercial interests.

DUAL USE COMMERCIALIZATION: Advanced rocket propulsion technologies will move toward ultimate achievement. Transition to prominent performance and diminish the expenses to the U.S. military and U.S. aerospace industry.

REFERENCES:
1. 1998 JANNAF Propulsion Meeting Proceedings Volume 1, Cleveland OH 15-17 July 1998. Chemical Propulsion Information Agency CPIA-PUB-675-VOL-1; (DTIC AD-A354191)

2. Air Force Research Laboratory Propulsion Directorate website address: http://www.pr.afrl.af.mil

3. Tuffias, Robert H., et al., "Advanced Material for Solar-Thermal Propulsion;" Proceedings of Solar Engineering 1992, 5-9 April 1992, Maui HI USA pp 783-786, ASME, New York, NY 1992, ISBN 0791807622

4. Morris, W. D. et al., "Defining Support Requirements During Conceptual Design of Reusable Launch Vehicles," AIAA-95-3619, Presented at the AIAA 1995 Space Programs and Technologies Conference, Huntsville, AL, Sept 26-28, 1995

5. Mead, F. B., Jr. and Larson, C. W., "Laser Powered, Vertical Flight Experiments at the High Energy Laser System Test Facility," AIAA 2001-3661, 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Salt Lake City, UT, 8-11 Jul 2001

KEYWORDS: rocket plume; rocket engine; rocket propellants; satellite propulsion; beamed energy propulsion; boost transfer; orbit transfer

AF05-202 TITLE: Liquid Rocket Engine Heat Transfer Tools

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop tools and methods capable of efficiently and effectively measuring the hot gas wall temperature of a firing rocket engine.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

Meeting the expected life and reliability requirements for liquid rocket engine combustion chambers is an extremely challenging task. Most existing liquid rocket engine design methods rely on historical hot gas wall data that is analytically deduced rather than directly measured from test firings. For these reasons, the accuracy and effectiveness of existing combustion chamber design tools and methods are limited. Accurate information about the rocket engine hot gas wall environment is essential in order to produce designs with the required life and reliability for future rocket engines. Development of methods to directly measure the hot-gas wall: 1) temperature, 2) species, 3) heat flux, or 4) velocity profile of a firing rocket engine are sought to improve the combustion chamber design process. The ability to directly acquire this data will significantly aid to reduce design time, remove uncertainty, and reduce costs associated with design, development of liquid rocket engine combustion chambers.

PHASE I: Identify potential approaches to directly measure the hot-gas wall: 1) temperature, 2) species, 3) heat flux, or 4) velocity profile of a firing rocket engine. Evaluate these potential approaches for efficacy in solving the problem and select and justify an approach most likely to succeed.

PHASE II: Develop, validate, and demonstrate the selected approach.

DUAL USE COMMERCIALIZATION: Improved heat transfer modeling data and tools would have broad applicability to both commercial and military terrestrial and aerospace propulsion and power generation organizations as well as existing commercial businesses supplying engineering and scientific analysis tools.

REFERENCES:
1. “Modern Engineering for Design of Liquid-Propellant Rocket Engines”, Huzel, Dieter and Huang, David; AIAA Progress in Astronautics and Aeronautics, Volume 147, 1992.

2. “Rocket Propulsion Elements”, Sutton, George; John Wiley & Sons, Inc., 1992.

3. "Fundamentals of Heat and Mass Transfer," F.P. Incropera and D.P. Dewitt; John Wiley & Sons, 3rd Edition, 1990

4. "Heat Transfer to RP-1 Kerosene in Turbulent Flow under Asymmetric Heating Conditions," W.S. Hines, Chem. Eng. Progress Symposium Ser, V59, N41, 1963, pp 193 - 200.

5. "Heat Transfer Characteristics of Liquid Hydrogen as a Coolant for LO2/LH2 Rocket Thrust Chamber with the Channel Wall Construction," M. Niino, A. Kumakawa, N. Yatsvyanagi, A. Suzuki; AIAA/SAE/ASME 18th Joint Propulsion Conference, 21-23 June 1982, paper # AIAA-82-1107.

KEYWORDS: heat transfer, heat load, rocket engine, combustion chamber, nozzle, heat flux, analysis tool, design tool, CFD

AF05-203 TITLE: Noise and Artifact Reduction in Computed Tomography (CT) Images

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop techniques employing both hardware and software to reduce or eliminate CT artifacts, noise, and CT number variability.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

X-ray Computed Tomography (CT) is the nondestructive inspection technique used to evaluate the 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. The ability to detect changes in defects and subtle changes in the solid rocket motor constituents over time is limited by noise and artifacts in the reconstructed CT image. Noise and artifacts are inherent in all CT images. This limits the ability to predict accurately adverse aging trends in large solid rocket motors. This topic does not apply to low energy CT systems and small solid rocket motors.

PHASE I: Identify the causes of artifacts and noise in CT images. Develop methods to reduce or remove noise, artifacts, and CT number variability from CT images without data loss.

PHASE II: Demonstrate prototype on actual CT images acquired on large solid rocket motors. Demonstrate developed software/hardware on both CT systems at Hill AFB, UT.

DUAL USE COMMERCIALIZATION: Improvements in CT number variability, reduction or removal of noise and artifacts in CT images will be beneficial in any industrial CT system. Although the military application would be implementation into ICT 1500 and 2500 CT systems at Hill AFB, UT, this technology could be used on any industrial CT system with the same results.

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.

3. ASTM E1695-95 (Reapproved 2001), "Standard Test Method for Measurement of Computed Tomography (CT) System Performance" (1995), West Conshohocken, PA.

KEYWORDS: Computed Tomography, nondestructive inspection, artifacts and noise, solid rocket motors, Aging and Surveillance, CT images

AF05-204 TITLE: High Power Hall Thruster Technology Development

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Design, develop, and validate innovative "high power" Hall thruster technologies that significantly improve thruster operating characteristics and/or reduce thruster life cycle cost.

DESCRIPTION: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR). As such, export-controlled data restrictions will be applicable. Offerors must disclose any proposed use of foreign nationals, their status, and what tasks each would accomplish in the statement of work in accordance with Paragraph d of Air Force Materiel Command (AFMC) Clause 5352.227-9000. In addition, this acquisition involves technology that has a military or space application. Only U.S. contractors who are registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek, MI 49017-3084 (1-800-352-3572) may receive an award. Contractors should be prepared to submit a copy of the approved DD Form 2345, Military Critical Technical Data Agreement, if selected for award.

The development of innovative Hall thruster technologies that can significantly improve thruster operating characteristics and/or reduce thruster life cycle cost is expected to provide greatly increased mission capability and system application. Improvements should be measured with respect to current state-of-the-art (SOTA). Topics of interest include, but are not limited to: thrust-to-thruster mass ratio (increase 150% over SOTA); thrust-to-thruster power ratio (increase 50% over SOTA); efficiency (increase 50% over SOTA); total impulse (increase 100% over SOTA); thruster production cost (decrease to 50% of SOTA); electromagnetic and contamination output and measurement (decrease to 50% of SOTA); ground test cost (decrease to 25% of SOTA). Research may focus on one or more improvement objectives. Since these characteristics are both interrelated and power dependent, it is necessary that such effects be accounted for when investigating technology improvements. Innovations may include, but are not limited to: thruster magnetic system; thruster geometry; thruster materials; thruster fabrication techniques; propellant type; ground test pumping system; thruster diagnostics. Research may focus on one or more innovations. Evaluation of technology improvements with respect to state-of-the-art should occur throughout the effort.

PHASE I: Identify and evaluate candidate technology improvements applicable to 10 kW and greater thruster power. Perform analysis to determine the feasibility of these concepts. Perform analysis to estimate the impact of these candidate technologies on the spacecraft level.

PHASE II: Demonstrate the feasibility of the design concepts created during Phase I by fabricating and testing hardware (sub-scale is acceptable). Incorporate changes and improvements as necessary to scale-up and demonstrate a full size prototype Hall thruster at a power greater than 10 kW.

DUAL USE COMMERCIALIZATION: Develop and qualify a flight quality Hall thruster for orbit transfer vehicle and space experiment applications. Both mission capability and profitability will increase through the introduction of this technology into both the military and commercial satellite marketplaces.

REFERENCES:
1. Jankovsky, R. S., McLean, C., McVey, J., "Preliminary evaluation of a 10 kW Hall thruster", American Institute of Aeronautics and Astronautics AIAA Paper 99-0456, Aerospace Sciences Meeting and Exhibit, 37th, Reno, NV, Jan 1999.

2. Oleson, S. R.; Myers, R. M., "Launch Vehicle and Power Level Impacts on Electric GEO Insertion", American Institute of Aeronautics and Astronautics AIAA-PAPER-96-2978, Joint Propulsion Conference, 32nd, Lake Buena Vista, FL, July 1996.

3. Kim, V., "Main physical features and processes determining the performance of stationary plasma thrusters", Journal of Propulsion and Power, v. 14 no. 5, Sep-Oct 1998. p 736-743.

4. Martinez-Sanchez, M., Pollard, J.E. "Spacecraft Electric Propulsion - An Overview", Journal of Propulsion and Power, Vol. 14, No. 5, 1998, pp. 688-699.

5. Tchuyan, R. K., Bagdasaryan, V. V., Belousov, A. P. Mosesov, S. K., "Estimation of possibilities of electric propulsion application for space Missions", IAF Paper 98-S407, International Astronautical Congress, 49th, Melbourne, Australia, Sept. 28-Oct. 2, 1998.

KEYWORDS: electric propulsion; Hall effect thruster; anode layer thruster; stationary plasma thruster; orbit transfer; high power

AF05-207 TITLE: Algorithms for Hyperspectral Sensor Fusion

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop algorithms for hyperspectral systems in multiple bands that are capable of fast response measurement.

DESCRIPTION: There is a need for improvements and advances in multi-sensor fusion algorithms. Recent advances in spectral imaging have demonstrated sensors that can measure the temporal evolution of energetic transient spectra such as explosions and plumes. The transient data can be used to (1) identify rapid energetic battlefield events, (2) perform dynamic, real time bomb damage assessment, and (3) detect and identify small, passive infrared threats. All of these capabilities evolve from the ability of the sensor to perform extremely rapid, spectral and temporal measurement of the target over a wide field of view, and compare the target signature to known libraries. Raw 3-d data from the scene 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. The transient spectra can last as long as several minutes for a plume or as short as several seconds for an explosion. Spectral sensors have measured spectral-temporal profiles of both stationary and moving targets; however, there has been limited success networking sensors in multiple bands to enable improvements in data fusion and dynamic sensor tasking.

Identify the primary methods for data processing and fusion.

PHASE I: Select a sensor technology capable of spatial-spectral-temporal measurement of transient events over multiple bands. Propose algorithms to extract event information, allow networking of multiple sensors, and fuse other ISR sensors to ID and classify targets.

PHASE II: Develop a complete suite of algorithms that takes raw sensor data, eliminates background effects, fuses the data, and updates and maintains a dynamic event library for use in target identification. The algorithms should be able to detect and separate multiple events for proper cataloging.

DUAL USE COMMERCIALIZATION: These algorithms could be applied in any work environment involving hyperspectral sensing or spectral analysis such as military bomb damage assessment of civilian disaster relief operations.

REFERENCES:
1. J. M. Mooney, C. Grotbeck, T. Reeves and P. Green, "Classification of explosions from spectral-temporal signatures," Proc. IRIS Passive Sensors Conf. 1 (1999).

2. Garcia, J.P.; Volin, C.E.; Sabatke, D.S.; Descour, M.R.; Dereniak, E.L.; Hamilton, T.K.; McMillan, R.W.; Sass, D.T., "MWIR computed tomographic imaging spectrometer experiments." Proc. SPIE, vol.4028, p.79-87, 2000

3. Mooney, J. M., et al., "Classification of Explosives from Spectral-Temporal Signatures(U)", Proceedings of the 1999 IRIS Specialty Group on Passive Sensors and Active Systems(U), Vol. 2(S), pages 91-99, Jan 2000.

KEYWORDS: Algorithms, Spectral, Spatial, Temporal, Fusion.

AF05-208 TITLE: High Fidelity Simulation Concepts/Technologies For Rapidly Evolving/Transitioning EW Countermeasure Techniques

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop new innovative simulation technologies for rapidly evolving/transitioning electronic warfare countermeasure techniques

DESCRIPTION: Electronic warfare countermeasure techniques are developed, evolved and evaluated through open-air range testing which is both time-consuming and costly. In today's combat environment, the effectiveness of a weapon system is predicated on the ability to deceive and negate enemy radar and communications, while resisting jamming from increasingly numerous, powerful and sophisticated emitters. Man/hardware-in-the-loop laboratory simulation is the most cost-effective prototyping methodology for developing/maturing EW countermeasures techniques because the battlefield can be brought to the laboratory enabling precise control of test conditions. Laboratory synthetic battlespace environment simulation allows candidate EW countermeasure techniques to be subjected to multiple realistic combat situations making it possible to identify/resolve technique issues before ever flying or fielding the capability. This laboratory synthetic battlespace simulation approach can significantly reduce the time, risk and cost associated with evolving/transitioning this type of advanced technology. Open-air range testing is being used because current laboratory hardware-in-the-loop simulator capabilities do not provide the required system fidelity to evaluate countermeasure effectiveness. This SBIR research will focus on defining new innovative simulation concepts/technologies that enhance electronic warfare countermeasure technique hardware-in-the-loop simulation fidelity. Research topic area of interest include off-boresight (as well as traditional on-boresight) antenna modeling (to enable incorporating antenna side-lobe effects), software modeling techniques for complex, tightly-coupled systems (to enable incorporating effects on automated processing analysis), and novel simulation concepts/techniques to measure/demonstrate benefits gained by combining effects from coordinated geographically separated networked transmitters. The dual-use "tool" technology base established by this research will enable significant reductions in the time/cost for both commercial and military aircraft avionics technology research.

PHASE I: The Phase I effort will identify new innovative hardware-in-the-loop simulation concepts/technologies that enable the rapid evolution/transition of electronic warfare countermeasure techniques. The Phase I research will identify the critical simulator challenges and define the Phase II approach for developing/demonstrating the required simulator concepts/technologies. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the simulator concepts/technologies for rapidly evolving/transitioning electronic warfare countermeasure techniques.

PHASE III DUAL USE APPLICATIONS: The simulator concepts/technologies can be implemented in government laboratories and test ranges for the development and evaluation of electronic warfare countermeasures techniques. The simulator concepts/technologies are dual use technologies that have extensive commercial applications for markets such as the avionics and telecommunications industry. Research under this topic will aid in the analysis of commercial communication systems and the impacts of undesirable effects due to near- and on-frequency interferers. With the advent of wideband wireless networks and communication devices, the industry must understand and correct for the effects of inadvertent "EW type" signals. These technologies reduce development costs and accelerate product movement to the market place through rapid prototyping in a laboratory development environment that incorporates realistic real-world effects.

REFERENCES:
1. Scrage, Michael. "Serious Play: How the World's Best Companies Simulate to Innovate. Boston, MA: Harvard Business School Press, 2000.

2. Edward Eberl, "Changing Requirements for EW Threat Simulation," ADA 355202 22 Oct 98.

3. David Adamy, "EW 101: A First Course in Electronic Warfare", Artech House/Horizon, 2001

KEYWORDS: Simulation, Countermeasures, Battlespace

AF05-209 TITLE: High Fidelity RF Emitter Parameter Generation Capability

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop real-time high fidelity RF generation technologies for evolving specific emitter identification RF receiver capabilities

DESCRIPTION: Current aircraft radar warning receiver upgrade programs and next generation radar warning receivers are utilizing scalable modular digital receiver technologies that enable the evolution and insertion of leading-edge specific emitter identification (SEI) capabilities. SEI techniques are used to recognize individual electronic emitters through the precise measurement of selected/unique signal externals (parameters and/or characteristics). In order to be identified by SEI techniques, a specific emitter must have one or more of these signal externals that are stable and unique within the measurement capabilities of most collectors. SEI will provide reliable and timely intelligence data for keeping track of individual target emitters and the particular units operating them. Traditional application research methodologies utilize open-air range testing to evolve these advanced SEI technologies because today's laboratory simulator RF generation capabilities do not provide the required RF waveform fidelity. Laboratory simulation is the most cost-effective prototyping methodology for maturing advanced SEI technologies because the battlefield can be brought to the laboratory enabling precise control of test conditions. Using a laboratory synthetic battlespace environment allows advanced SEI technologies to be subjected to multiple realistic combat situations making it possible to identify and resolve technology issues before ever flying or fielding the capability. This laboratory synthetic battlespace simulation approach significantly reduces the time, risk and cost associated with developing and transitioning advanced SEI technology. Research for this SBIR topic should focus on defining innovative RF simulator generation technology that can produce the key RF emitter attributes required to evolve advanced SEI receiver technologies needed to enhance the survivability of current and next generation aircraft. Technologies of interest will include research into innovative high fidelity RF generation concepts to produce RF emitters with highly-accurate control of current and postulated SEI parameters; the identification or discovery of novel SEI parameters; and the advanced RF devices needed to repeatedly replicate SEI parameters with high fidelity while generating dense emitter environments. The dual-use "tool" technology base established by this research will enable significant reductions in the time/cost for both commercial and military aircraft receiver technology research.

PHASE I: The Phase I effort will determine the state-of-the-art for techniques used to uniquely locate and track specific RF emitters and will identify innovative real-time simulator RF generation technologies required to evolve SEI radar warning receiver capabilities in laboratory synthetic battlespace environments. The Phase I research will identify the critical simulator RF generation challenges and define the Phase II approach for

developing/demonstrating the required RF generation simulator technology. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate prototype real-time RF simulator generation devices or scaleable processes for evolving advanced SEI receiver technologies for radar warning receivers.

PHASE III DUAL USE APPLICATIONS: The parameter definition and generation technologies can be implemented in government laboratories and test ranges for the development and evaluation of advanced RF receiver/processor capabilities. RF parameter definition and generation technologies are dual use technologies that have extensive commercial applications for markets such as the telecommunications industry. These technologies can be utilized to improve laboratory capabilities enabling telecommunications algorithms and equipment to be developed faster and more cheaply. These technologies reduce development costs and accelerate product movement to the market place through rapid prototyping in a laboratory development environment that incorporates realistic real-world effects.

REFERENCES:
1. Scrage, Michael. "Serious Play: How the World's Best Companies Simulate to Innovate. Boston, MA: Harvard Business School Press, 2000.

2. Edward Eberl, "Changing Requirements for EW Threat Simulation," ADA 355202 22 Oct 98.

3. Kenneth I. Talbot, Paul R. Duley, and Martin H. Hyatt, “Specific Emitter Identification and Verification,” Technology Review Journal Sprign/Summer 2003.

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5. “Advanced Digital Receiver Offers Precision Location, Identification,” SIGNAL Magazine, July 1998.

KEYWORDS: Simulation, RF, Threat

AF05-210 TITLE: Collaborative Virtual Combat Simulation Technology For System of Systems Research

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop dual-use collaborative simulation tools for rapidly evolving system of systems concepts/technologies

DESCRIPTION: Current/next generation aircraft will utilize capabilities-based system of systems (SoS) concepts to enhance combat operations. A “System of Systems” can be defined as an assemblage of components which individually may be regarded as systems and with 2 additional properties: A) Operational independence of the components – the component systems fulfill operator purposes on their own, and B) Managerial independence of the components – component systems are separately managed and integrated. These capabilities-based SoS concepts involve the seamless connectivity of external (to a combat aircraft) Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) assets, and internal situational awareness and threat warning systems in joint battlespace environments. The information from external and internal systems is assimilated into a coherent tactical picture to provide the warfighter rapid access to mission critical information and data concerning time sensitive/critical targets. Current application research demonstration methodologies evolve system of systems concepts/technologies through large-scale open-air range testing. This approach is time-consuming and requires extensive and costly flight testing. Open-air ranges cannot fully generate the system of systems environments that would be experienced in actual combat situations. Real-time synthetic battlespace simulation provides a cost-effective methodology for evolving system of systems concepts through collaborative research. However, the connectivity throughput and multiple player limitations of current simulation capabilities/technologies result in unacceptable data latencies for system of systems simulation providing a very

challenging research area. Approaches are sought that lead to the creation of innovative, user friendly, dual-use virtual combat man/hardware-in-the-loop simulation methodologies and technologies that enable the rapid development/evolution of system of systems concepts/technologies for current and next generation aircraft through system of systems synthetic battlespace simulation. Simulation technologies of interest could include integrated Network-Centric System of Systems demonstration concepts, novel methods to integrate and synchronize disparate real-time hardware and software simulations (such as RF emitter simulation, GPS constellation emulations, and detailed Command and Control communication simulations), and research into sensor resource management (SRM) technologies which can be applied to spatially separated linked simulation environments to maximize network operations throughput in system of systems simulation. Laboratory simulation technologies and processes will be pushed forward that enable detailed "what-if" System of Systems analysis to determine the military utility of system of systems concepts/solutions. The goal of this research is to evolve affordable dual-use man/hardware-in-the-loop virtual combat simulation technologies that will reduce the cost and time required for developing system of systems capabilities for current and next generation aircraft. The dual-use simulation technology base established by this research can be applied to developing advanced networked sensors for both commercial and military aircraft.

PHASE I: The Phase I effort will conduct the research required to define affordable dual-use man/hardware-in-the-loop virtual combat simulation methodologies/technologies for evolving system of systems concepts/technologies for next generation aircraft. The key objective of this research is to create innovative dual-use simulation technologies which enable collaborative research that increases productivity of system of systems research while reducing development costs and time. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing/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 II: The Phase II effort will implement and demonstrate the critical system of systems man/hardware-in-the-loop virtual combat simulation concepts/technologies.

PHASE III DUAL USE APPLICATIONS: Virtual combat simulation concepts/technologies that increase the productivity of system of systems research and reduce development costs are dual-use technologies that have extensive commercial applications for markets such as the commercial networked sensor industries. These simulation concepts/technologies enable advanced networked sensor concepts/technologies to be evolved/demonstrated in a laboratory environment which can significantly reduce risk/cost and the time to insert the technology into the market place. These same concepts/technologies can be implemented in government laboratories and test ranges for military networked sensor research.

REFERENCES:
1. Scrage, Michael. "Serious Play: How the World's Best Companies Simulate to Innovate. Boston, MA: Harvard Business School Press, 2000.

2. "Network Centric Warfare," Department of Defense Report to Congress, July 2001.

3. Mark W. Maier, "Architecting Principles for Systems-of-Systems," www.infoed.com/Open/PAPERS/systems.htm

4. Ann G. Arnold and William F. Kujawa, "Test and Evaluation of Complex Systems of Systems," www.terec.gatech.edu/graphics/EconT&E/Kujawa_paper.pdf

KEYWORDS: System of Systems, Battlespace, ISR

AF05-211 TITLE: Database Expansion Issues

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Enable Radar Combat ID (CID) Data Base Development

DESCRIPTION: Emerging radar CID capabilities are dependent upon synthetic signature database development technology. Several CID transition candidates are currently pacing the development rate of companion signature databases. Key enabling synthetic signature technologies are required to support faster development of new targets.

The goal of this research is to develop complex target and background scattering phenomenology to enable the "portability" of measured data for training and testing of target detection and recognition algorithms. In addition to this, the scattering phenomenology will be used to explore the use of synthetic feature based modeling techniques for use in rapid database expansion processes.

This topic solicits innovative solutions in the following areas: (1) Radar signature prediction and analysis techniques that characterize the performance of feature based models within an automatic target classification context. (2) New modeling fidelity metrics for use in model based synthetic radar signature prediction and performance assessments. (3) Innovative visualization, data analysis and feature extraction techniques (4) New signal processing techniques for characterizing and removing unique sensor effects to field and range collected measured radar. (5) Modeling and simulation methods for characterizing algorithm performance. Proposals that address one or a combination of the technology areas one through five will be considered.

Existing target geometry and material build techniques for CAD modeling of complex targets are equipment and time intensive. Innovative physics-based phenomenology modeling and analysis techniques that support the implementation of feature based models are needed. Synthetic target feature prediction and analysis techniques for use in CID databases should allow for an assessment of target separability as a function of feature fidelity. Traceability from feature level modeling detail up through classifier performance is needed to analyze the tradeoffs between classifier design and database complexity. Advanced analysis and feature extraction techniques that identify stable scattering features are also needed. Novel techniques that use dominant scattering source characterization to capture significant target information content are desired.

PHASE I: The effort should evaluate concepts for the use of universal source measured data for automatic target classification (ATC) training, testing, and calibration. Develop signal processing techniques to quantify model fidelity requirements and algorithms for feature based target models.

PHASE II: This effort should develop analytical techniques to verify equivalence in ATC performance using measured data from various radars and/or quantify the improvements in ATC performance due to the signal processing techniques developed in Phase I using model build metrics to relate production level tolerances to ATC performance.

DUAL USE COMMERCIALIZATION: These key signature database technologies will be directly applicable to all tactical, strategic, and reconnaissance DoD systems employing the state-of-the-art radar CID technologies. RF sensor modeling and signal processing techniques have applications for a broad range of communication system design applications. Feature extraction, modeling, and innovative algorithm concepts have application to advanced data analysis for consumer marketing analysis. The model based ATC techniques addressed in this SBIR are directly applicable to a wide range of technologies involving model based approaches to object classification and pattern recognition. Several examples include object relocation and assembly techniques for production line robotic technology, personal identification scanning technology for entry control and other homeland security applications, and finally overhead land survey/assessment for mining applications.

REFERENCES:

1. R. A. Mitchell. (1997, December). Robust High Range Resolution Radar Target Identification Using A Statistical Feature Based Classifier With Feature Level Fusion. [Ph.D. Dissertation]. University of Dayton, Dayton, OH.

2. R. M. Mitchell, J. J. Westerkamp. (1998, April). Statistical Feature Based HRR Radar Classification. Presented at RTO SCI Symposium.

3. Steve Worrell. (1997, July). High Range Resolution Automatic Target Recognition Performance Estimation. DARPA Tech Report.

4. Introduction to Statistical Pattern Recognition (Computer Science and Scientific Computing Series) by Keinosuke Fukunaga.

KEYWORDS: CID Technology, Target Recognition, Radar, Database, Automatic Target Classifications

AF05-212 TITLE: Air to Ground Signature Database Development Technologies for Combat Identification

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop target signature prediction techniques for targets in background terrain settings to support database development.

DESCRIPTION: The Air Force Research Laboratory (AFRL) is investigating physics-based modeling and simulation technologies that could provide the Air Force with an improved capability to find, identify, and engage stationary and mobile ground targets. The Air to Ground Community is looking at putting air to ground Combat Identification (CID) capability into future avionics systems. These CID techniques require the research and development of accurate signature prediction methods for complex targets in terrain settings and signature validation methods. Research and development of techniques to model sensor observables, target signature features, derived features and algorithm performance characteristics is required to support database development.

Exploratory research in the area of physics-based signature modeling of target and background radar signature data is sought with the goal of reducing risk in target recognition algorithm development. Innovative prediction techniques that model complex target scattering, background clutter phenomenology and phenomenology for target/background interactions are needed to enable the development of processing algorithms and recognition techniques. Accurate characterization of moving target signature phenomenology is also required to support air to ground database development. Phenomenology modeling methods that support signature prediction for stationary and moving targets are needed. Phenomenology prediction and analysis methods that incorporate stochastic modeling of input parameters that capture target variability efficiently are of interest. Application of modeling methods to develop and validate signature databases requires the development of robust processes for processing and analyzing measured data and developing target geometry and material Computer Aided Design representations. Existing target geometry and material build techniques for CAD modeling of complex targets are equipment and time intensive. CAD modeling methods that incorporate quantitative assessment of parts and materials accuracy are needed for robust signature prediction and analysis.

The main goal of this research is to develop physics-based modeling techniques for complex target and background scattering phenomenology for CID database research. This topic solicits innovative research solutions in the following areas: (1) Target signature and local background radar clutter modeling and prediction methods. (2) Clutter phenomenology modeling techniques (3) Radar phenomenology prediction methods for dynamic targets in backgrounds (4) Extended background radar clutter modeling and prediction. (5) Development of innovative and efficient CAD modeling techniques for capturing and modeling target and background geometry and material information.

PHASE I: Prototype methods for target signature and local background clutter modeling and prediction methods. Prototype methods for radar clutter modeling. Prototype methods for moving target signature prediction. Prototype concepts for CAD geometry modeling of targets.

PHASE II: Radar signature prediction prototype for targets in local clutter backgrounds. Radar clutter modeling prototype. Moving target signature prediction method prototype. CAD modeling technique for representing target and terrain geometry and material information.

DUAL USE COMMERCIALIZATION: Signature modeling and validation tools for targets in clutter have application to communication system design and transportation system management and tracking system development. These key ground signature database technologies will be directly applicable to all future air to ground DoD systems employing the state-of-the-art radar CID technologies.in the future.

REFERENCES:
1. Bhalla, R. H. Ling, J. Moore, D. J. Andersh, S. W. Lee, and J. Hughes, "3D Scattering Center Representation of Complex Targets Using the Shooting and Bouncing Ray Technique: A Review, " IEEE Antennas and Propagation Magazine, Vol. 40, No 5, October 1998, pp. 30 – 39.

2. 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.

KEYWORDS: Target Modeling, Clutter Modeling

AF05-213 TITLE: Trajectory Shaping Vehicles Accuracy Assessments

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Provide an accurate prediction and assessment of Trajectory Shaping Vehicle (TSV) impact accuracy.

DESCRIPTION: For the future mission of interests, improvements in achieving better impact accuracies are needed for longer flight ranges. A TSV design is one way of achieving these objectives. The central issue is: what accuracy can a TSV achieve with the current sensor technologies (e.g., Global Positioning System (GPS) receivers and Inertial Navigation System (INS)), and Thermal Protection Systems (TPSs)? To achieve this goal, it requires an algorithm to simulate many complex technical issues and integrate them to get the end product, i.e., TSV accuracy. Since, the estimation of TSV accuracy involves many disciplines, such as Inertial Measurement Units (IMU) modeling, GPS receiver and antenna design, aero- thermodynamics and plasma physics (the potential of GPS signal black-out due to plasma effects, the GPS signal reacquisition), and the TSV lifting control authority, the models in each discipline must be of adequate fidelity in order to obtain accurate and reliable results. In many cases, ground tests and flight data are required to validate the models.

This project seeks the development of innovative models and simulations that can predict the TSV impact accuracy in several practical flight trajectories of interest (e.g., attack deeply buried targets). It involves the development and integration of a covariance analysis with aero thermal/trajectory development, guidance and control models, which characterize the different technical disciplines adequately.

PHASE I: Develop models and simulations to (1) predict a ballistic Reentry Vehicle (RV) impact accuracy including the modeling of GPS signal acquisition, IMU accuracy and calibration, coupling of INS and GPS, effects of free stream wind and density, RV boundary layer transition divergence, Post Boost Vehicle (PBV)-RV separation and RV spin-up phenomenon; (2) model the potential plasma black out; and (3) GPS re-acquisition after black out.

PHASE II: Extend the Phase I effort to a TSV at angle of attack and vehicle configuration with a non-circular cross section. Altitudes of interest range from exo-atmospheric to impact, with emphasis placed on $h < 300$ kft. The effect of the RV's dynamic motions (e.g., spinning, pitching and yaw motion) upon the GPS signal acquisition should be assessed. The numerical results will be validated with government supplied test data. The computational time for a complete TSV trajectory from PBV separation to impact will be less than 20 hours on a fast Personal Computer (PC) (2.5 GHz). At the end of phase II, the deliverable items include: (1) the computer software for assessing the TSV impact accuracy, (2) technical report, and user's manual. The user's manual will include documentation of the developed algorithms including the comparison with flight data.

DUAL USE COMMERCIALIZATION: The proposed modeling and simulation effort will have benefits to space and military communities. Applications include: spacecraft communication, accurate estimation of general vehicle aerodynamics and surface heating, accurate prediction on vehicle optical and Radar Cross Section (RCS) signature, and using the numerical algorithms and flow field solver for other general problems of interest (e.g., commercial aircraft design etc.).

REFERENCES:
1. Parkingson, W., “Global Positioning System: Theory and Applications,”, Volume 163, Progress in Astronautics and Aeronautics, Published by the American Institute of Aeronautics and Astronautics, Inc., Washington DC 20024. 1996.

KEYWORDS: GPS System Performance, Electro-Magnetic Wave Propagation and Blackout, Antenna Window Designs in Hot Environments, and High Temperature Plasma Phenomena

AF05-214 TITLE: Low Cost High Efficiency Millimeter Wave Electronically Scanned Antenna

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop innovative integrated concepts and implementations for the near-term realization of low-cost/high efficiency monolithic Millimeter Wave (MMW) Electronically Scanned Antenna (ESA) arrays.

DESCRIPTION: ESA arrays offer tremendous potential benefits for enabling broadband communications and radar sensors for a variety of military and commercial applications. This particular class of antenna implementation typically consists of a very large number of discrete antenna radiating/phase-shifting elements phased in such a manner as to create a single agile antenna beam that is electronically steerable. Significant component and assembly costs together with comparatively high RF losses (particularly at MMW frequencies) have unfortunately precluded the practical application of ESA arrays from all but the highest performance (and least cost-sensitive) applications.Proposed technologies should directly enable “breakthrough” improvements in addressing cost and efficiency limitations with special emphasis placed on high efficiency (low-loss) fully integrated antenna approaches compatible with near-term verification, demonstration, and fielding in support of specific military (and commercial) needs. The target aperture for MMW applications should support gains of 30 dB with efficiency of 50% including all feed, transition, phase shifter and radiator losses. Target goal for cost is <$20 per square-wavelength in large commercial quantities. The advantages of using MEMS components and commercially viable substrates other than GaAs should be considered.

Warfighter Impact: To enable effective C2, communications connectivity to a great number of airborne platforms must improve. The key hurdle to overcome relative to this connectivity is the affordability of acquiring the antenna that must be integrated onto the aircraft. While ESC is developing the first and next generation of antennas, further reductions in antenna costs would expedite the ubiquity of this communications on airborne platforms.

PHASE I: Develop design concepts for practical implementation(s) of high-efficiency low-cost monolithic MMW ESA arrays. These design concepts will address, in an integrated manner, all requisite subcomponents including power dividers, transitions, phase-shifters, and high-efficiency radiators.

PHASE II: Develop, fabricate, and test an engineering prototype antenna in support of direct demonstration (by measurement) of the improved packaging, reliability, scale integration, and antenna efficiency metrics investigated in Phase I. These measurements will include: input VSWR, gain, and antenna patterns over a prescribed range of MMW frequencies and antenna scan angles.

DUAL USE COMMERCIALIZATION: Exclusive of obvious military and homeland defense applications, principle commercial opportunities include both MMW sensor (automotive radar, landing aid radar, MMW radiometers and imaging systems) and MMW communication applications (multi-beam terrestrial Point-to-Multipoint, SATCOM, Satellite Crosslinks, etc.).

REFERENCES:
1. R. Johnson, H Jasik, "Antenna Engineering Handbook, 2nd Edition McGraw-Hill 1984.

2. Alan Lemons, Robert Lewis, William Milroy, Ralston Robertson, Stuart Coppedge, and Todd Kastle, "W-Band CTS Planar Array," 1999 IEEE International Microwave Theory and Techniques Symposium, Los Angeles, CA, USA.

3. Gabriel Rebeiz, “RF MEMS: Theory, Design, and Technology,” by Gabriel Rebeiz, John Wiley & Sons, 2002 (ISBN: 0471201693)

KEYWORDS: ESA, Millimeter-Wave, MEMS, Electronically Steerable, Antenna Radiating, Phase-Shifting Elements.

AF05-215 TITLE: Multi-band Electronically Configurable Feed for Ground Antennas

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Investigation into the application of low loss switching devices to implement an electronically reconfigurable feed for multiband operation of reflector antenna system.

DESCRIPTION: The military often employs multiband ground antennas to provide a flexible communications link for the forces. For example, the Ground Mobile Terminal (GMT), is designed to operate at C, X, Ku, Ka, and EHF frequencies. Typically, each band of operation uses a unique feed. When deployed, the full suite of feeds are included as part of the deployed equipment, adding significant weight and size to what is transported. In addition, to change the frequency of operation, the feeds are manually switched, introducing undesired time to bring the new communication link on line. There has been significant investment into low loss switches for a variety of applications. This effort is to address the application of low loss switches to enable the design of an electronically reconfigurable multiband feed. This new feed design could be used to replace a suite of antenna feeds and dramatically reduce the time to change the band of operation. The emphasis is to design a feed for a 7 foot diameter reflector. Bands of operation include X-band (7.25-7.75 GHz rx, 7.9-8.4 GHz tx), Ku-band (10.9-12.5 GHz rx, 14.0-14.5 GHz tx), and Ka Band (20.2-21.2 GHz rx, 30.0-31.0 GHz tx).

Warfighter Impact: Dramatic reduction in required time to switch between frequency bands of operation. Increases reliability of the equipment and reduces deployed equipment weight. The warfighter is provided with more flexible communications capabilities to execute the combat mission.

A simulation of the performance and aspects of integrating the switch to the feed will be prototyped.

PHASE I: The effort will propose a reflector feed based upon a 7' diameter. Alternative switches will be investigated, a baseline selected and quantify the switch parameters Compare concepts using, phase issues, efficiency, integration, and pattern control.

PHASE II: Produce prototype hardware based on Phase I design. Characterize the operation of the antenna.

DUAL USE COMMERCIALIZATION: Commercial antenna industry could take advantage of this technology by standardizing the build of different frequency antennas with a reconfigurable feed. Could have major cost reduction implications. Also develop multi-functional ground based radar systems.

REFERENCES:
1. Operational Requirements Document (ORD), CAF-AMC-AFSOC 002-95-III-C for Advanced Wideband Terminals.

KEYWORDS: Electronically Reconfigurable, Antenna Feed, MEMS, GMT, Multiband Feed, Low Loss Switches.

AF05-216 TITLE: Passive Ground Moving Target Indication for Gunship Aircraft Using Unmanned Airborne Vehicles (UAV-PGMTI)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Demonstrate a real-time, ground moving target detection and tracking capability for unmanned aerial vehicles (UAVs) to support target acquisition for Gunship aircraft.

DESCRIPTION: Detecting small moving targets on the ground is a difficult problem for aircraft. Passive ground moving target indication (PGMTI) algorithms that exploit the movement of the target against a stationary background can solve the basic detection problem. Using unmanned air vehicles (UAV) operating at low altitudes can improve the PGMTI performance by virtue of its higher resolution, but robust algorithms are needed to compensate for platform motion and detect and track small moving targets in the scene. Such algorithms should be able to operate on visible, intensified, and thermal imagery, and declare both the presence and ground track of detected targets with few false alarms. Algorithms that operate in real-time with reasonable processors on-board small UAVs are preferred to support immediate handoff of targets to Gunship aircraft.

PHASE I: Develop novel moving target detection and tracking algorithms that address the technological issues of platform motion cancellation, false alarm suppression, and real-time operation. Develop a design concept for various UAV platforms and perform feasibility experiments as necessary.

PHASE II: Develop a real-time PGMTI processing system and perform a concept demonstration based on a representative UAV visible, intensified, and/or thermal imaging camera. Demonstrate moving target detection and tracking capabilities, and potential for supporting off-board target acquisition for standoff Gunship aircraft.

DUAL USE COMMERCIALIZATION: The UAV-PGMTI technology has military applications for missile warning systems, aircraft avoidance, and target acquisition systems. It has civilian applications for aircraft avoidance and intrusion detection systems.

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

KEYWORDS: Moving Target Detection, Target Acquisition, and Discrimination Techniques

AF05-217 TITLE: Radio Communication Through The Hypersonic Plasma Sheath

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Demonstrate innovative techniques to transmit and receive radio frequency signals through the plasma sheath surrounding a hypersonic aerospace vehicle.

DESCRIPTION: The National Aerospace Initiative put forth by the Director, Defense Research and Engineering, has focused Air Force attention on the military applications of hypersonic flight. Hypersonic air vehicles travel through the atmosphere at speeds (generally greater than Mach 5) sufficient to heat and ionize the surrounding air. The resulting plasma sheath alters the phase and amplitude of radio signals transmitted and received by the vehicles and often blacks them out altogether. Blackout affects all military and civilian reentry vehicles, including the Space Shuttle, and prevents them from receiving communication and Global Positioning System (GPS) signals. Proposed hypersonic air vehicles, such as the Common Aero Vehicle (CAV) are expected to suffer from blackout over a significant portion of their trajectory. The technique developed in this effort will enable a hypersonic air vehicle to transmit and/or receive radio signals in some or all of the frequency bands and waveforms used for communication (UHF), telemetry (S-band), and GPS. The technique must provide signal amplitude and signal-to-noise ratio compatible with modern military radio receivers. The technique must be capable of miniaturization and flight qualification.

PHASE I: Exploit radio frequency propagation phenomenology to develop concepts for communication directly through the hypersonic plasma sheath. 2) Perform modeling and simulation of the proposed concepts in the hypersonic environment to validate their feasibility. 3) Use the simulation results to complete design tradeoffs and to predict the performance, size, weight, and power requirement of the leading design.

PHASE II: Develop a hardware prototype of the Phase I design. 2) Test the prototype in a terrestrial plasma chamber to establish proof of concept. 3) Adapt the design as required to qualify prototype for flight test.

DUAL USE COMMERCIALIZATION: The technology demonstrated in this effort will be applied directly to communication and guidance for future Air Force hypersonic air vehicles. The technology will be equally applicable to the Space Shuttle and commercial launch and reentry vehicles

REFERENCES:
1. Morris, R. A., P. M. Bench, K. E. Golden, and E. A. Sutton, Characterization and Prediction of Hypersonic Plasma Effects, Proceedings of 37th Aerospace Sciences Meeting and Exhibit, January 11-14, 1999, Reno, NV (AIAA99-0630).

2. National Research Council, Review and Evaluation of the Air Force Hypersonic Technology Program, National Academy Press, Washington, D.C., 1998.

3. Nazarenko, S., V., A. C. Newell, and A. M. Rubenchik, Communication with reentry space vehicles via short pulses, Radio Sci., 30, 1753, 1995.

KEYWORDS: Hypersonic aircraft, plasmas (physics), electromagnetic radiation, atmosphere reentry, maneuverable reentry vehicles

AF05-218 TITLE: Compact, Multi-Spectral Measurement System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a miniature, automated measurement system and supporting process capable of rapidly capturing 3-dimensional and multi-spectral data for target recognition and sensor fusion algorithm development.

DESCRIPTION: The Air Force Research Laboratory is investigating various methods by which multi-signature target data is collected against military targets, vehicles and objects of interest to support research and development of ATR, CID and SF algorithm. As part of this process it is necessary to precisely and comprehensively generate representative multi-dimensional models of the objects being sensed. Presently these models are produced by gathering information through a combination of physical measurements, observations and still photography and then manually generating the desired results. The process of capturing and recording this information is both cost and time prohibitive. New technology promises a more efficient and expeditious method by which researchers can measure objects up close and generate high-accuracy three-dimensional geometric models in a laboratory environment. A technology upgrade is desired to improve these models to include spectral data. Spectral cameras are also currently under development but they lack the spatial resolution to adequately support target model development. The spectral data will be used to determine the unique material and paint characteristics of target objects. ATR, CID, and SF algorithm performance can be degraded by camouflage, concealment, and deception techniques applied to target objects. Natural phenomena such as dust, fading, and damage to targets also impacts target signature. This new multi-dimensional capability will enable researchers the ability to effectively document the sources of target signature variation and gain training in the area of algorithm evaluation.

A number of experiments need to be conducted over the spectral areas of interest to ensure the accuracy of the models being produced. A typical experiment would consist of the measurement of scale models of military targets, with different paint treatments or external configurations. The models would be used to train algorithms and the recorded algorithm performance would be used to determine if target variations had been documented during the sensing process.

PHASE I: Design and implement a prototype of a table-top hardware system capable of rapidly capturing returns from sensed objects over a broad frequency spectrum using both visible and infra-red light sources and producing high-fidelity models from the returns.

PHASE II: Extend the prototype system into a fieldable model capable of measuring the phenomenologies of full size military targets. In addition, automatic generation and recording of image and ground truth should be developed to encapsulate truth information with the multi-spectral imagery.

DUAL USE COMMERCIALIZATION: Combining 3-dimensional geometry with hyperspectral imagery could aid medical diagnosis and treatment of lesions, tumors and other conditions. Target modeling techniques developed on this effort have applications to algorithm development programs for ATR, CID, and SF. In addition to military applications, department of Homeland Defense and the Justice Department are developing algorithms to track vehicles and suspected terrorists. The techniques developed under this SBIR would be useful for supplying models to train a variety of algorithms for anti-terrorism missions.

REFERENCES:
1. Sensor exploitation technology of particular interest to AFRL/SNA may be seen in the several dozen papers at: http://www.mbvlab.wpafb.af.mil/paper.html.

2. The Sensor Data Management System (SDMS), an excellent source of sensor data for research is at: https://www.mbvlab.wpafb.af.mil/public/sdms/ and includes the Adaptive SAR ATR Problem Set (AdaptSAPS).

KEYWORDS: Automatic Target Recognition, Confirmatory ID (CID), Sensor Fusion (SF), Evaluation

AF05-219 TITLE: Sensor Exploitation by Adaptive/Learning Systems (SEALS)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop approaches to improve the exploitation of sensor data by allowing the exploitation system to adapt to changing operating conditions or to new mission requirements.

DESCRIPTION: The quantity and complexity of sensed data (e.g., from radar, infrared, laser, visual or threat warning systems) has grown to the point that the effectiveness of ISR and weapon systems can be limited as much by our ability to extract useful information from the data as it is by gathering the data. The extraction of information (i.e., "exploitation") from the sensed data includes such things as finding objects of interest (e.g., targets or terrain features), geo-locating such objects, tracking such objects through time and space, determining the type of object, and determining its affiliation (e.g., Friend/Foe/Neutral), its configuration (e.g., does a missile launcher have missiles loaded?), or state of damage. The expense of collection platforms, sensors, operators, etc. is such and the importance of getting any resulting information is such that the exploitation capability must be effective. Improving exploitation simply by increasing the number of human analysts is not feasible for several reasons. The cost of human exploitation, both in terms of direct financial costs and in the forward footprint of ISR weapon systems, is prohibitive. Human exploitation performance suffers over time with such a monotonous task and the non-literal character of advanced sensors (e.g., hyperspectral imaging) makes it an unnatural domain for humans, further limiting performance and/or extending training requirements. While technology for aiding and automating the exploitation of sensor data is being applied to this problem, the first generation of such tools have proven to have a common weaknesses. The aided/automated exploitation systems tend to perform well under those conditions that were exactly anticipated in their development. However, when, as is often the case in military applications, the conditions of operation differ from those anticipated, the performance drops precipitously. A related problem is that unanticipated mission requirements (e.g., a new type of target or the necessity to operate the collection platform at different altitudes or different stand-off ranges) have the same detrimental effect on aided/automated exploitation systems. Fortunately, there are indicators that adaptive/learning exploitation is possible. First, because humans do eventually exploit the sensed data (e.g., in after action analyses, an aircrew may wish they had noticed that SAM or an image analyst may confirm that indeed we had an image of a SCUD hours before a launch, but had not noticed it until after other systems detected the launch), the requisite feedback on current operating conditions is available. Second, there are successful applications of adaptive systems in other problem domains (e.g., adaptive control systems, adaptive filtering, and email "spam" filters that learn). Although the risk is high, with sufficient innovation, there is promise of a technical solution to a critical Air Force problem.

The overall goal of this effort is to develop innovative techniques to enable sensor exploitation systems to adapt to changing operating conditions and / or changing mission requirements. AFRL/SNA is especially looking for innovations based on a principled approach, where training data will naturally be part of the solution, but that also leverage all applicable knowledge, including physics-based or empirical models. A second desirable attribute of an adaptive / learning system is that it accurately characterize its uncertainty about any reported exploitation results. It

is even preferable to have reports with higher uncertainty when that uncertainty is accurately characterized than reports with lower uncertainty when that uncertainty is not understood.

PHASE I: Identify and define variations in operating conditions (especially how operational data might vary in character from the data collected for use in system development) and in mission requirements. Identify and define existing data available for demonstration of the adaptive / learning system's application (e.g., from AFRL's Sensor Data Management System, or SDMS). Identify and define sources of feedback (e.g., the format, the quality, and the time lag) that might be available to an operational adaptive system. Develop an initial design (e.g., specifying the overall process flow of systems interfacing with the adaptive / learning system, major subsystems of the adaptive / learning system, a baseline approach to each subsystem, and the principal trade-studies needed) and test approach (e.g., including the source of the test data, the test methodology, and measures of performance) for the adaptive system. The strengths and weaknesses of the resulting design should be identified and defined.

PHASE II: Finalize and implement the design for the adaptive / learning system that was developed in Phase I. Acquire data and conduct the testing specified in Phase I to demonstrate technical feasibility. Define field test methodology, including how the demonstrated level of performance translates to operational benefits and costs.

DUAL USE COMMERCIALIZATION: A wide of potential applications exist for adaptive systems including ISR sensed data exploitation, combat aircraft acquisition sensed data exploitation, medical diagnosis, forensic analysis, and automated facial recognition applied to anti-terrorism screening.

REFERENCES:
1. Sensor exploitation technology of particular interest to AFRL/SNA may be seen in the several dozen papers at: http://www.mbvlab.wpafb.af.mil/paper.html.

2. The Sensor Data Management System (SDMS), an excellent source of sensor data for research is at: https://www.mbvlab.wpafb.af.mil/public/sdms/ and includes the Adaptive SAR ATR Problem Set (AdaptSAPS).

3. A general introduction to adaptation and learning technology may be found in:
Bishop, Christopher M., "Neural Networks for Pattern Recognition", Oxford University Press, 1995.

4. An example of adaptive system research that does not involve neural networks (in which we have no special interest) would be:
Chibelushi, Claude C., Farzin Deravi, and John S. D. Mason, "Adaptive Classifier Integration for Robust Pattern Recognition", in IEEE Trans. on Systems, Man, and Cybernetics – Part B: Cybernetics, Vol. 29. No. 6, December 1999.

KEYWORDS: Adaptive Systems, Sensor Exploitation, Detection, Tracking, Automatic Target Recognition.

AF05-220 TITLE: Efficient Interaction Methodologies for Simulating the Scattering from Electrically Large Objects and Scenes

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop innovative physics based interaction methodologies for simulating the scattering from electrically large objects and scenes.

DESCRIPTION: The Air Force Research Laboratory is interested in finding efficient methods for calculating the scattering from electrically large objects and objects in scenes. The capability to simulate the scattering from electrically large objects, or objects in reasonably sized scenes, in a reasonable amount of time has been elusive.

The goal of this research is to find an innovative method to calculate the interaction of objects in scenes and small features on large objects so the overall scattering can be determined in a reasonable amount of time. Some examples of problems that could be solved with this method would be a tank in foliage, a truck in cityscape, or the gaps on a car. The problem could also be inverted to find the radiation of, for example, a cellular phone in cityscape. The

ability to accurately calculate these electrically large problems in a reasonable time, on the order of hours instead of days or weeks, would greatly increase the ability to simulate various objects of interest and militarily relevant scenarios.

PHASE I: Develop an innovative algorithm to compute the interaction between a collection of objects or portions of a large object in the context of computing the scattering from an electrically large object or scene. Code a prototype of the algorithm and show that the results are reasonable and can be computed in a reasonable amount of time.

PHASE II: Complete the development of the code to compute the scattering from electrically large objects and show the results for various test cases involving both electrically large objects and scenes, thereby showing its accuracy and reasonable computation time.

DUAL USE COMMERCIALIZATION: Besides various military applications, the use of such a code in the cellular phone arena could be used to determine the optimal position for base stations and the sensitivity of cellular phones to various positions in a metropolitan area. This capability could also be used in a system to simulate search and rescue scenarios. For example, it could be used to determine whether a car hidden in a forest can be found using a specific type of radar and what the return should look like.

REFERENCES:
1. Liu, Z. and Carin, L., "MLFMA-Based Quasi-Direct Analysis of Scattering from Electrically Large Targets," IEEE Transactions on Antennas and Propagation, vol. 51, no. 8, August 2003.

2. Sarabandi, K. and Polatin, P., "Electromagnetic Scattering from Two Adjacent Objects," IEEE Transactions on Antennas and Propagation, vol. 42, no. 4, April 1994.

KEYWORDS: Radar Scattering, Electromagnetics.

AF05-221 TITLE: Next Generation Laser Detectors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop ultra-miniature detection concepts to characterize lasers relevant to the battlefield.

DESCRIPTION: The focus of this program is to initiate development of next-generation laser detection concepts, techniques and technology. Emerging micro– or nano-scale sensors and materials technology, such as photopolymers or nano – detectors, offer potential for laser characterization in an ultra-compact form. The long range mission is to develop sensors to help protect aircrews and aircraft from laser-based weapons, blinders and dazzlers. The ultimate goals of the technology development effort should be to perform these main functions: 1) separate lasers from false alarm light sources (natural or manmade), 2) determine the wavelength of the laser, 3) determine the location of the laser threat, 4) determine the pertinent laser event temporal and power characteristics for both CW and pulsed lasers and 5) cover a wide dynamic range of laser powers, sensitive to energy levels many orders of magnitude lower than those which are dangerous to vision. Concepts should define issues such as employment methods, the effects of the operational environment limitations such as atmospheric turbulence and background illumination sources, detection and characterization algorithms, and communications.

PHASE I: Develop a conceptual design and a proof of concept demonstration in a realistic laboratory setting. The end products will be a final report, and a final presentation and laboratory demonstration. A proof-of-concept laboratory demonstration as an end product is desirable, but not mandatory.

PHASE II: Develop a hardware prototype of the laser sensor and test it under appropriate conditions of operation. The end products will be a final report, a final presentation, and the prototype hardware.

DUAL USE COMMERCIALIZATION: The laser sensor technology developed in Phase I and II will be transitioned to the production of sensor systems suitable for aircraft or aircrew. This type of laser sensing may also

be transitioned to commercial manufacturing operations, clandestine law enforcement, optical communication receivers, and laser safety use in laboratories or in the medical field. Other remote sensing fields may also benefit from this effort.

REFERENCES:
1. Nanotechnology Research Directions IWGN Workshop Report, "Vision for Nanotechnology Research and Development in the Next Decade", September 1999, http://itri.loyola.edu/nano/IWGN.Research.Directions/, Chapters 6 & 8.

2. Photopolymers and Applications in Holography Optical Data Storage Optical Sensors/Volume 2042: 16-18 August 1993, Quebec, Canada (Proceedings of Spie--The International Society for Optical Engineering, V. 2042.) by Roger A. Lessard (Editor), Society of Photo-Optical Instrumentation Engineers, American Physical Society.

KEYWORDS: Laser Detection, Remote Sensing, Geolocation, Laser Characterization, Nano-Technology, Micro-Technology, Miniaturization

AF05-222 TITLE: Low Cost Adaptive Optics for Tactical LADAR

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Design and build an adaptive optic LADAR enhancement system.

DESCRIPTION: Active systems have a number of challenges associated with operation in realistic air-to-air and air-to-ground environments. Long range propagation through atmosphere can degrade image resolution as well as contribute to beam scintillation. Scintillation and beam breakup cause the loss of even illumination in 1-D, 2D, and 3D LADAR flash imaging systems, and bit errors in laser communications systems. Recent progress in sparse aperture imaging and adaptive optics has demonstrated the potential for significant enhancement of resolution and image quality for active systems. In this effort, novel concepts utilizing sparse apertures and/or adaptive optics techniques for tactical LADAR or laser communications system enhancement will be investigated. Sparse aperture imaging techniques could be used to effect improvements in geometric imaging resolution or improve performance of non imaging systems such as remote vibrometers. The adaptive optic systems can be used with conventional or sparse aperture concepts to improve image quality. Such adaptive optic systems must be able to sense the wavefront aberration and apply a correction at speeds commensurate with that of atmospheric turbulence as viewed from moving platforms. Use on tactical platforms also requires rugged, low cost implementations suitable for harsh operational environments. The adaptive optic systems can be implemented with tip/tilt or tip/tilt/piston devices in the transmit beam and/or receiver path. Adaptive optics in the transmit beam path should have high damage thresholds to support LADAR applications.

PHASE I: Develop systems requirements and concepts. Analyze techniques and develop a conceptual system design that includes specifications of adaptive optic and/or sparse components for enhancement of a tactical LADAR or laser communications systems. Estimate expected performance enhancement.

PHASE II: Develop and demonstrate a prototype system in an active EO system. Conduct testing to prove feasibility over extended operating conditions.

DUAL USE COMMERCIALIZATION: This system could be used for various LADAR modalities including 1D, 2D, 3D, polarization, dial, multispectral, and vibration sensing. Atmospheric turbulence mitigation would enhance range finding and sensing by allowing more concentrated energy on target.

REFERENCES:
1. Modeling atmospheric wave aberrations and astronomical instrumentation using the polynomials of Zernike', T.A. ten Brummelaar, Optics Communications 132 (1996).

2. Feedback Interferometry with membrane mirror for adaptive optics', D.C.L. Cheung, T.H.Barnes, & T.G.Haskell, Optics Communications 218 (2003)

3. Image Sharpness and Beam Focus VLSI Sensors for Adaptive Optics", M.Cohen, G.Cauwenberghs, & M.Vorontsov, Applied Optics, V2,N6, DEC 2002

4. Electrostatic micromirrors for subaperturing in an adaptive optics system', M.Horenstein, S.Pappas, A.Fishov, & T.Bifano, Journal of Electrostatics, 54(2002)

KEYWORDS: Sensors, Adaptive Optics, LADAR, Image Processing, Laser Communications.

AF05-223 TITLE: High Speed Readout for Photodiode Focal Plane Arrays

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Readout-integrated circuit architectures with nanosecond class sampling rates.

DESCRIPTION: In most electronic imaging systems, arrays of photodiodes are used to sample the image. Typically, these applications require temporal sampling rates of a few milliseconds. New active sensing applications are proposed that require sampling on the order of a nanosecond. These include the use of a short laser pulse to illuminate the object scene where the receiver then measures the shape of the returned pulse. Other applications, such as coherent vibration measurement, require precise (less than a nanosecond) knowledge of sample time over a few hundred microsecond period. Both approaches require high speed sampling of the return pulse over tens of nanoseconds followed by an inactive period of as much as 100 microseconds.

Commonly, the array of photodiodes is electrically bonded to a readout integrated circuit (ROIC). The ROIC integrates and samples the signal from each photodiode. The proposed active sensing applications will benefit from detectors with a bandwidth of 1 GHz or greater and ROIC capable of capturing this high-bandwidth signal. Current research devices exist that can sample at nearly a 1/2 GHz rate. Novel approaches, as well as advanced hybridized detector/ROIC are of interest. Although applications will require imaging at a variety of optical wavelengths, technology demonstrations near 1.5 micron will be most useful.

PHASE I: Investigate novel approaches to high-rate temporal sampling and generate a high-level readout/detector design.

PHASE II: Develop detailed designs, fabricate and test readout/detector devices.

DUAL USE COMMERCIALIZATION: In addition to the military use of these devices in active sensing, cameras using these high-speed imaging focal plane arrays can be used to support civil engineering investigations of structures.

REFERENCES:
1. COHERENT LASER RADAR AT 2uM USING SOLID-STATE LASERS, S. W. Henderson, P. J. M. Suni, C. P. Hale, S. M. Hannon, J. R. Magee, D. L. Bruns, E. H. Yuen, IEEE Transactions on Geoscience and Remote Sensing Volume 31, Issue 1, January 1993, pp. 4-15.

2. US CELRAP LASER RADAR DESIGN CONSIDERATIONS, J. A. Hutchinson, C. W. Trussell, T. H. Allik, S. J. Hamlin, CLEO/Pacific Rim Conference on Lasers and Electro-Optics, July 15, 2001, pp. 576-577 vol 1.

KEYWORDS: Laser Radar, Multi-Pixel, Coherent Focal Plane Array, High Speed Readouts.

AF05-224 TITLE: Broad Bandwidth Components for Advanced Microwave Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop innovative multi-octave broad bandwidth signal control components to enable advanced airborne radar, electronic warfare (EW), and communications sensors to support global intelligence, surveillance, and reconnaissance (ISR), global strike, and homeland security capabilities. Component mass, power consumption, cost, and adaptability to sensor operating signal environments are important drivers along with performance.

DESCRIPTION: The USAF has the need for advanced sensors that provide the warfighter with enhanced capabilities to counter a broad range of dynamic threats. Future Air Force sensors must be adaptable, reconfigurable, multifunctional, and networked. The sensors must be effectively operated in severe electromagnetic environments that are constrained by frequency spectrum management, dense signal environments, jamming, co-site interference, multipath, and operation in urban environments. These conditions place severe demands on the sensor components and subsystems to effectively operate with the needed bandwidth, low loss, dynamic range, isolation, and efficiency. The developed components must be able to meet the airborne platform size, weight, prime power, and cost constraints. The scope of this effort addresses sensor components that would be used on manned and unmanned airborne vehicles. The frequency ranges of interest include 1-6 GHz, 2-12 GHz, and 2-20 GHz. Components may have instantaneous bandwidths cited above or they may have bandwidths of several hundred MHz that are tunable across the cited bandwidths. The range of potential high performance components of interest are extremely high isolation/low loss circulators (3-5 ports), high tunability phase shifters (4-6 bits) and switchable bandpass filters, and greater than 500 ps true time delay units. It is anticipated that these components will have a power handling of 5 watts, be highly linear, and have minimal insertion loss subassemblies of these components shall also be considered where the microwave, bias, and control circuits are on one chip. For these integrated subassemblies, chip compaction advances are sought. Candidate technologies to be explored include ferro-magnetic and ferro-electric materials, MEMS, and other technologies may be considered.

PHASE I: Identify and develop high-priority components for advanced RF airborne sensors using novel, state-of-the-art technologies. Effort would focus on the trade-off of approaches, as well as design, modeling, initial component prototyping, and testing. At the end of phase one, a demonstration of the proof of principle is expected.

PHASE II: Apply advanced technologies to the results of Phase 1. The focus of the effort would be to integrate and enhance component design and fabrication processes in order to achieve performance, size, weight, and prime power constraints. Demonstrate advanced component performance. Investigate, develop, and demonstrate high-priority integrated component subassemblies that would enable advanced microwave airborne radar, EW, and communications sensors.

PHASE III DUAL USE APPLICATIONS: The developed technology has potential use in Homeland Security, communications, law enforcement, and emergency rescue applications.

REFERENCES:
1. F. Martin, et al., “Dual Electromagnetic Bandgap CPW Structures for Filter Applications,” IEEE Microwave and Wireless Components Letters, September 2003, Volume 13, Number 9, pp. 393-395.

2. C. Rauscher, “Reconfigurable Bandpass Filter with a Three-to-One Switchable Passband Width,” IEEE Transactions on Microwave Theory and Techniques, Volume 51, Number 2, February 2003, pp. 462-467.

3. L. Hsieh and K. Chang, “Tunable Microstrip Bandpass Filters with Two Transmission Zeros,” IEEE Transactions on Microwave Theory and Techniques, Volume 51, Number 2, February 2003, pp. 520-525.

4. E. Schloemann, “Integrated DC/RF Design of Dual-Ferrite Circulators,” IEEE Transactions on Magnetics, Volume 33, Number 5, September 1997, pp. 3430-3432.

5. I. Toyada et al., “Highly Integrated Three-Dimensional MMIC Single-Chip Receiver and Transmitter,” IEEE Transactions on Microwave Theory and Techniques, Volume 44, Number 12, December 1996, pp. 2340-2346.

KEYWORDS: Microwave Components, Broad Bandwidth, Filters, Circulators, Transmit/Receive Chips, Phase Shifters, Chip Compaction

AF05-225 TITLE: Performance Improvement of a Receiver on a Chip (ROC)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop techniques to improve the performance of a ROC in detecting exotic signals.

DESCRIPTION: The USAF has developed a wideband Electronic Warfare (EW) receiver technology called Monobit. The objective of this development was to determine frequency and time of arrival of pulsed signals in real time. Other objectives were to accomplish this with minimum size and power. A special kernel function was developed for Monobit to compute the Fast Fourier Transform (FFT) of a wideband (1 GHz) signal in approximately 100 nanoseconds. A new development is under way to improve the instantaneous dynamic range and resolution. The Analog to Digital Converter (ADC) and FFT processor will be implemented on a single substrate as a ROC. The Monobit and ROC architectures are in many ways different from conventional EW receivers. Simulations and tests have been performed on this receiver to determine the ability of it to process pulsed Radio Frequency (RF) signals. However, the performance of this receiver to detect and identify exotic signals such as phase coded and frequency modulated signals needs to be investigated. Detection improvement through correlation and identification through signature extraction are commonly suggested approaches for conventional EW receivers. An investigation into digital signal processing (DSP) components that are Commercial off the shelf (COTS) parts would make the prototype design low cost and able to be tested before ROC insertion. Matched filtering and techniques to detect Intentional Modulation On Pulse (IMOP) are two areas that have been pursued in the past for conventional EW receivers.

PHASE I: Develop algorithms to detect exotic signals utilizing the Monobit FFT processing core. Signals of interest include, but are not limited to, phase code, frequency hop, linear FM and non-linear FM. Perform simulations to determine the ability of the proposed algorithms to detect/classify selected complex signals. AFRL has models of the basic Monobit FFT kernel and can provide real (laboratory) data collected form the current Monobit receiver for selected signals. Identify Monobit hardware improvements for detection of complex signals.

PHASE II: Perform detailed simulation of selected algorithms vs. simulated and laboratory collected data. Procure/modify the exiting Monobit receiver or fabricate a new/improved Monobit brassboard receiver with COTS components. Identify the most promising signal processing techniques that can be implemented efficiently in hardware. Demonstrate the signal processing techniques with the Monobit hardware in real-time.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where detection performance requires improvement. For example, these developments could be used in foreign peacekeeping operations, tracking techniques or the observation of specific signals. Also, the COTS packaging of RF components and high speed DSP modules would have applications in additional EW receiver algorithms beyond Monobit.

REFERENCES:

1. Tsui, J.B.Y., Digital Techniques for Wide Band Receivers, Second Edition, Norwood, MA, Artech House, 2001.

2 Pok, D.S.K., Chen, C.H., Schamus, J.J., Montgomery, C.T., and Tsui, J.B.Y., Chip Design for Monobit Receiver, IEEE Trans on Microwave Theory and Techniques, Vol.45, No.12, Dec. 1997

3. Tsui, J.B.Y., Fourier Transform Mechanization Using One Bit Kernel Function, USPTO, Patent No. 5917737, June 29, 1999.

4. Tsui, J.B.Y., Monobit Kernel Function Electronic Warfare Receiver for Characterizing Two Input signals, USPTO, Patent No.5963164, October 5, 1999.

KEYWORDS: Sensors, Radio Receivers, Signal Correlation, Electronic Warfare

AF05-226 ~~TITLE: Passive Position-Adaptive Radar Modes For Non-LOS Interrogation Of Embedded Objects~~

TOPIC DELETED

AF05-228 TITLE: Waveforms for Simultaneous Air and Ground Surveillance Operations

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop advanced waveforms and processing techniques that provide simultaneous surveillance of air and ground targets over overlapping coverage regions.

DESCRIPTION: Surveillance radars are typically designed to perform multi-mode operations by sequentially cycling through the various modes and waveforms in a sequential (i.e. non-simultaneous) manner. This is in contrast to the current state-of-the-art, which provides multi-mode operation only sequentially. The JSTARS platform, for example, includes both GMTI and SAR modes. However, due to the sequential nature of the multi-mode operation, it is often difficult to provide data for both missions in a timely manner, due to the frame times consumed for these varied missions. This places significant burdens on limited radar resources and can result in sensitivity degradation, inadequate revisit rates and dropped tracks. Under this effort advanced waveforms, and subsequent processing techniques and architectures, will be developed that overcome current limitations (such as time line differences, area coverage rate differences, etc.) of simultaneous multi-mode operation.

PHASE I: In Phase I a multi-step approach is envisioned where the following are addressed. First, establish metrics and performance criteria for future multi-mode surveillance radar systems as a baseline against which to compare the performance of innovative waveforms (and receive processing) developed under this effort. Second, develop radar waveformsincorporating temporal diversity, spatial diversity, polarization diversity, and novel coding/modulation techniques and associated signal processing techniques that enable simultaneous multi-mode operation. Surveillance modes to be considered include AMTI, GMTI and SAR. Minimum Detectable Veleocity (MDV), clutter cancelation, and ambiguity performance, and mearurement resolution and accuracy will be important performance criteria. Third, develop and deliver a Phase II plan that addresses the Phase II research objectives.

PHASE II: In Phase II emphasis will be placed upon implementation of the techniques developed in Phase I and demonstration of simultaneous multi-mode operation that addresses the criteria established in Phase I. Towards this end, laboratory demonstrations will be a critical component. Critical aspects of waveform generation, direct digital synthesis, signal processing, and coding techniques (temporal, spatial, polarization, modulation/coding) will undergo laboratory implementation, testing, evaluation and demonstration. Consider a notional multi-channel airborne phased array, with a programmable waveform generator and adequate receive processing. Demonstrations can be done via computer simulation and/or with existing prototype hardware.

DUAL USE COMMERCIALIZATION: The commercialization potential is excellent for transitioning this technology into various airborne and spaceborne sensor and navigation systems where energy management and measurement accuracy must be more effectively managed to improve system operation. Results will be applicable to civilian satellite earth surveillance systems, global positioning systems, and telecommunications systems.

REFERENCES:
1. Proceedings of the 1st Annual Waveform Diversity Workshop, February 4-7, 2003, Washington, D.C.

2. Proceedings of the 2nd Annual Waveform Diversity Workshop, February 2-4, 2004, Verona, NY.

KEYWORDS: Simultaneous, Surveillance, Air, Ground, Waveforms, Waveform Diversity.

AF05-230 TITLE: Tunable, Low Mass, Low Loss, Millimeter Wave, MEMS RF Filters

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop tunable RF MEMS filters in the 10GHz to 60GHz frequency range.

DESCRIPTION: MicroElectroMechanical Systems (MEMS) switches and variable capacitors have been applied to monolithic Radio Frequency (RF) filters. By utilizing MEMS devices, the performance of monolithically fabricated filters approaches the performance of current state of the art filters. However, the MEMS filters have the potential for significantly lower cost and mass. When used in the front end of an antenna system for channel selection, image rejection, or diplexing, MEMS based filters can have a significant impact on overall system performance and cost.

To date, the application of MEMS in military systems has been limited due to the relative immaturity of the technology. Under this SBIR, the proposer must demonstrate a clear path towards realizing a packaged device with performance and cost comparable to or better than currently used YIG filters. The filters for this project must operate in the 10Ghz to 60GHz frequency range. In addition to developing the filter, the proposer must include sufficient analytical performance, reliability, and cost models. This project requires significant technical risk in the development of MEMS devices and packaging.

PHASE I: Identify existing MEMS filter and resonator technology in the Microwave and Millimeter Wave frequency range. Create and simulate novel MEMS based designs that increase the tuning range, reduce filter insertion losses, and improve out of band isolation. Develop MEMS component insertion strategies to facilitate RF sub-system insertion strategies. Simulate device performance with electromagnetic and electromechanical tools, and breadboard high technology risk concepts.

PHASE II: Build on experience gained in Phase I to design, develop, and test tunable, space qualifiable, MEMS Millimeterwave band pass filters at 50 GHz. Devices must be packaged and suitable for integration into an RF sub-system used for space applications. Proposed MEMS packaging and part qualification test flows must not preclude the intent of that outlined in “MEMSM Reliability Assurance Guidelines for Space Applications” (ref. 7). At least 10 packaged filters must be delivered for government testing.

DUAL USE COMMERCIALIZATION: Next generation multimedia wideband communication systems in the 10-50GHz frequency range need low cost, high performance, frequency agile RF component technology. Devices developed under this effort would have direct application to transmitters and receivers used in Cable Television, Wireless Local Area Networks, Satellite Communication systems and Radar applications.

REFERENCES:
1. “The MEMS Handbook,” Mohamed Gad-el-Hak, ISBN: 0849300770, CRC Press.

2. “Symposium on Design, Test, Integration and Packaging of MEMS/MOEMS,” 2003 IEEE, ISBN 0-7803-7951-9, IEEE Product No. EX713C-TBR.

3. “2003 International Conference on MEMS, NANO, and Smart Systems (ICMENS 2003),” ISBN 0-7695-1947-4, July 2003, IEEE Catalog No. PR01947.

4. G.M. Rebeiz, "RF MEMS: Theory, Design, and Technology", John Wiley & Sons, ISBN 0471201693

5. Youngwoo Kwon, Changyul Cheon, Nyuntae Kim, Chungwoo Kim, Insang Song and Cimoo Song, “A Ka-band MMIC Oscillator Stabilized with a Micromachined Cavity,” IEEE Microwave and Guided Wave Letters, Vol. 9, No. 9, September 1999, pp. 360–362.

KEYWORDS: RF MEMS, Microelectromechanical Systems, RF Integration, MEMS Cavity Resonators, MEMS RF Filters, MEMS RF Resonators.

AF05-232 TITLE: High Speed Double Balanced Photodetectors for Lasercom

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Design and fabricate a wideband (3dB bandwidth >50 GHz) balanced detector with an integrated low noise amplifier (LNA).

DESCRIPTION: Coherent detection schemes are useful when dealing with weak coherent signals, as well as communications protocols involving phase or frequency modulation. A conventional single detector optical heterodyne receiver can be severely degraded by intensity fluctuations of the receiver's local oscillator (LO), which produce a photocurrent in excess of the usual quantum shot noise. Using two receivers in a balanced heterodyning configuration can effectively suppress the noise due to the LO intensity fluctuations. The balanced configuration has the additional advantage of utilizing all of the signal and LO power. This advantage can be significant in situations where the LO power is limited, either through saturation of the detector or the limited availability of optical power.

A balanced detector is preferable in certain lasercom applications where the improved performance and reduced LO power requirements place fewer restrictions on the LO to be used in the coherent detection. For weak signals and limited LO power, the sensitivity of the receiver can be limited by the noise of the RF amplifier. Therefore, achieving the shot noise limit in this circumstance requires a low noise amplifier (LNA). Ideally, the LNA would be integrated with the photodiodes to achieve a wide IF bandwidth (3dB bandwidth >50 GHz) balanced detector with nominally flat response, large transimpedance gain (>105 V/W), noise equivalent power (NEP) of less than 1 pW/(Hz^1/2), and intensity noise suppression greater than 40 dB. Additionally, while the output will be AC-coupled, there should be DC-coupled low frequency monitors for the individual photodiode currents as well as the difference photocurrent.

PHASE I: Develop and validate innovative designs for wide bandwidth (3 dB point >50 GHz) balanced heterodyne detectors. Proposals should focus on integrated photodiode and LNA implementations, with emphasis on minimum detectable signals and frequency/phase response of the system. Theoretical performance limits should be described as well as limits imposed by environmental conditions.

PHASE II: Design, fabrication, and experimental validation (to mutually [AF/Contractor] agreed characteristics) of a prototype wide bandwidth integrated balanced detector and LNA. Performance should be charactercompared to the limits described in Phase I. Characterization should also include performance as a function of environmental conditions.

DUAL USE COMMERCIALIZATION: Wide-bandwidth balanced detectors with an integrated LNA that is useful in the weak field limit would be useful for both terrestrial and satellite communications. Improvements in this area would benefit many applications in communications and remote sensing and be of interest to both DoD and commercial programs.

REFERENCES:
1. Islam, M., et al., "Velocity-Matched Distributed Photodetectors and Balanced Photodetectors with p-i-n Photodiodes," IEEE Trans. on Microwave Theory and Tech., vol. 49, pp. 1914-1920 (2001).

2. Alexander, S., "Design of Wide-Band Optical Heterodyne Balanced Mixer Receivers," J. of Lightwave Tech., vol. LT-5, pp. 523-537 (1987).

3. Abbas, G., et al., "A Dual-Detector Optical Heterodyne Receiver for Local Oscillator Noise Suppression," J. of Lightwave Tech., vol. LT-3, pp. 1110-1122 (1985).

4. Yamashita, S., et al., "Suppression of Common-Mode Beat Noise From Optical Amplifiers Using a Balanced Receiver," Electronics Letter, vol. 28, pp. 1970-1972 (1992).

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KEYWORDS: Detector, Communications, Amplifier, Free-Space, Wide-Bandwidth, Photodetector

AF05-233 TITLE: Space-Based Light Weight Radiation-hardened Integrated Monolithic Tunable Laser

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a space qualifiable tunable laser to increase optical communication data rates.

DESCRIPTION: Anticipated increases in data rate requirements associated with the Transformational Communications program are expected to create a need for laser communication (lasercom) links for UAV-to-satellite uplinks as well as satellite-to-satellite crosslinks. As such, a capability to compensate for doppler shifts in wavelength due to the relative motion between the transmitting and receiving platforms is desirable.

The objective of this topic is to develop reliable, light weight tunable laser technology that is traceable to space applications. Goals include a
wavelength range between 1300 and 1500 nm, wavelength resolution to 0.1 pm, tuning speed > 100 nm/s, wavelength repeatability < 0.5 pm, output power > 6.0 dBm peak, power linearity +/- 0.1 dB, power stability +/- 0.01 dB/hr, power flatness versus wavelength < 0.2 dB, power repeatability +/- 5dBm, side mode suppression ratio > 40 DB. Additional goals include
a demonstrated reliability consistent with 15 year satellite design life, radiation hardness to total dose of 100 Krad and operating temperature range between -40 to + 80 deg C.

PHASE I: Survey tunable laser designs and select promising architecture. Develop a feasible concept for the design of a tunable laser. Provide preliminary modeling of laser performance including the reliability and radiation objectives identified in description.

PHASE II: Fabricate and demonstrate (to Air Force/Contractor agreed parameters) a prototype lightweight tunable laser meeting performance goals as identified in the topic description. The prototype should be of a design that is traceable to a radiation hardened device. The laser assembly will be delivered to the government for independent evaluation.

DUAL USE COMMERCIALIZATION: Tunable lasers are used extensively in terrestrial fiber optic networks

REFERENCES:
1. Bruce, Elizabeth, "Tunable Lasers", IEEE Spectrum, Feb 2002, pp 35-39.

2. M. Ohtsu, "Highly coherent Semiconductor Lasers", Artech House, Boston, 1992

KEYWORDS: Wavelength, Tunable Laser, Uplink, Downlink, Wavelength Division Multiplexing,Output Power.

AF05-238 TITLE: High-Strength and High-Durability Radio Frequency (RF) Transparent Structures

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate RF transparent structures with improved structural performance.

DESCRIPTION: Emerging systems designs will utilize conformal load-bearing antenna structures (CLAS) to increase RF sensor performance and mitigate integration penalties. CLAS concepts feature RF antennas embedded in loadbearing aircraft skin. CLAS concepts are typically multi-layered composite structures. CLAS concepts sometime require surrounding structures and control surfaces to be RF transparent to allow beam propagation. In either case, the CLAS concept requires the use of RF transparent materials. The technical challenge is that RF transparent materials are inherently less stiff, strong, and durable than traditional structural materials and reduce the structural performance of CLAS concepts. The goal of this effort is to exploit novel structural concepts, advanced materials, and advanced reinforcement concepts to develop RF transparent structures with improved structural performance and integrity. Concepts such as highly unitized structures and 3-dimensional reinforcement concepts may provide a solution.

PHASE I: Develop and demonstrate structural performance improvement and basic electromagnetic performance on a subscale component.

PHASE II: Demonstrate concept scale up, structural performance, and RF performance, on a full scale representative aircraft structure.

DUAL USE COMMERCIALIZATION: This technology will be applicable to all Air Force vehicles with RF apertures. Applications include leading edge structures and control surfaces. This technology will also be applicable to emerging CLAS, which feature RF antennas embedded in load-bearing structure. Numerous dual use applications exist for all forms of commercial transportation systems that require RF communication and data links such as aircraft, buses, trucks, and marine systems.

REFERENCES:
1. Smart Skin Structure Technology Demonstration (S3TD)AFRL-VA-WP-TR-1999-3040, ADB275129.

2. 3-D Composites with Integrated Woven Structural Rods for Airframe Structure. Phase I WL-TR-96-3089, ADB212176

KEYWORDS: structures, dielectric materials, fiber preforms, electromagnetic, radio frequency, transparent

AF05-239 TITLE: Macrostructure Integration via Friction Stir Welding (FSW)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop processes to join inexpensive aluminum sheets into fuselage shapes.

DESCRIPTION: Friction stir welding has been used to join smaller, inexpensive aluminum sheets, eliminate many fasteners, and form the assembled sheets into a fuselage shape. In this program aluminum sheets of differing thicknesses would be utilized to tailor the structural properties.

Empirical data to date has shown that FSW coupons exhibit higher fatigue resistance and increased joint efficiencies over separate-sheet/fastened designs. There is no degradation in damage tolerance performance and corrosion performance is equivalent to the baseline material.

Utilizing FSW to produce unitized structure allows maximum flexibility in material product form usage. This has been well studied. By tailoring the material to allow higher strength capability near stress concentrations, doors or other features, weight can be reduced by using lower strength material and/or thinner product than is conventionally used. Higher cost materials are used only where necessary.

PHASE I: Perform analysis on materials and thickness combinations required for potential design improvements with regard to weight and cost reductions. Optimal combinations of panel thicknesses and/or materials would be determined.

PHASE II: Perform testing on FSW material/thickness combinations selected in Phase 1 to obtain data needed to determine where maximum benefit potential exists. Optimize analysis with testing results and conduct a more detailed analysis study on a potential airframe application.

DUAL USE COMMERCIALIZATION: FSW technology will be applicable to commercial as well as military vehicle structures. Other than combat requirements for military vehicles and design criteria (for example, fighter aircraft), the basic structural technology advancements will be applicable to both military and commercial classes of vehicles. Commercial airliners and military transports have similar loading requirements and thus the technology generated for one class would be generally applicable to the other class.

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KEYWORDS: friction stir welding, welding, unitized structures, metallic structures, joining techniques, aerospace structures

AF05-241 TITLE: Coupling of Computational Fluid Dynamics (CFD), Reentry Vehicle Surface Ablations, and In-Depth Conductions

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Provide innovative algorithms for assessing and sizing the trajectory shaping vehicle (TSV).

DESCRIPTION: Reliable CFD tools were developed over the years for assessing ballistic reentry vehicle (RV) and TSVs for the three-dimensional (3-D) flow fields including the chemical reacting flow, and wall ablation phenomenon. The body geometry can be non circular cross section. However, in most cases, the flow fields and RV surface ablations are not coupled and are largely limited to blunt conic geometry. For future emerging mission needs, more advanced and unconventional heatshield material and complex body configurations are involved. The existing modeling and simulation tools used are inadequate to assess and to size future vehicle (e.g., the TSVs) aerodynamics, thermal heating, and thermal protection systems. Additionally, the CFD numerical results can greatly reduce the expensive wind tunnel tests, and provide insight for the engineering parametric calculations.

PHASE I: Develop multi-dimensional, fully coupled CFD Reynolds-averaged Navier-Stokes code (laminar and turbulent flows) and the thermal response modeling of hypersonic RV at zero angle of attack using composite heatshields and bonding materials on a blunt conic body with control surfaces such as flaps or jet reaction control. The thermal protection materials can be a sublimer such as carbon-carbon. The computations start at a given TSV trajectory of 300 kft altitude and end at impact.

PHASE II: Extend the Phase I effort to a TSV with non-circular cross section (e.g., high lift-to-drag (L/D) ratio vehicle). The computations should constitute the whole maneuvering trajectory starting at reentry (e.g., h ~ 300 kft altitude) and ending at impact. The heatshield will include the candidate materials such as a sublimer, charring ablator, radiating surface, and melting ablators. The numerical results will be validated with government supplied flight data. The numerical computation time on a representative trajectory will be limited to 32 hours on a relatively fast personal computer (PC) (2.5 GHz). At the end of Phase II, the delivered items include a final report, computer code user manual, sample cases, and the numerical software.

DUAL USE COMMERCIALIZATION: The proposed modeling and simulation effort will have benefits to space and commercial communities. Applications include general, multicomponent body TPS, use of the numerical algorithms, and flow field solver for other general problems of interest (e.g., commercial aircraft design).

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1. Y. K. Chen and F. S. Milos, “Two-Dimensional Implicit Thermal Response and Ablation Program for Charring Materials,” Journal of Spacecraft and Rockets, Vol. 38, pp. 473, July 2001.

KEYWORDS: computational fluid dynamics, thermal protection system, trajectory shaping vehicle, aerodynamics

AF05-242 TITLE: Diagnostic Techniques for High Speed Flows

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop nonintrusive diagnostics for measuring flow field conditions for high-speed regimes with limited optical access to the experimental area.

DESCRIPTION: Development of new experimental techniques to measure transonic and higher (Mach 0.6 to 3.0) velocity flow fields is crucial to keep the U.S. Air Force on the cutting edge of technology. The critical areas that are in need of the new nonintrusive diagnostic techniques include but are not limited to directed energy integration, weapons bay cavities, engine inlets, combustion chambers, and exhausts. Current experimental diagnostics have limited capability in measuring velocity flow fields for validation of Computational Fluid Dynamics (CFD) results, and the U.S. Air Force wants to surmount this deficient area by increasing spatial and temporal sampling rates of its experimental diagnostics.

Comparing the instantaneous results from an experiment to CFD would greatly improve both the experimental and computational communities, but current experimental techniques cannot measure the entire velocity flow field at the high spatial and temporal rates required. Many laser-based systems, i.e., laser doppler anemometry (LDA), particle image velocimetry (PIV), Malley Probe, and Shack-Hartman Sensor, lack the spatial or temporal resolution to fully measure the velocity flow field effectively. The results obtained from these experimental techniques are directly compared with CFD results, but only with the statistics, i.e., mean, Reynolds stresses and optical path difference (OPD). Even older experimental methods, i.e., pressure probes, hot-wire anemometry, Shadowgraph, and Schlirelen Imaging, have their own drawbacks when dealing with transonic and higher conditions, i.e., tunnel blockage, vibrations, integrated optical path, etc., and have become rapid analysis tools to determine placement of other experimental diagnostics.

The goal is to improve on an existing or develop a new nonintrusive diagnostic method for transonic and higher speed regimes, to measure the off-body instantaneous velocity flow fields with high spatial and temporal resolution. Design consideration is warranted because the tunnels that meet the flow regime requirements may have limited optical access, which can interfere with the optical measurements. A proper interrogation volume is necessary and is dependent on tunnel and model size to obtain direct comparison with CFD results. These new techniques will improve our understanding of several key areas that are currently being examined by the U.S. Air Force, i.e., open and closed-loop flow control, high frequency actuation, separation control, boundary layer perturbation and shear layer instability analysis.

PHASE I: Research nonintrusive diagnostics for transonic and higher speed regimes. Develop or improve nonintrusive diagnostic concepts and test the concepts in similar speed regimes comparing the results with existing data, computational or experimental. Determine relative strengths and merits of new or improved concepts compared to existing diagnostic methods.

PHASE II: Build a portable prototype of the nonintrusive diagnostic device and demonstrate the diagnostics capability. Evaluate the results and compare them with existing experimental or computational data.

DUAL USE COMMERCIALIZATION: Vehicle systems that are designed and analyzed with experimental data will benefit from this technology. CFD software validation will be more comprehensive due to the results obtained from this technology. High-payoff military applications include enhanced performance for most near-term platforms. Examples of potential commercial applications include commercial aircraft and general aviation.

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KEYWORDS: flow diagnostics, experimental methods, high spatial resolution, high temporal resolution, PIV, nonintrusive diagnostics

AF05-243 TITLE: Integration of Flight Control and Flow Control

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate the integration of active flow control and flight control to improve the aerodynamic performance of air vehicles.

DESCRIPTION: Given recent successes in aerodynamic flow control technologies, the integration of flight control with active flow control actuation is now an achievable goal with inherent technical risks. Active flow control promises to improve aerodynamic performance (e.g. increased agility, extended loiter), allow air vehicle designs to be optimized for criteria other than aerodynamic performance (e.g., radar cross section or embedded sensor effectiveness), and/or allow the partial or complete replacement of hinged flight-control surfaces. The objective of this research is to demonstrate the integration of flight control and active flow control for a small or micro (wing span of less than ten feet) unmanned air vehicle. A goal is to demonstrate the use of aerodynamic flow control to reduce or eliminate the use of conventional aerodynamic flight-control surfaces. A system of sensors and actuators coupled through feedback control, integrating stability and control of the airframe dynamics with active aerodynamic flow control, is desired. The vehicle may be flown autonomously or piloted remotely, but the active flow control actuators should be fully integrated with the flight control system such that no special input by a pilot is required for use of the flow control actuator(s). The use of existing active flow control actuators is encouraged. A successful program will be strong in each and all of the following areas: aerodynamics, actuators, sensors, and control law design. The proposed project should address the use of active flow control for maneuvering flight, not simply for steady flight conditions. Consideration should also be given to air vehicle integration, including modeling of the aerodynamic effects of the control concept, control law design for the aircraft-actuator integrated system, modeling and allocation of control power, overall control architecture, and impact on the overall air vehicle design. Both Micro Electro-Mechanical Systems (MEMS) and non-MEMS technologies will be given equal consideration. The most appropriate feedback control technique will depend on the overall system architecture, but distributed parameter control, robust control, learning control, adaptive control, and/or other advanced control technologies may be required to meet the full flight envelope requirement. The demonstration of the technology is to be carried out through flight-testing representative of the entire design envelope.

PHASE I: 1) Develop a preliminary design of a small or micro unmanned air vehicle that uses active flow control for control of the longitudinal and/or lateral dynamics of the vehicle with minimized or no conventional flight control surfaces. 2) Estimate increased performance with respect to some or all of the following design criteria: range, payload weight, payload volume, landing speed, loiter time, and maneuverability.

PHASE II: 1) Construct and demonstrate, in flight, the vehicle designed in Phase I over a range of flight conditions. 2) Demonstrate, in flight, improved performance with flow control technology compared to a vehicle flown only with traditional moving flight control surfaces.

DUAL USE COMMERCIALIZATION: All classes of air vehicles may benefit from this technology. This capability will ultimately be useful for improving aerodynamic performance, especially of non-aerodynamically optimized designs, as well as enabling flight control without external moving surfaces. Further, significant dual-use

potential for air, ground, and water-borne vehicles exists for this technology. Users of tractor trailers and large ships can benefit from reduced drag, thereby lowering fuel consumption. Use on automobiles may reduce aerodynamic noise in the passenger compartment.

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KEYWORDS: flow Control, Flight Control, Feedback Control, Unmanned Air Vehicles

AF05-244 TITLE: Technologies for Control of Morphing Aircraft

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Investigate methodologies and develop control system designs for morphing aircraft structures and deformable wing surfaces.

DESCRIPTION: Morphing technologies have the potential to expand the flight envelope of aircraft beyond the current state of the art, and early research has demonstrated that significant vehicle mission-level benefits can be achieved through these large-scale geometrical changes, especially in unmanned air vehicle (UAV) applications. To fully realize all of the capabilities of morphing aircraft, there is a need for control system research to enable active control of morphing wing structures. The primary control challenge associated with morphing aircraft structures is controlling large-scale vehicle (wing) transformations. In controlling these large-scale shape changes, the ultimate objective is to enable efficient in-flight transformation between vehicle states. The control system technical challenges specific to this morphing aircraft area are as follows:

·Modeling and analysis of the control system given known aerodynamic loads.
·Development of an integrated morphing wing control system to include innovative power management and distribution techniques, design of advanced control system architecture, and analysis of actuation systems (electromechanical actuators, smart material actuators, etc.), smart material actuators, etc.) for use in a distributed control environment, with focus on load and rate sizing requirements and efficient use of power.
· Development of control algorithms to enact state transformations, emphasizing considerations unique to morphing aircraft, such as redundancy management and jamming/sticking prevention.

PHASE I: For a small UAV to (UCAV)-sized aircraft (500 to 10,000 lbs), research and demonstrate technologies necessary to address one or more of the technical challenges presented in this topic. It is envisioned that the demonstration will consist of computer modeling, analysis, and simulation of the actuation system, including analysis of the relationship between aerodynamic, electrical, and mechanical loads. Control algorithms could also be demonstrated for a representative state transformation while maintaining overall vehicle stability and control.

PHASE II: Fabricate and test a scaled, integrated wing section in a hardware-in-the-loop (HWIL) laboratory environment. Integration should include the wing structure with distributed actuation system, power electronics, and

control electronics. Representative aerodynamic loads should be applied during testing to demonstrate morphing capabilities.

DUAL USE COMMERCIALIZATION: Morphing technologies have the potential for nonmilitary applications such as commercial aircraft (small and large), where drag reduction and aerodynamic tailoring would lead to significant improvements in performance measures (range, speed, overall fuel cost, etc.). Examples of military potential areas that can benefit directly from this work are laser tracking systems, satellite systems, and telecommunications.

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KEYWORDS: morphing aircraft, wing deformation, adaptive structures, distributed actuation, wing shaping, servo control, mechanization, mechanism control

AF05-245 TITLE: Mechanical Attachments for Advanced Thermal Protection Systems (TPS)

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a novel design for mechanical attachment of reusable space access vehicle thermal protection systems.

DESCRIPTION: The current solution to protecting low-temperature reentry vehicle structures from the most severe heating conditions involves adhesively bonding insulating tiles to the outer skin. While this attachment method has proven reliable and durable, it lacks maintainability and operability. The approach proposed by this topic is to investigate attachment methods which would allow faster, nondestructive removal and reinstallation of TPS segments to simplify maintenance and repair and to allow ready access to the TPS substructure. The attachment system should be applicable to ceramic matrix composite (CMC) concepts, including CMC-wrapped tiles. The system needs to be designed to withstand the severe thermal and acoustic environment associated with launch and atmospheric reentry. Consideration also needs to be given to the thermal and structural integration of the attachment mechanism with lower temperature vehicle substructure and cryogenic tanks. Such capability is suited to a future, all-rocket, two-stage-to-orbit (TSTO) space operations vehicles (SOV) that will provide reusable access to low-earth orbit (LEO) or to an air-breathing hypersonic cruiser.

PHASE I: Develop one or more concepts for a durable, operable attachment system. A representative vehicle component should be selected upon which to base design development. Candidate approaches will be conceptualized and subjected to thermal structural analyses to assess durability and thermal compatibility with the TPS and substructure. For those approaches deemed feasible, mechanism specimens will be designed, fabricated, and tested to assess feasibility.

PHASE II: Concepts developed in Phase I will be validated by experimentation. Phase II will involve the integration of the concept developed in Phase I to attach a TPS segment to a cold structure such as a cryogenic tank. The assembled structure will be evaluated through thermoacoustic testing. Issues such as manufacturing efficiency and quality control will need to be addressed to mature this technology for system application. A durability objective is no mechanism failure after a one hour thermoacoustic test with a TPS surface temperature of 1800F and 165 dB

sound pressure level. An operability objective is a demonstrated component removal and replacement (R&R) time of less than one hour. While items such as fasteners and seals may be considered disposable during R&R, the TPS panel must be reusable.

DUAL USE COMMERCIALIZATION: Issues such as manufacturing efficiency and quality control will need to be addressed to mature this technology for system application. Military applications for this operable TPS include reusable space access systems and hypersonic air platforms. Civilian applications include any follow-on to the Space Shuttle concept.

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KEYWORDS: thermal protection systems, cryogenic tanks, military space plane, hot structures, space operations vehicle, mechanically attached TPS

AF05-246 TITLE: Innovative Transformational Aircraft Configuration Technology

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Identify, assess, and demonstrate innovative unmanned air vehicles (UAVs) with performance enabled by transformational applications of advanced air vehicles technology.

DESCRIPTION: The Air Force is seeking transformational technology to enable new air platform concepts responsive to modern threat environments and mindful of fiscal constraints. While revolutionary transformations are not expected in airframe aerodynamics, rational assimilation of new technologies in flow physics, structures, flight control, energy storage, materials, etc. can enable revolutionary gains in aircraft performance. The emergence of UAVs presents opportunities for significant performance gains and cost savings relative to manned vehicles. Small size, long endurance and high accelerations are three obvious examples of advantages unique to UAVs. Typical of the type of vehicle/technology/mission features envisioned are high-altitude long-endurance platforms used for intelligence gathering and/or communication, possibly with unconventional propulsion methods (ram accelerators, balloons, rail launchers, air launched) to reach and/or maintain mission altitude. At the opposite end of the spectrum are mini- or even micro-UAVs, whose small size is a revolutionary departure from conventional air vehicle design, and allows the leveraging of miniaturization of sensors, electronics, energy storage, and munitions.

Micro Air Vehicles (MAVs) – Typically UAVs with a wingspan on the order of 15 cm or less, MAVs have been demonstrated as feasible in steady level flight, and to a lesser extent in maneuvering flight. The low-Reynolds number flowfields associated with MAVs are characterized by flow separation, unsteadiness, and viscous interactions, resulting on poor aerodynamic efficiency relative to that of larger UAVs and manned aircraft. Sensitivity to wind gusts is high, challenging both airframe and control system design.

Recent interest in flapping wings as an unconventional means of generating both lift and propulsion has resulted in flight demonstrators, though performance remains inferior to comparable fixed-wing or rotary systems. Flexible and morphing materials/structures concepts are required technologies for flapping wing concepts. Studies of examples in nature, such as fruit flies and hawk moths, have revealed spectacular performance gains from exploiting separated vortical structures and the delay of leading edge vortex shedding. Phase-sensitive wing rotations and translations introduce a mechanism for maneuvering and robust gust rejection. For flapping to be useful for practical MAVs, fundamental research is necessary to extend the existing knowledge of unsteady wing aerodynamics, flexible structures and microvehicle control.

Small UAVs – With wingspans of 2 to 20 feet, small UAVs tend to be designed by the build-and-test method rather than by a rigorous design process rooted in analysis. This complicates the design process, making optimization difficult and inhibiting the maturation of engineering design practice. The development and demonstration of automated design methods for small UAVs is necessary for such UAVs to be fully accepted by the aerospace design community.

Development of a novel vehicle concept would begin with identifying the relevant configuration parameters; for example, for flapping-wing MAVs, identifying the issues in flapping-wing aerodynamic performance, structural concepts and flight control. The conceptual design would be validated in an experimental program. Again in the case of MAVs, this would identify the relationship between prescribed wing kinematics and the resulting flowfield behavior. Experimental results would be used to close the loop with a conceptual-level design code to predict vehicle flight performance.

PHASE I: Identify unique vehicle and technology integrations that conceptually provide mission capability beyond that currently available with conventional systems. Assess the performance, technology requirements, cost, and utilization of the proposed concept, to establish proof of concept.

PHASE II: Detailed engineering analysis and test of the conceptual design to establish benchmark mission capability. Refine and execute the test program developed in Phase I. Again in the example of a flapping-wing MAV, design and build a hovering flapping-wing MAV capable of station keeping in gusts equal in magnitude to the cruise velocity. For micro and small UAVs, develop a working prototype. For larger UAVs, complete a conceptual design. Validate the conceptual-level vehicle design code with wind tunnel and flight tests, if feasible.

DUAL USE COMMERCIALIZATION: Vehicles emerging from this research could be used for a host of civil applications ranging from search and rescue, police surveillance, telecommunications applications, environmental sampling, remote inspections etc. Design codes for small UAVs would benefit designers of military and civilian UAVs, for present applications and applications not yet envisioned, by greatly reducing the wind tunnel/flight testing time necessary for vehicle development. Military intelligence, surveillance and reconnaissance; precision targeting and weapons delivery.

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KEYWORDS: unmanned air vehicle, high altitude long endurance, micro-vehicles, conceptual design, hovering, unsteady aerodynamics

AF05-247 TITLE: Advanced Heat Pipe Concepts for Leading Edges

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop novel designs for a durable, lightweight, leading edge heat pipe cooling system.

DESCRIPTION: Aerothermal heating of nose, wing, and stabilizer leading edges of space access vehicles during reentry creates stagnation point temperatures beyond the limits of most materials. For certain projected vehicle configurations and flight trajectories, no passive material solution exists. Application of heat pipes appears promising as a means of moving the thermal energy to cooler regions of the vehicle for reradiation to space. Transporting the energy away from the leading edges would keep the temperatures of these critical areas well within the capabilities of high temperature materials. Innovative solutions are desired to the design of a metallic heat pipe cooled leading edge that has the thermal performance desired and is both durable and light weight. Such a system would have application to reusable launch vehicles such as the space operations vehicle (SOV) or to a hypersonic cruise vehicle. In either case, the system must be designed for reusability, maintainability, and all weather operation with consideration also given to thermal and structural integration with the vehicle substructure.

PHASE I: Develop one or more concepts for a durable, light- weight, metallic heat pipe cooled leading edge. A representative vehicle thermal loading profile should be selected upon which to base design development. Candidate approaches will be conceptualized and subjected to thermal structural analyses to assess performance, durability, and thermal compatibility with internal vehicle structure. For those approaches deemed feasible, detailed test specimen designs will be created.

PHASE II: Concepts developed in Phase I will be validated by experimentation. Phase II will involve fabrication and test of a heat-pipe-cooled leading edge segment sufficient to demonstrate thermal performance and impact and weather durability.

DUAL USE COMMERCIALIZATION: Military applications for heat pipe technology include reusable space access systems, hypersonic air vehicles, and propulsion systems. Civilian applications include reusable shuttle or crew return vehicles as well as high-temperature manufacturing processes.

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KEYWORDS: thermal protection systems, military space plane, space operations vehicle, heat pipes, leading edges, heat-pipe-cooled leading edges

AF05-248 TITLE: Innovative, Weight Efficient, Composite/Metallic Structural Joining Concepts

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative solutions to improve joint design tools and/or to explore unconventional joint concepts.

DESCRIPTION: Joints have always been the toughest challenge for aircraft structure designers and manufacturers. Joints add weight, cost, and complexity to any design. The purpose of this effort is to examine the feasibility and establish the weight benefits of advanced hybrid composite/metallic structural joining concepts that are efficient at carrying aerodynamic vehicle body loads while minimizing thermal stresses. Meaningful structural joining studies on materials, structural concepts, cross sectional dimensions, and layups require specific design details, analysis accuracy, and many failure mode predictions. Additionally, to quantify the benefits of hybrid structural joining designs, reliable weight predictions need to be performed based on sizing each candidate material and concept to its natural capability. An analysis and sizing tool is required to find the optimal shape, material, and thicknesses in order to carry all of the aerodynamic load cases, while minimizing thermal stresses. Without analysis and design detail, the benefits of one design compared to another are not quantifiable and do not lead to definitive technologies to pursue. This effort includes quantifying thermally induced stresses and strains from thermal expansion coefficient mismatches, including their severity and minimization through part sizing and material compatibility of layup stacks

and hybrid material layers. This effort also includes finding hybrid designs that are naturally efficient without forcing them to follow metallic preconceived notional designs, performing analyses not only on materials and panel concepts, but also on compatible bonded and bolted joints, connections, material transition regions, and damage tolerance, including the effects of Thermal Protection System (TPS) for high-speed flight vehicles.

Future aircraft design concepts feature a high degree of structural unitization to minimize weight, manufacturing / assembly costs signature, and aerodynamic drag. Alternatively, the practicalities of assembly and flight system equipment support access drives designs toward multipiece bolted assembly concepts with numerous access panels. One possibility of an unconventional joining concept is a joining solution that combines the benefits of unitized continuous structure with convenience of bolted assembly. One example of this could be a nanoscale hook-and-loop fastening system actuated through a nonmechanical means such as shape memory or piezoelectric or analogous phenomenon. Nanoscale is desired to provide an extreme areal density of fastening sites and high structural integrity. Nonmechanical actuation is desired for ease of assembly and disassembly and to allow the joining of complex shaped surfaces.

PHASE I: Develop innovative analytical tools and/or advanced metallic/composite structural joining concepts, and integrated TPS design concepts applicable to Air Force space access, Uninhabited Combat Aerial Vehicle (UCAV), and future strike vehicles. Candidate approaches will be conceptualized, feasibility demonstrated, and subjected to realistic mechanical and thermal vehicle flight loadings to assess weight, thermal compatibility, and structural integrity. Candidate analytical/reliability methods will be demonstrated to size structural joints with respect to failure load application to realistic structural joints. Demonstrate the basic feasibility of the concept and generate an initial indication of the structural integrity potential of the concept.

PHASE II: Determine new conceptual hybrid structural joining concepts that have robust designs that lead to efficient certification. Explore the feasibility and establish the weight benefits of advanced hybrid composite/metallic structural joining concepts and designs for a representative space access, UCAV, or a future strike vehicle. Select and develop a typical structural joint design concept, and manufacture and test to verify the concept and to verify the analytical tools used.

DUAL USE COMMERCIALIZATION: The structural technology developed will be applicable to commercial as well as military vehicles. Other than combat requirements for military vehicles and design criteria (for example, fighter aircraft), the basic structural technology advancements will be applicable to both military and commercial classes of vehicles. Commercial airliners and military transports have similar loading requirements, and, thus, the technology generated for one class would be generally applicable to the other class.

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KEYWORDS: hybrid structures, metallic structures, composite structures, unitized structures, dissimilar materials, structural joints, aerospace structures, functionally gradient materials

AF05-249 TITLE: Influence Boundaries in Computational Fluid Dynamics (CFD)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and implement algorithms to locate a priori influence boundaries for specified configurations and their flowfield simulations.

DESCRIPTION: For many flowfield conditions and vehicle geometries, experience has shown that geometric and/or physical model simplifications can have negligible influence on the overall solution. In many cases, large-scale changes in geometry or changes in physical modeling have limited influence in the flowfield. The primary

goal of this effort is to develop the technology that will enable these influences to be exploited in grid generation and computational fluid dynamics (CFD).

By quantifying influence regions of geometric components or physical models, it would be feasible to utilize flowfield solutions over less complex forms of the original geometry or less complicated physical models as a baseline solution to which specific effects could be added. If the extent or "region of influence" of a geometry change or physical phenomenon is known, the baseline flowfield solution (over the simpler geometry or obtained with the simpler physical model) could then be used to establish a restricted computational domain for a more detailed computation within the region of influence. There are important advantages to this approach; overall time for grid generation is reduced, and because flowfield quantities are available everywhere along the boundary of influence, multiple equation sets or multiple flow solvers could be used for a single flowfield. The use of overset methods [1] has most of these advantages. Overset methods will also benefit from the present effort because influence regions will provide a guide to construct overset grids that minimize regions where grid-to-grid interpolation may affect computed solutions.

The technical goal of this SBIR is to develop two types of interfaces describing influence boundaries: the first is geometric and the second is physical. The first interface will allow specification of the geometric influence boundary so that grid generation can be performed in a building-block manner. In supersonic inviscid flows the geometric influence boundary can be specified knowing only the freestream Mach number and geometry [2]. Upstream influences in viscous supersonic flows are discussed in [3]. In transonic and incompressible flows, the specification of influence boundaries is less obvious although it has been discussed in the literature [4,5]. For flowfields about highly complex geometries, influence boundaries cannot be easily determined when only freestream conditions are known. For these complex flowfields, "rules of thumb" need to be developed. For example, visualization of the flowfield could simplify the identification of influence boundaries. Influence boundaries could be determined from experience or by correlations for the specific type of configuration considered. Some typical examples of complex air vehicle geometries can be found at http://www.va.afrl.af.mil/COE/CompS/comps_index.html.

The physical interface would enable flowfield properties to be determined at the influence boundary. Knowledge of the flowfield properties at the influence boundary will allow boundary conditions to be developed for the region of influence. Therefore, with flowfield properties specified on the influence boundary, each portion of the flowfield could be computed with the most efficient solver or most appropriate physical model.

PHASE I: Demonstrate the feasibility of determining influence boundaries in external inviscid flows given the freestream Mach number, angle of attack, and model geometry. The model geometry must be defined in at least one of the following formats: analytical, PLOT3D [6] or IGES [7]. More information regarding IGES formats can be found at http://www.eeel.nist.gov/iges.

PHASE II: Develop and demonstrate the capability to interactively create PLOT3D or IGES files describing influence boundaries for geometries in external viscous flows. The developed technology will permit the model geometry to be read in at least one of the following three formats - analytical, PLOT3D or IGES -and enable the visualization and analysis of computed flowfield solutions to be used as a guide in creation of the influence boundaries. Allow creation of Fortran 90 or C subroutines that output flowfield variables given the Cartesian coordinates on the influence boundary. The deliverable will be an integrated environment capable of the following: limited display of steady and unsteady CFD datasets, display of geometry models, manipulating influence boundaries, automatically determining influence boundaries given free stream conditions or local flow field properties, and exporting geometry and flow field data on the influence boundary. Develop specifications for import and export file formats that differ from those specified by the Government. Demonstrate the utility of the environment by using it to selectively refine a sample geometry. Show comparisons between full geometry computations and reduced-geometry computations using a CFD flow solver.

DUAL USE COMMERCIALIZATION: Extraction of influence boundaries would benefit the design of air vehicles in all flight regimes for both military and industry applications. Utilization of this technology would benefit the design process earlier because geometry changes could be readily incorporated into high-fidelity computational analysis.

REFERENCES:
1. Benek, J.A.; Buning P.G.; and Steger, J.L., “A 3-D Chimera Grid Embedding Technique,” AIAA Paper 85-1523, July 1985.

2. Billig, F.S., “Shock-Wave Shapes Around Spherical- and Cylindrical-Nosed Bodies,” Journal of Spacecraft and Rockets, Vol. 4, No. 6, pp. 822-823, June 1967.

3. Miller, J.H.; Tannehill, J.C.; and Lawrence, S.L., “Parabolized Navier-Stokes Algorithm for Solving Supersonic Flows with Upstream Influences,” AIAA Journal, Vol. 38, No. 10, pp. 1837-1845, Oct. 2000.

4. Davis, M.B.; Welterlen, T.J.; and Corfeld, K.J., “Minimized Domain CFD for Store Separation,” AIAA Paper 2003-1245, January 2002.

5. Lange, C.F.; Durst, F.; and Breuer, M., “Momentum and Heat Transfer from Cylinders in Laminar Crossflow at 10-4 < Re < 200,” International Journal of Heat and Mass Transfer, No. 41, pp. 3409-3430, 1998.

6. Buning, P.G. and Steger, J.L., "Graphics and Flow Visualization in Computational Fluid Dynamics," AIAA Paper 85-1507, July 1985.

7. Oakes, J.E. and Doelling, A.E., "Digital Product Definition Data Exchange via IGES," AIAA Paper 87-2913, September 1987.

KEYWORDS: domain decomposition, minimized domain, shock shapes, sonic line location, upstream influence, IGES file

AF05-250 TITLE: Novel Computational Approaches for Solving Optimization Problems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Development of a robust methodology for solving optimization problems based on new methods for approximating initial values.

DESCRIPTION: Deployment of future aerospace systems will require an intensive system–level integration of components to meet the urgent need at all system levels to minimize risk and cost. The growing complexity of aerospace systems and the resulting increase in susceptibility to failure due to improperly designed/integrated components, dictate a critical need for improved analysis and design methods for predicting, evaluating, and optimizing performance. Traditionally, air vehicle analysis and design has relied almost exclusively on extensive trade studies and very costly prototype development of complete aircraft systems that provide only limited insight. The numerous combinations of test parameters required for an overall system–level analysis make complete optimization of complex configurations prohibitively expensive if not impossible due to lack of ground–testing facilities capable of replicating critical trajectory regimes. Research is needed to bridge the gap between solving the optimization problem and reliable/robust means of setting initial conditions. Knowledge gained from this research can then be applied toward the development of effective techniques that can be used to streamline the optimization process [1]. Practical methodologies for the determination of reliable, robust initial values required for finding optimal values of a constrained or unconstrained objective function shall be implemented and incorporated with a variety of solvers. Many existing solvers (commercial and public domain) are known to work well when an initial guess is provided, ideally close to the optimum. A significant challenge associated with this is how to select the initial guess wisely. Problems associated with choosing an initial value incorrectly include divergence, nonuniqueness (dependent on initial guess), or no solution at all. At present, no robust methodology or tools exist to set the initial guess for general problems, although this has been done for low-dimensional problems via visualization, and the elegant solution to chemical equilibrium as addressed by Reynolds [2]. The present initiative seeks innovative solutions to the challenge of initializing a general optimization problem. This should include developing a set of criteria for defining a “good” (i.e., effective and robust) initial guess for any given optimization problem and evaluating existing optimization software for coupling with the method or methods chosen.

PHASE I: Explore, develop, and determine feasibility of method or methods for obtaining and evaluating computationally effective initial values for solving optimization problems. Testing and validation should be performed on a variety of problems characterized by both constrained and unconstrained optimization algorithms.

PHASE II: Development, detailed validation, and incorporation of best approach(es) into a prototype software system.

DUAL USE COMMERCIALIZATION: The end product could be used for military applications for solving realistic (aerospace systems) optimization challenges. This includes but is not limited to engine-airframe integration, shape optimization, lifting surface-structures optimization, etc. Commercial applications include any system or sub-system level optimization where maximum performance effectiveness is desired, especially problems where intialization of the optimization problem is vaguely understood and mission-critical.

REFERENCES:
1. C. Bliek, et al., Algorithms for Solving Nonlinear Constrained and Optimization Problems: The State of the Art, The Coconut Project, 8 June 2001, http://www.mat.univie.ac.at/~neum/glopt/coconut/StArt.html.

2. W. C. Reynolds, The Element Potential Method for Chemical Equilibrium Analysis: Implementation in the Interactive Program STANJAN, Unnumbered Report, Department of Mechanical Engineering, Stanford University, Palo Alto, CA, 1986.

KEYWORDS: optimization, computational steering, visualization, constrained/unconstrained optimization, objective functions

AF05-255 TITLE: Non-Destructive Grain Orientation Verification in Directionally Solidified Nickel Super alloy Turbine Blades

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Produce a methodology for non-destructive primary and secondary grain orientation verification in directionally solidified nickel superalloy turbine blades.

DESCRIPTION: Directionally solidified nickel superalloys are commonly used in parts for high temperature propulsion applications. The casting of these parts does not always assure perfect grain direction orientation, allowing other than desired grain orientations. There does not exist a method to check for grain orientation non-destructively. Due to Air Force executive level interest in recent engine failures and aircraft mishaps with these parts as the causal factor, it is imperative to have the ability to verify the part's grain orientation.

Extensive basic research and development of grain orientation has occurred during the introduction and production of superalloys in the marketplace. However, non-destructive methods are unknown to check grain orientation. Our project will require the offerer to gather all past and present research data and testing methods and apply that knowledge to develop an innovative concept to verify grain orientation non-destructively. This research effort could include but is not limited to eddy current, x-ray diffraction, and photon induced positron annihilation. Combination of existing capabilities or exploration of novel methods is highly encouraged.

SBIR Topic #AF05-261, Non-Destructive Residual Stress Measurement in Superalloy Turbine Blades, is also proposed by this organization. Some approaches, e.g., x-ray diffraction, may be applicable to both; however, the final objectives are distinctly different.

PHASE I: Demonstrate a non-destructive methodology concept to verify grain orientation on directionally solidified nickel superalloy turbine blades.

PHASE II: Implement the Phase I developed methodology concept into a prototype that demonstrates measurements on actual directionally solidified nickel alloy turbine blades. The measurements must be verified by other systems and or linked to the actual parts checked destructively.

PHASE III: Based on the success of the prototype methodology demonstration, develop working equipment for use in a production environment with common directionally solidified turbine blades. Additionally, equipment must be sized for portability. Commercial benefits include competitive opportunities for equipment development, production, and sales to public and private developers, producers, and users of nickel superalloy land, air, and space turbine components. The extension of innovative research into this aspect of nickel superalloys will also benefit both the government, scientific community, and public by increasing flight safety, escalating knowledge of surface phenomena, and extending the life of superalloys.

REFERENCES:
1. Superalloy History: http://www.tms.org/Meetings/Specialty/Superalloys2000/SuperalloysHistory.html

KEYWORDS: Directionally Solidified Nickel Superalloys, Non-Destructive Testing, Crystallographic Orientation

AF05-257 TITLE: Aircraft Battle Damage Assessment Tool, (Aircraft Battle Damage Repair (ABDR))

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a sustainment tool for load modeling of airframe and condition codes for avionics to support system stability and real-time system mission-capability assessment during war-time/peacekeeping.

DESCRIPTION: With the increasing complexity of weapon system (composite) structural and avionics components (old technology coupled with new technology) on the varied weapon systems within DoD, the importance of assessing system performance/capability is a critical issue for operations and planning during war-time. Current during ABDR type scenario the engineering community is required to support or provide mission-capability status of weapon system/components. Today in the field this process is very labor intensive and is accomplished with very little decision supporting information, such as airframe properties and characteristic, and avionics component fault codes need to aid in determining state of weapon system/components. This effort would require research to develop algorithms base on load characteristic and incorporate a neural network mythology to the functionality of the tool. This will involve visiting the depot, interfacing with the engineering community of the selected weapon system to get structural and avionics data needed to forecast mission-capability of the entire weapon system. Additionally, load modeling is an essential element in weapon system mission-capability-reporting, providing models to aid in determining structural integrity or system delivery capability after impact/intrusion. In the context of system mission-capability, “load” refers to the representation of the aggregate effect of aircraft battle damage to weapon system or end items.

PHASE I: Select a Department of Defense weapon system, identify a subsystem of that weapon system, research and identify ABDR data characteristics, collect design load data, perform a theoretical investigation on the load properties and characteristics then develop an ABDR loads model. Then conceptually build a model of an aircraft that contains load parameters for the structure and fault codes for the avionics components that will allow for a simulated intelligent assessment of total weapon system integrity or capability. Then provide a demonstration of how an efficient access by ABDR sustainment community can geographically navigate thru the model and define metrics and benefits.

PHASE II: Develop a prototype based on the concept demonstration of Phase I in an actual web environment. Before roll out, prove the viability to the management of the weapon system using the metrics set in Phase I. During this phase, there will be a lot of discussion of the capabilities with the appropriate personnel from the depot ABDR community. Prepare a detailed final report on the lessons learned and implementation procedures.

DUAL USE COMMERCIALIZATION: The mission assessment information system has commercial application in any software package and in the aircraft sector. Any engineering community that interact with aircraft supportability

can use the tool to aid in determining the overall structural integrity of a system and/or the functionality of its avionics components, which will aid in making a more accurate decision as to system capability or system support.

REFERENCES:
1. Maintenance data documentation T.O. 00-20-2

2. Aircraft Battle Damage Repair Manual T.O. -39

3. Martin T. Hagan, Howard B. Demuth & Mark Beale, Neural Network Design, ISBN 0-9717321-0-8. http://www.enm.bris.ac.uk/research/neural/neural.html

4. Ian Nabney, Netlab: Algorithms for Pattern Recognition, Springer, ISBN, 1-85233-440-1. http://www.ncrg.aston.ac.uk/netlab/

KEYWORDS: Keywords: Aircraft Battle Damage,Assessment Tool,Aircraft Battle Damage Repair

AF05-258 TITLE: Methodology for Determining Optimal Injection Techniques for Remediation of Contaminated Groundwater

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Explore various injection methodologies

DESCRIPTION: Soil and groundwater contaminated with chemicals such as chlorinated solvents, BTEX and metals are problematic for a vast majority of Department of Defense facilities as well as private industrial sites. The most optimal manner of remediation is to treat the contamination in-place. One method of treating in-place requires the injection of a material into the contaminated soil or groundwater. Innovative, pilot-scale and laboratory tested materials to be included are those such as micro-bubble ozone, peroxide-coated ozone, nano (submicron) zero-valence iron, sodium dithionite, etc. Also, testing on current injectables such as potassium permanganate, Fenton's Reagent, lactate, molasses, etc should be included. The material to inject is selected based on both the contaminants of concern and the site-specific hydrogeologic conditions. The intent of this project is to determine the best injection methodologies under specific geologic conditions for the various 'injectables', (such as continuous injection, geoprobe slug injection, injection/extraction, etc) to treat the contaminated plume. Optimal injection methods for specific geologic conditions and for specific contaminants will further improve the effectiveness of in-situ treatment and will enable system designs that yield 'more bang for the remedial buck'. The research will determine the optimal injectables and injection technologies for specific geologic conditions and contaminants. Advantages and disadvantages will be determined through laboratory and field research to assist future work and the test site and for other government installations and the private sector.

PHASE I: Obtain and analyze soil and groundwater samples contaminated with chlorinated solvents from several varied sites and determine which injectable material is best suited for the different hydrogeologic site conditions (groundwater and sediment characteristics) and the contaminant characteristics (contaminant type, concentration) found at the site. Based on the information gained, design and conduct a pilot test to establish the feasibility of the technology as well as aid in fine-tuning the Phase II parameters. The site(s) selected will consist of groundwater contaminated with chlorinated solvents migrating through preferential pathways. The contaminant source location may not be known and the proposal should include techniques for source location. The project design must include methodologies for obtaining accurate site-specific groundwater flow direction as well as indications of preferential pathways.

PHASE II: Using the data gathered in Phase I, design and conduct an actual field test of the technology. This field test should be conducted such that actual site remediation will be an added result of the field-testing.

DUAL USE COMMERCIALIZATION: Information gained from this project can be used at any contaminated site that is remediated using by the injection of the materials tested.

REFERENCES:
1. Kerfoot, W.B. “Microbubble Ozone Sparging for Chlorinated Ethene Spill Remediation,” Chlorinated solvent and DNAPL remediation: innovative strategies for subsurface cleanup, Susan M. Henry and Scott D. Warner eds. ACS Symposium Series 837, (2002), pp. 86-108.

2. Masciangioli, T., Zhang, W.,”Environmental Technologies at the Nanoscale,” Environmental Science and Technology, 2003; 37(5): 102A-108A.

3. Amonette, J.E., Szecsody, J.E., Schaef, H.T., Templeton, J.C., Gorby, Y.A., and Fruchter, J.S.,”Abiotic Reduction of Aquifer Materials by Dithionite: A Promising In-Situ Remediation Technology.” 33rd Handford Symposium on Health and the Environment, Nov. 7-11, Pasco, WA, Battelle Press, (1994), Columbus, OH.

KEYWORDS: Microbubble Ozone, Nano zero-valent iron, Sodium dithoinite

AF05-259 TITLE: Fixture Design Tool with Enhanced Input/Output Interface Capability and Internal Graphical Correlation/Reconciliation Of Engineering Data

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a new ‘Manufacturing Technology System’ for use in the reverse engineering and manufacturing of aging aircraft parts & repair fixtures. A broadly based methodology is required.

DESCRIPTION: New technology innovation is required to implement a cost effective support foundation for continuous process improvement in the DOD depot industrial base. Leveraging of past knowledge by correlating bits and pieces of data, then rapidly displaying and utilizing them is essential for the effective repair of older aircraft. Seamless input/output interfaces are required to import engineering part & fixture data from multiple sources, analyze and correlate the data, reconcile the data, then export the resultant to multiple manufacturing or prototyping systems. With older aircraft, support for the war fighter is dependent on improving the availability of depot repaired and re-manufactured items. Fundamental to improving the repair process is fixture design relatable to one or more selected machining processes. The ability to design or redesign fixtures can be enhanced by a new technology software system that creates a mechanism for capturing “best practices” for families of fixtures. The new fixture design system shall include enhanced input capability from different scanning/measuring systems where the part data must be created and from various computer aid design systems when the part data is available. The system shall include a library of fixture design families and be capable of easy user expansion as new designs are created. The system shall include a highly flexible, easy-to-use graphical package that allows designer to import, modify, change tolerance, rotate, merge and view designs from multi-views including internal or hidden perspective. The ability to use portions of previous fixture designs as rapid building blocks to merge with new innovations is a desired feature. Seamless interfaces with third party software (such as finite element analysis) are required. The database of the system’s rule base process decisions shall be user adjustable for various machining conditions. Output of model data for manufacturing or rapid prototypes in multiple formats is also required. Optional outputs to third party commercial software packages that allow improved cost effective process programming should be considered.

PHASE I: Develop & demonstrate a new, generic concept to which will allow maximum use of: sheet metal and machining processes, creation of new or revised fixtures or parts, and rule sets which may be tailored for different objects or materials at DOD depots.

PHASE II: The offeror shall develop and demonstrate an enhanced Phase I system, populated with a library of fixture and part families for depot application, with third party software, to demonstrate functionality and productivity improvements.

DUAL USE COMMERCIALIZATION: This tool will have commercial application for the sponsoring Air Force Depots, the Department Of Defense industrial base, and the aircraft & automobile overhaul and manufacturing industry.

REFERENCES:
1. Fixture Design: http://www.coe.ou.edu/manufacturing/FixtureDesignFiles/Start.htm

KEYWORDS: Part design, fixture design, processes, graphical, computer aided design, analysis

AF05-260 TITLE: Advanced Technology for Improving Composite Material Ply Utilization in Aircraft Construction and Maintenance

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Use advanced stochastic computerized optimization techniques to improve composite part material utilization, reducing consumption of materials while maintaining part performance.

DESCRIPTION: Computerized techniques exist for transferring 3-D Computer Aid Design and solid models into flat plies, automatically cutting these plies, and then automatically positioning and nesting cut plies for additional processing to construct the desired part. These techniques may be used on a wide range of part designs and composite materials, including glass fabric, quartz plies, graphite textiles, and may be used on both raw fabrics and on prepregs. By carefully cutting and positioning these composite plies, the overall part may be built up, cured, and put into service. Once cured, these individual nested parts reflect the designed-in orientation and shape of the needed part, providing the needed structural properties.

Because the strength of composite parts is based in part upon the type of fabric used and the orientation of the part outline relative to the warp and woof of the textiles, the process of determining the optimum part layout prior to cutting is based upon the unique and completely determined orientation of the desired shape on the composite materials. Significant amounts of wasted scrap material are inevitable in this process. It would be advantageous to reduce the amount of scrap material while still maintaining the required part strength, since material saved translates directly into cost savings. Since the Air Force consumes huge amounts of composite materials in new aircraft construction and in depot maintenance, there is a large potential cost savings associated with reducing composite ply scrap.

This research effort will investigate use of advanced stochastic optimization processes to improve the utilization of composite materials in aircraft construction and repair. The successful proposal will address the use of advanced stochastic optimization, especially Monte Carlo techniques, combined with finite element analysis of the composite parts to determine the correlation between accessible variables in the part design and determine alternative configurations that can perform the same function as the baseline part while saving material. These techniques will then be coupled with the automatic part nesting routines to provide measurable savings in composite material without increasing fabrication time and while preserving operational suitability of the composite parts.

The United States Air Force already (USAF) has extensive facilities and contractor support for fabrication of parts. This effort does not include modification or enhancement of part fabrication techniques after ply cutting, but will need to conform to the requirements of the existing fabrication processes to the greatest extent possible. Proposals for substantive modification of part fabrication processes will not be considered. The USAF will provide requirements and formats for conformity with existing fabrication practices.

PHASE I: Develop a concept demonstration that can provide a definition of finite element analysis-based stochastic optimization processes for improving composite material utilization in aircraft repair. Demonstrate key underlying technologies. Develop a detailed plan for prototyping the technology, accommodating existing and planned part fabrication technologies and practices within the Air Force, metrics required and benefits that can be obtained.

PHASE II: Based on the success of the Phase 1 project, develop a prototype system for use in aircraft maintenance at one of the AF depots, obtain metrics as defined in Phase I and measure the benefits.

DUAL USE COMMERCIALIZATION: This technology can be applied to military and commercial aircraft, composite ship hulls, and virtually every other composite structure manufactured from textile materials.

REFERENCES:
1. http://www.math.gatech.edu/~shenk/soc.pdf

KEYWORDS: Stochastic optimization, finite element technology, automatic ply optimization.

AF05-261 TITLE: Non-Destructive Residual Stress Measurement in Superalloy Turbine Blades

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop a methodology for non-destructive residual stress measurement in single crystal and directionally solidified superalloy turbine blade roots with complex geometries.

DESCRIPTION: Nickel superalloys are commonly used in parts for high temperature propulsion applications. The surfaces of the parts are mechanically treated and the resulting residual stress helps to deter fatigue crack initiation, which is essential for meeting the service life of the part. However, there does not exist a method to check for residual stress coverage at the turbine blade root surface non-destructively. Due to Air Force executive level interest in recent engine failures and aircraft mishaps with these parts as the causal factor, it is imperative to have the ability to quantify the residual stress in the part surface and sub-surface.

Extensive basic research and development of residual stress has occurred since the introduction of superalloys into the market. Our project will require the offerer to gather all past and present research data and testing methods and apply that knowledge to develop an innovative concept to quantify residual stress non-destructively. Residual stress measurements will be provided in bulk and at discrete depths of a part's surface. This research effort could include but is not limited to eddy current, Laue, x-ray diffraction, and photon induced positron annihilation. Combination of existing capabilities or exploration of novel methods is highly encouraged.

SBIR Topic #AF05-255, Non-Destructive Grain Orientation Verification in Directionally Solidified Nickel Superalloy Turbine Blades, is also proposed by this organization. Some approaches, e.g., x-ray diffraction, may be applicable to both; however, the final objectives are distinctly different.

PHASE I: Demonstrate a non-destructive residual stress measurement concept for complex geometry surfaces of single crystal and directionally solidified alloy parts.

PHASE II: Implement the Phase I developed concept into a prototype method that demonstrates residual stress measurements on actual nickel single crystal and directionally solidified alloy parts and specifically, turbine blade roots with complex geometries. The measurements must be verified by other systems and linked to parts checked destructively with correlation to cast test bars or other appropriate methods.

PHASE III: Based on the success of the prototype methodology demonstration, develop robust equipment with documented repeatability for use in a production environment with common turbine blades and parts. Additionally, equipment should be sized for portability. Commercial benefits include competitive opportunities for equipment development, production, and sales to public and private developers, producers, and users of nickel superalloy land, air, and space turbine components. The extension of innovative research into this realm of residual stress will also benefit both the government, scientific community, and public by increasing flight safety, escalating knowledge of surface phenomena, and extending the life of superalloys.

REFERENCES:
1. Superalloy History: http://www.tms.org/Meetings/Specialty/Superalloys2000/SuperalloysHistory.html
2. Residual Stress Measurement Techniques:
http://www.npl.co.uk/npl/cmmt/residualstress/technique_information.html

KEYWORDS: Residual Stress, Single Crystal Superalloys, Non-Destructive Testing, Shot Peening

AF05-262 TITLE: Dimensional and Positional Locations for Manual Aircraft repair Processes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an integrated data and hardware system which provides full scale location and dimensional guidance for manual processes used for aircraft inspection, testing and repair.

DESCRIPTION: Many of the processes required to support aircraft are performed manually. Human mobility, dexterity, visual and reasoning skills will continue to be used to position sensing instruments and perform support processes, both on and off the aircraft. These types of manual activities are hindered by a lack of precise dimensional references on large and complex aircraft surfaces. Additionally, there is a lack of data compatibility among systems involved in defining inspection, testing and support processes. The issues of data compatibility and dimensioning for manual processes result in long periods, as well as the associated costs, of Aircraft On Ground (AOG). The shortening of process time for AOG will significantly reduce the indirect costs of aircraft support. The improvement in data delivery and process accuracy will lower direct costs for support. The establishment of a data standard for manual inspection, testing and repair will improve long term aircraft reliability by enabling quantitative analysis of trends for each individual aircraft, as well as the entire fleet.

PHASE I: Research and develop a concept demonstration of your findings that shows drastic improvement in reducing maintenance actions with a dimensional guidance capability. For the concept demonstration, fastener locations may be method to show and test dimensional tolerances of locations. Provide report of findings of the technology(s) selected, metrics, and potential benefits.

PHASE II: Based on the results of concept demonstration shown during Phase I, produce a prototype for shop floor for actual use on aircraft in a depot. Develop, operate, refine and document the cost savings and support benefits from the prototype system utilizing a common data specification for use with a standardized system of integrated inspection, test, metrology and laser projection which supports manual inspection and test and repair processes on large aircraft structures.

DUAL USE COMMERCIALIZATION: The systems developed will be applicable to all forms of support for large, complex structures, including military and commercial aircraft, spacecraft, land vehicles, as well as naval and maritime vessels.

REFERENCES:
1. Aircraft Locator:
http://www.casmeo.org/CASI/Non-Contact_Technology.doc

KEYWORDS: Manual, Dimensional References, Repair, Inspection, Testing, Data Compatibility

AF05-263 TITLE: Pattern Recognition for Aircraft Maintainer Troubleshooting

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Intelligently decipher text strings and determine when one Work Unit Code is related to a National Stock Number.

DESCRIPTION: When an analyst trouble-shoots a component, the system should provide related maintenance and supply data. This involves the association of Work Unit Code (WUC), Part Number (P/N) and National Stock Number (NSN) to the part. Currently there is no way of accomplish this for older weapon system. To provide the capability for analyst to use Reliability & Maintainability and supply data within the a single submittal for information this NSN-WUC-P/N cross-reference needs to be built since the tech orders do not provide direct or indirect linkage; relations have to be built by analyzing descriptions and other information. There must be some way to recognize certain texts that identify related WUC and NSN. Over time the system should get "smarter", either with a neural network or some other kind of feedback comparison mechanism. There is significant flexibility in developing an innovative approach to meet the technical objectives. In theory, the exact same discrepancy should

have the exact same corrective action. Each of these two sections will have a slightly different text string to describe the problem and the algorithm should be able to determine when WUC and NsN are related. Access to tech orders and other legacy system will be needed to perform the data mining and collect as much information as possible.

PHASE I: Develop a methodology and concept of a software application that can determine the best course of action for an aircraft maintainer based on past corrective actions in the specific problem area and supply data. The methodology should include benefits to a depot center with the improved approach.

PHASE II: Develop a prototype based on the concept demonstration in Phase I and validate the benefits identified. The protoype should be tested on a few WUC's first before being expanded to every system on an aircraft

DUAL USE COMMERCIALIZATION: Commercial applications could include any industry that determines a problem and then must determine what to do to fix it. Airline industry, telephone industry, any company that receives calls from customers to try and help them troubleshoot on their own before using a more expensive method of sending a technician to the site, heavy equipment industry, etc... Military applications could include retrieving information from the maintenance information system database to compare with your current problem and suggest a course of corrective action.

REFERENCES:
1. Bergren, S. (1999). IMDS Operational Requirements Document, USAF 002-95-I. November 10, 1999.

2. Castrigno, J., Gilmartin, B., Rovnack G., Bala, J. (2003) Predictive Failures and Advanced Diagnostics (PFAD) for Legacy Aircraft Final Report, Contract Number F33615-00-D-6019. January 2003.

3. Cooke, G., Jernigan, J., Huntington, M., Myers, T., Gumienny, C. (1990). Maintenance Diagnostic Aiding System (MDAS) Enhancements, Systems Exploration Inc. January 1990.

4. Donahoo, C., Gorman, M., Kancler, D., Quill, L., & Revels, A. (2002). Point of Maintenance Usability Study Final Report (Spiral 1 Usability Test, Spiral 3 Synthetic Usability Test, and Spiral 3 Field Usability Test), Final Report AFRL-HE-WP-TR-2002-0100 September 2000-January 2002.

5. Donahoo, C., Gorman, M., Quill, L., Jernigan, J. & Goddard, M. Capt. (2002). Point of Maintenance Ruggedized Operational Device Evaluation and Observation Test Report, Interim Report AFRL-HE-WP-TR-2002-0251 April 2002-November 2002.

KEYWORDS: Maintenance mentors, diagnostics, interactive electronic technical data, decision support, text recognition algorithms, neural networks, advanced troubleshooting

AF05-264 TITLE: Correlation and Reconciliation of Engineering Data - Master Gage - Actual Parts in Aging Aircraft

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a tool for converting stable based media drawings (mylars) into Master Gage 3-D Computer Aided Design (CAD)Data Sets.

DESCRIPTION: Aging aircraft present a unique challenge for part replacement. These aircraft were designed and placed on stable based media mylar which constituted the engineering data set of dimensions. Then original mylar drawings were translated by craftsmen into templates and masters, then used to create parts that constituted the prototype airframe. From the prototype a set of Master Gases and Master Tools were developed to define the configuration and fit of all critical aerodynamic surfaces and interface points of the aircraft. They further fix the location in space of all the critical shapes and interface points of the aircraft. The actual engineering data points were subordinated to the craftsman’s original interpretation and all future parts manufactured were measured against the Master Templates and Master Gages rather then the engineering drawings. Further complicating the aging aircraft parts replacement are the frame and skin distortions caused by the stress of flying.

At the depot, aircraft parts that are determined to need replacement may very dimensionally from the original part configuration, if they are not gaged to the original Master gigs. Further, part configuration may vary from the Master Gage dimensional data due to the stress of flying arid any previous repairs. Complicating the task is the fact that the Depots may not have the original Master Tools for the particular parts being replaced. Parts are typically made from reproductions of the original mylars, again subject to media distortion and printing error. The parts made from this data therefore are difficult to fit to the airframe. All this results in reject parts or post manufacturing rework to the parts to force the best part fit to the aircraft.

This research project proposes to develop a tool for converting mylar based data sets into a 3-D or Virtual Reality CAD Data Set. The utilization of the tool and developed process should make it very economical and method of choice for converting or replacing the stable based media data sets used today. The research should analyze the processes necessary such as Reverse Engineering process so that replaced data sets are placed on Air Force data sets or process for obtaining Original Equipment Manufactures (OEM) continued ownership and design authority of new data sets if Mylar data is utilized in the replacement. Research should consider all alternatives and approaches. Utilizing new technology developments, the research after the analysis is performed should have an approach for a tool to perform the replacement of mylar type media. The new data set will still be able to produce templates used for manufacturing if that is required. The tool set should also have an information management capability for serial number based tracking since many parts are now unique to an airframe. When an aircraft arrives for repair the new solid model database will allow the determination of the best fit possible within the bounds of the Engineering Data and Master Gage Data. This will result in higher parts acceptance at the repair site and less rework. By comparing the data from the aircraft to be reworked, the data set will also be able to determine of the interface and connection points of the aircraft in question are within the acceptable bounds.

PHASE I: Research and develop a concept of the innovative approach. Select several aircraft structures with various level of Mylar or other media. Clearly document approach and identify all Reverse Engineering or data right issues and how your approach addresses them. In final report document concept, metrics and benefits.

PHASE II: Based on Phase I findings, design and develop a prototype capability tool for converting/replacing mylar data sets of various degrees of complexity to validate tool and process methodology. Final report will document validated measured metrics and benefits.

DUAL USE COMMERCIALIZATION: Commercial applications would be applied to all OEMs with aging aircraft support, air industry with similar stable based media data sets, and contract repair facilities.

REFERENCES:
1.http://www.casmeo.org/CASI/ADCS_Report.pdf

KEYWORDS: Drawing Conversion, Mylar Conversion, Stable Based Media Drawings

AF05-265 TITLE: Next Generation Aircraft Depot Maintenance Management Technologies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Find the next generation of manufacturing technologies and human systems enabling timely and efficient management of the dynamic depot aircraft maintenance challenge.

DESCRIPTION: At any given time, aircraft maintenance organizations must decide what set of maintenance tasks to work on next given a large set of known and anticipated maintenance requirements and factors; current operational demands and priorities, available resources, and so forth. These decisions must be made in the context of considerable uncertainty and variability, particularly with regard to work content, component part reliabilities, and replacement part acquisition lead time. Maintenance planning and scheduling decisions either minimize the impact of these uncertainties or exacerbate them, as evidenced by large awaiting parts inventory levels, unrealistic production schedules, inflated time and cost estimates, inconsistent flow day performance, and low availability rates. Traditional scheduling is done above the shop floor and dispatched to the shop supervisor, ignoring the inherent

characteristics of the depot maintenance domain that make classic scheduling and schedule optimization cumbersome and counterproductive. The current global sudden response mission in tandem with force transformation require increased operational availability, responsiveness to dynamically changing operational requirements, and cost control. There is a critical need for immediate response to any change from all levels of the system to enable a smooth and uniform action for any given global event. The depot shop has long been considered a non-player in engagement sustainment. This is wrong for today aggressive operational pace. The depot shop floor must have effective tools for maintenance personnel to daily support the mission through maintenance task planning and scheduling.

In aircraft depot maintenance there are a vast number of alternative sequences by which the workload can execute. The best sequence varies from aircraft to aircraft and from day to day, all based on preferences and what work is discovered. The first activity of aircraft depot Maintenance Repair Overhaul (MRO) is adding to the work package the work discovered during the initial inspections, and as much as half of the total work is identified during inspections and regular work. This is an inherent characteristic of aircraft depot MRO because aircraft continue to wear out and break in new ways. The key to efficient timely execution is not the original master schedule but the rapid specialized rescheduling based on found work. In project management and enterprise resource planning environments, the sequence decisions are based on knowledge before work starts. In aircraft depot MRO, the sequence cannot be established until the work starts, is specific to that aircraft, and re-sequencing continues until the work is completed. So, while in the manufacture of an aircraft, the production sequence primarily originates with engineering and the nature of absolute precedence; in the maintenance of an air frame, the production sequence constantly changes based on results from shop floor discoveries and non-absolute preferences.

PHASE I: Select and evaluate candidate methods/tools for managing three aircraft depot MRO functions: capturing shop floor events, revising/predicting resource requirements and schedule, and communication with and satisfaction of the customer.

PHASE II: Compose a next generation system of methods/tools for depot aircraft maintenance.

DUAL USE COMMERCIALIZATION: Multiple application in both government and industry for maintenance of large complex systems, e.g. aircraft, ship, railroad, etc.

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

2. Project Management Institute; http://www.pmi.org/info/default.asp

3. Joint Depot Maintenance Activities Group; http://www.jdmag.wpafb.af.mil

4. Open Directory Project; Enterprise Resource Planning (ERP); http://dmoz.org/Computers/Software/ERP/

KEYWORDS: Depot Maintenance Management, Project Management, Enterprise Resource Planning

AF05-267 TITLE: Technology for Aircraft Maintenance Part Inspection and Production

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Accelerate delivery and reduce cost of engineered structural components for aircraft maintenance and repair.

DESCRIPTION: Depot overhaul is sometimes very lengthy, in part because of the length of time required to define, design, fabricate, and inspect replacement parts. Processes that accelerate the overhaul process and reduce depot maintenance time, returning the aircraft to service sooner and reducing overhaul costs, are vital to accomplishing the OBJECTIVE. Producing replacement parts can be a lengthy process, delaying the aircraft's return to service and driving up maintenance costs. The process of producing replacement parts includes metrology of the existing

damaged part, generation of a Computer Aided Design (CAD) model consistent with the original part and its intended use, with modifications if necessary to correct design defects, fabrication of a replacement part, and inspection/test of the replacement part. The overall process can involve many different functional groups and contractors, production and integration of numerous datasets related to the part, and large amounts of overhead associated with managing the process.

Modern technology, including advanced inspection techniques, advanced metrology, and supporting software, hold the promise of accelerating overhauls by reducing the time to identify defective parts, reducing the time to design replacement parts, reducing the time to test and inspect replacement parts, and reducing overhead costs associated with the process.
This research effort needs to investigate advanced nondestructive inspection (NDI) and test capabilities to accelerate fabrication and delivery of aircraft replacement parts, including identifying defects in metal, bonded metal, and composite parts; developing processes using advanced technologies for accelerating mechanical component design and development; and reducing the cost of designing, producing, testing, and inspecting aircraft maintenance and overhaul replacement parts.

The United States Air Force already has extensive facilities and contractor support for fabrication of parts. This effort does not include modification or enhancement of part fabrication, but will need to conform to the requirements of the existing fabrication processes to the greatest extent possible. Proposals for substantive modification of part fabrication processes will not be considered. The USAF will provide requirements and formats for conformity with existing fabrication practices

PHASE I: Research and develop a concept demonstration of new innovative methodology or process that will drastically reduce the cost and time in fabrication of low volume aircraft critical parts. Provide a definition of processes and tools for accelerating delivery and reducing cost of engineered structural components for aircraft, with a focus on the most appropriate NDI Technologies. The concept demonstration should demonstrate key underlying technologies. A final report should address metrics and potential benefits.

PHASE II: Based on the success of the Phase 1 project, deign and develop a prototype system for use in the aircraft maintenance depot. The prototype should validate the methodology of new process(es) or tools and measure metrics identified in Phase I.

DUAL USE COMMERCIALIZATION: This technology can be applied to other Department of Defense aircraft depot lines as well as commercial aircraft inspections.

REFERENCES:
1.http://www.casmeo.org/CASI/RE_Non_Contact_Final_Report.doc

KEYWORDS: Production technology, Advanced Nondestructive Inspection Technology, Reverse Engineering

AF05-268 TITLE: Non-Intrusive Method and System for Inspection of Aging Electronic Systems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a non-intrusive method and system for inspection of aging electronic systems used in weapon systems.

DESCRIPTION: Sophisticated electronic and computer circuitry used in military weapon systems have been compacted into high density printed circuits, inter-layered together into multi-layered printed circuit boards and populated with electronic components and solid state devices. These fully assembled printed circuit boards are central to the function, performance and reliability of their associated weapon systems. With an aging arsenal, the Department of Defense (DoD) is in constant need of maintaining systems that may have exceeded life expectancies.

Sophisticated imaging systems such as laminography and digital tomosynthesis have been developed to view images of slices of an electronic component's connection to a printed circuit board. These imaging systems require

adaptation for use in the inspection of aging electronic systems. Adaptable hardware and software development are required to establish imaging technology as a useful tool to inspect aging electronic systems. Development of a non-intrusive method and system for using advanced imaging concepts would be a significant benefit to the DoD. This SBIR effort will develop a non-intrusive method and system including hardware and software for the non-intrusive inspection of aged electronic circuit boards. The method and system will be evaluated using samples of aged electronic circuit boards. Additionally, this effort will develop a prototype commercializable system that will allow for the non-intrusive inspection of aged electronic circuit systems. The prototype tool will be designed such that it can be integrated with any required commercial analyzing or imaging tools.

PHASE I: Provide a design and detailed description of proposed method for achieving non-intrusive inspection of aging electronic populated circuit boards including materials, components, interface requirements, limitations, and expected performance criteria. Details shall include particular subsystems to be enhanced, programs to be utilized, proposed hardware and software development platforms, software development methodologies, as well as any necessary interaction with existing systems.

PHASE II: Develop a working prototype of the system and implement a proof of concept demonstration. The prototype shall be able to fully demonstrate the benefits of the proposed technology. Perform system analysis to determine the performance benefits of the technology. Cost, time, and manpower savings shall be quantified.

DUAL USE COMMERCIALIZATION: Non-intrusive inspection of aging weapon system electronic circuit boards will allow detection of below the surface failures in solder points and circuit traces in the military and commercial market.

REFERENCES:
1. Mamaros, T. C., Fullwood, R. R., “Ultra-Sonic Imaging of Multi-Layer Printed Circuit Boards”, AFWAL Final Report No. AFWAL-TR-84-1147, Oct 1984, 172p.

KEYWORDS: Non-intrusive, Imaging, Interlayer, Laminated Circuit Imaging, Electronic Circuit Card, Laminography, Digital Tomosynthesis.

AF05-269 TITLE: Non-Destructive Inspection of Parent Material Around Encapsulated Bushing

TECHNOLOGY AREAS:

OBJECTIVE: Develop a Non-Destructive Inspection (NDI) method to inspect parent metal surrounding encapsulated bushings, particularly within a stacked structure.

DESCRIPTION: Flawed fastener holes are a common defect encountered during aircraft structural repair/rework operations. Flaws are initiated in a fastener hole due to a variety of factors: corrosion growth, fatigue cracks, manufacturing errors, etc. The typical repair strategy for a flawed fastener hole is as follows: Ream the fastener hole until the defect is removed. Install a bushing or (or bushings in a multi-layer stack up). Install a repair member to help carry the load for the damaged structure, effectively encapsulating the bushings and/or removing the ability to inspect the hole for damage. In critical, primary structure, it is often necessary to inspect behind/beneath the repair to ensure cracking or corrosion growth has not reinitiated. If a crack or corrosion reinitiates, the damage cannot be detected until it extends beyond the repair member. Removal of the repair member and bushings for an inspection is extensive, time consuming and can result in additional damage to the structure. This project seeks to develop a new NDI technique capable of inspecting through a ferrous or non-ferrous bushing and detecting flaws in the primary aluminum structure. Additional objectives are as follows: (i) minimize inspection preparation, (ii) detect a minimum flaw size of 0.020-inch, (iii) detect flaws in multi-layer stack-ups, and (iv) identify orientation of the flaw.

PHASE I: Develop new NDI techniques capable of detecting a 0.020-inch flaw in an aluminum structure through ferrous or non-ferrous bushings under the following conditions: (i) bushing wall thickness ranging between 0.032-inch and 0.150-inch, (ii) multi-layer stack-ups ranging from 2 to 6 layers, (iii) flaw orientation located within 1-

degree of a reference plane established through the fastener hole, and (iv) method does not require removal of repair members.

PHASE II: Develop and/or adapt commercially procurable NDI equipment capable of performing the specified technique. Write operation procedures to use the NDI equipment. Develop standards to calibrate the NDI equipment for prior use.

DUAL USE COMMERCIALIZATION: The proposed NDI technique will have numerous applications for military and industrial communities including inspection of existing repairs installed on commercial aircraft and building structures.

REFERENCES:
1. W. Avrin, (2000) "Eddy current measurements with magneto-resistive sensors: Third-Layer Flaw Detection in a Wing-Splice Structure 25 mm Thick." Proc SPIE, vol. 3994 (2000), pp. 29-36,.

2. R. Palanisamy and K.M. Larkin, "Development of an Eddy Current Inspection Technique for Sleeved Engine Disk Bolt Holes", Review of Progress of Quantitative NDE, D.O. Thompson and D. E. Chimenti, Eds. (Plenum Press, NY,
Vol. 2A, 1983), pp. 205-223.

3. Y. Sun, T Ouyang, and R. Lord, (2001) "Detecting 1st and 2nd Layer Simulated Cracks in Aircraft Wing Spanwise Splice Standards Usimg Remote-Field Eddy Current Technique", Proc 5th Joint NASA/FAA/DoD Conf on Aging Aircraft,.

KEYWORDS: NDI, Encapsulated Bushings, Multi-layer Structure, Steel, Aluminum, Non-ferrous Material, Ferrous Material

AF05-270 TITLE: Low-Cost Electro Magnetic Interference (EMI) Composite Shelter

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a low cost, high performance composite structure, providing EMI shielding for the Department of Defense's next generation of tactical shelters.

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. RWRS have the potential for better operational characteristics than do similar all-metal structures. Many tactical shelters are designed to house electronic communications equipment and thus require shielding against electromagnetic interference (EMI). Metallic structures can provide adequate shielding against EMI problems. Metals like aluminum, however, are relatively dense and require frequent maintenance to preserve their structural integrity. Composite materials can be developed to have conductivity like metals to handle EMI issues. According to Specifications for Engineering and Design Criteria For Rigid Wall Relocatable Structures (ASTM E 1925), the shelter components must possess minimum flexural strength, impact resistance, fire resistance, and EMI shielding capacity.

PHASE I: Develop a composite structural configuration for application as an EMI-shielded composite tactical shelter. The composite panel fabrication method must be affordable and yield components that are highly mobile. In addition, the composites must be manufactured by a cost-effective fabrication method.

PHASE II: Further develop, fabricate and test prototype composite sandwich panels for mechanical strength, EMI shielding, fire resistance and impact properties in accordance with ASTM E 1925. Design and build prototype shelter component to allow pilot plant manufacturing of composite shelters.

DUAL USE COMMERCIALIZATION : Prepare a manufacturing plan to produce the EMI-shielded composite shelter structures in quantity. The benefits of a pultrusion-processable composite system for producing EMI-

shielded structures include: economical manufacturing methods, corrosion resistance, good fatigue strength, and structure weight savings. This process will have numerous applications for both the military and industrial communities, including but not limited to: military EMI-shielded composite shelters, highly sensitive financial information processing area, EMI-shielded computer rooms, or any other relocatable EMI-shielded structures for shipboard, trains etc.

REFERENCES:

1. DoD Standard Family of Tactical Shelters, Natick Soldier Center, January 2000. Website http://www.sbccom.army.mil/hooah/pubs/jocotas.pdf

2. ASTM E 1925, Specification for Engineering and Design for Rigid, Relocatable Shelter. Website www.astm.org

3. Jana, P.B., Mallick, A.K., De, S.K., Ch. 7 in Short Fibre Polymer Composites, De, S.K. and White, J.R., Eds., Woodhead Publishing, LTD, Cambridge, England, 1996.

4. MIL-STD-810E, Standard Test Method for Electromagnetic Shielding Effectiveness of Durable Rigid Wall Relocatable Structures.

KEYWORDS: Composite, Shelter, EMI, Shielding, Low Cost, Pultrusion, Sandwich Panels

AF05-271 TITLE: Flight Line Intermittent Fault Detector

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide an analog neural network-based circuit analyzer and aircraft/tester interface cables, certified to operate in explosive environments.

DESCRIPTION: Test pilots report flight control, fire control, and landing gear subsystem anomalies during post-depot modification program functional check flights that frequently are later determined as “no fault found” conditions. Because the “no fault found” (NFF) conditions are not replicated during on-the-ground troubleshooting, the impact of these NFF conditions is not fully understood. This project seeks to develop advanced analog neural system technology so as to improve troubleshooting of pilot-reported discrepancies that had not been found with current use of digital average measuring equipment. The nanosecond intermittent fault detectors shall function in a fueled aircraft environment, shall monitor test points simultaneously and continuously so that there are no scanning nor missed events during testing, and shall include feedback analysis software. Additional objectives are as follows: (i) The equipment shall be portable and battery-operated so that it can be moved to an aircraft, (ii) the equipment shall be explosion-proof in accordance with MIL-STD-810E, Method 511.3 criteria, for use in a fueled aircraft environment, and (iii) the equipment shall interface with aircraft in accordance to a system safety program plan approved by an appropriate System Program Manager, and as validated by an appropriate flight test avionics activity.

PHASE I: Design or research intermittent fault detection technology in accordance with system safety methodology, suitable for aircraft flight control, fire control, and landing gear diagnostics.

PHASE II: Develop a prototype that is portable, explosion-proof, and can troubleshoot intermittent faults on flight line aircraft. Demonstrate the device by diagnosing reference an aircraft subsystem and by comparing the results with “digital average” diagnostics equipment.

DUAL USE COMMERCIALIZATION: The proposed advanced technology development will have numerous applications for military and industrial communities including for use at military aircraft depots maintaining other weapon systems and for use at civilian fleet aircraft repair stations.

REFERENCES:
1. David Evans, “When the Average is Not Good Enough”, Avionics Magazine, October 2002, http://www.aviationtoday.com/reports/avionics/previous/1002/1002safety.htm

2. Brent Sorensen, Paul Sorensen, Gary Kelly, Artur Sajecki, “An Analyzer for Detecting Aging Faults in Electronic Devices”, IEEE, AutoTestCon94, http://www.usynaptics.com/ieeenew.doc

3. Stephen Dunwoody, Edward Bock, AMP Inc., John Sofia, Anatech Inc., “A Practical and Reliable Method for Detection of Nanosecond Intermittency”, http://amp.com/products/technology/5jot_8.pdf

4. Walter Shawlee II, “The Analog Digital Coin Toss”, Avionics Magazine, Sept. 1999, http://www.aviationtoday.com/reports/avionics/previous/sept99/09avsystem.htm

5. Walter Shawlee II, “How Parts and Systems Age”, Avionics Magazine, http://www.aviationtoday.com/reports/avionics/previous/1100/column2.htm

KEYWORDS: Avionics, Sensors, Diagnostics, Reliability, Testing, Explosive Environments, Wiring Analyzers

AF05-272 TITLE: Alternative Energy Sources Augmenting and/or Replacing Existing Generators

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Build integrated energy storage and management units controlling energy input from various sources and provide continuous electrical power on demand.

DESCRIPTION: The military is seeking to build a more agile, more lethal, and less expensive fighting force. This is especially true of air portable units where weight and volume are a major concern. A major impediment to this goal is the over-reliance on JP-8 battlefield diesel fuel. Over 80% of the logistics re-supply is battlefield fuel. Typically this costs $40 per gallon in theatre and over $400 per gallon if air-lifted in. This project seeks innovative solutions to replace diesel generators and alternate power units (APUs) with field deployed missile, radar, and communications systems as well as military shelters and tactical bases. The use of fuel would therefore be reduced, giving a smaller logistics footprint and a less heavy structure. This project seeks to integrate solar power and high performance advanced (NiMH) batteries into power modules. Large power modules should be capable of controlling and taking input power from a variety of sources including field-deployed solar arrays, wind turbines, fuel cells, hybrid-vehicles and conventional diesel generators. The generation, use, and storage of hydrogen and its use in fuel cell and internal combustion engine generators should also be considered.

PHASE I: An evaluation of military power requirements will be combined with a detailed engineering analysis of off-the-shelf and near term alternative power technologies including flexible, thin-film light-weight solar panels, wind turbines, advanced (NiMH) batteries, advanced compact low-pressure hydrogen storage, and fuel cells.

PHASE II: The two systems will be designed and built using tried and tested off-the-shelf or near-term commercial units. The systems will serve as demonstration systems to enable military engineers to specify procurement requirements for similar systems and to issue contracts for companies to tender to design, build, and supply these systems.

DUAL USE COMMERCIALIZATION: Alternative power systems such as thin-film triple junction solar panels, advanced prismatic (NiMH) batteries, compact hydride based hydrogen storage units and proton exchange membrane fuel cells are all being currently developed for dual military and civilian use.

REFERENCES:
1. ASTM E1925, Specification for Engineering and Design for Rigid, Relocatable Shelter. Website http://www.astm.org

2. DoD Standard Family of Tactical Shelter, Natick Soldier Center, January 2000. Website http://www.sbccom.army.mil/hooah/pubs/jocotas.pdf

KEYWORDS: Power Generation, Emergency Power, Alternative Power Sources, Hydrogen, Solar, Advanced Batteries, Fuel Cell

AF05-273 TITLE: Automated Delivery of Pigmentation for Camouflaging Patterns for Composite Shelters

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Provide a controlled, automated computer delivery system to produce selected patterns and randomize them during the manufacture of composite shelters.

DESCRIPTION: Currently, the Air Force uses metal shelters that have a unique visual and radar signature. In order to maintain this unique targeting signature for existing metal shelters, each must be hand painted in a random manner that is not repeated for any other shelter. The Air Force is currently investigating composite technologies to replace the existing design and materials for tactical shelters. The composite materials can be impregnated with pigment, but the issue of the random theater camouflage patterns must be addressed. The design of an automated system that will randomly distribute the camouflage pattern would eliminate the need for painting composite shelters. An automated system would greatly increase the accuracy of the colors and patterns impregnated into the shelters and auxiliary equipment. Specific capabilities include:
• Accuracy in pattern distribution
• The ability to design random or fixed patterns
• Increases composite use in commercial products by providing a capability to pigment composite materials with the same degree of accuracy of painting operations
• Removal of paint products results in significant reductions in environmental waste streams
• Reduction in air emissions

PHASE I: Design a prototype system that will randomly distribute camouflage pigment in a non-repeating pattern that will comply with Air Force specifications.

PHASE II: Develop and test a prototype pigmentation system, demonstrating a viable process that can be used to camouflage all DoD tactical shelters and provide the accuracy needed for detailed pigmentation necessary for commercial purposes.

DUAL USE COMMERCIALIZATION: The resulting system will provide precision computer generated pigmentation. However, the military application of this system will also require the ability to randomize pigmentation in order to ensure the uniqueness of camouflage patterns.

REFERENCES:
1. ASTM Standard E1925, Specification for Engineering and Design Criteria for Rigid Wall Relocatable Structures. Website http://www.astm.org

2. DoD Standard Family of Tactical Shelters, Natick Soldier Center, January 2000. Website http://www.sbccom.army.mil/hooah//pubs/jocotas.pdf

3. FM 20-3, Camouflage, Concealment, and Decoys, 30 August 1999, 105 pages, Military Info Publishing.

KEYWORDS: Tactical Shelter, Random Pigmentation, Camouflage, Composite, Automated, Pattern Distribution

AF05-275 TITLE: Complementary Methods for Non-Invasive Printed Circuit Board (PCB) Component Performance Evaluation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop an Automatic Test Equipment (ATE) system for non-invasive evaluation of PCBs and components using alternative methods.

DESCRIPTION: Current methods of testing printed circuit boards and components require costly generation and application of test program sets. Furthermore, statistical pattern based testing is time consuming and does not always result in satisfactory results. Alternative approaches to current test methods are desired in the ATE arena. Prognosis of faults and decreased performance in components that are not identifiable through current methods would greatly reduce field failures and Test-Retest-OK scenarios. For example, laser-based approaches to testing can provide multiple avenues for testing, including passive image-based testing and active signal-based techniques. The spectrum of electromagnetic radiation from microwave to near infrared can be used to take advantage of the various properties of printed circuit board components. These include the transparency of silicon and plastic at various wavelengths, and the perturbation of material properties due to an electric field. Because no one method is suitable for all testing requirements, systems comprised of parallel, complementary non-invasive techniques are highly encouraged.

PHASE I: Determine which techniques are most amenable to non-invasive testing of PCB components. Propose a multi-technique platform for component performance evaluation.

PHASE II: Develop a prototype ATE system based on the measurement techniques identified during Phase I. Demonstrate capabilities and advantages over current electrical test pattern methods.

DUAL USE COMMERCIALIZATION: This technology is directly applicable to medical, astrophysics, and other imaging applications requiring extremely high precision testing.

REFERENCES:
1. Vallet, D.P. “FA Future Requirements,” in Failure Analysis of Integrated Circuits: Tools and Techniques, Kluwer Academic, pp 241-249. 1999

2. Semiconductor Industry Association, “International Technology Roadmap for Semiconductors”, 2001

3. S. Kasapi, C. Tsao, K. Wilsher, W. Lo, and S. Somani, “Laser beam backside probing of CMOS integrated circuits,” Microelectronics Reliability, vol. 39, pp. 957-961, 1999.

4. Curran, L.J., “Near-IR Camera Sees Wafer Defects,” VisionSystems Design, pp 18-19, June 2002.

KEYWORDS: Imaging, Integrated Circuit, Laser, Sensors, Software, Laser

AF05-276 TITLE: Automatic Development of Test Program Sets (TPS) Without a Board Model

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and implement automated methods to create a TPS without using a board model.

DESCRIPTION: Due to the high cost and associated problems with using standardized model-based methods for testing Unit Under Test (UUT) performance, method(s) to develop a TPS automatically without using a board model must be investigated. Board model methods use theoretical philosophies that tend to be only partially valid. Applying techniques to perform TPS development using random generation of stimulus signals and monitoring a typical response can be used to determine UUT functionality. A more dependable method to develop a TPS without the use of theoretical philosophies must be found. Currently Automatic Test Equipment (ATE) is configured with a prolific number of stimulus and sensor instruments to perform unit testing. Using a limited number of

stimulus/measurement devices for Automatic Test Equipment can significantly reduce the cost of ATE and can enhance the UUT testing environment significantly. A software method and hardware configuration needs to be developed to create a TPS automatically using a limited stimulus/sensor set.

PHASE I: Determine the feasibility of software methods to control ATE instruments and to automatically develop a TPS using a limited set of stimulus and measurement devices.

PHASE II: Create a detailed design and the implementation for evaluation of a working prototype will be accomplished.

DUAL USE COMMERCIALIZATION: The technology underlying this topic is quite generic, and is applicable to a wide variety of applications and technologies. It is particularly relevant to aircraft and plant maintenance, industrial process control, medical, and other applications where large numbers of diverse signals are monitored, and overall system performance is characterized through the interpretation of the combination of signals, in addition to the discrete interpretation of individual signals.

REFERENCES:
1. Kirkland, L.V., “ATE Enabling Technologies”, AUTOTESTCON 94' Anaheim, California, 21-24 September, 1994.

2. Vallet, D.P. "FA Future Requirements," in Failure Analysis of Integrated Circuits: Tools and Techniques, Klower Academic, 1999.

KEYWORDS: Electronics, Circuit modeling, Sensors, Test Program Sets, Automatic Test Equipment, Software, Circuits

AF05-277 TITLE: Low-Cost Composite Ball and Roller Bearings

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a material and a process by which durable composite bearings with high radial and axial load capacities can be produced.

DESCRIPTION: Metallic bearings are used when high shaft load, namely radial or axial thrust load, capacity is required. The load bearing components of metallic bearings (i.e. the rings and the rollers) are typically made of either chrome steel or stainless steel, the former used when load capacity is the main consideration and the latter used when corrosion-resistance supersedes load capacity in importance. Ball and roller bearings are usually used in industrial and agricultural motors, as well as in ships’ propellers and rotational radars. Larger bearings are currently being used on many Department of Defense (DoD) weapon systems and are usually exposed to harsh weather environments. Consequently, many DoD bearings have suffered pre-mature failures due to corrosion and lack of maintenance. In order to avoid the corrosion problems associated with steel, it is proposed that composite bearings be developed that can replace steel ball and roller bearings as per their applications. Ideally, these composite bearings would be heat and friction-resistant and could support large axial and radial loads without the need to be lubricated. They could consequently be used in high-speed applications and could replace their steel counterparts successfully. Composites have not traditionally been used in bearings due to the rigorous demands of operations requiring bearings coupled with the economic hurdles associated with developing and using high load capacity composites. However, the goal here is to produce bearings with longer life-cycles than steel bearings, thereby minimizing the importance of the upfront costs associated with using high load capacity composites by reducing the overall life-cycle costs.

PHASE I: Design new materials and processes or research existing materials and processes that will allow durable composite bearings to be developed that have high axial and radial load capacities for use in high-speed applications.

PHASE II: Develop and test a cost-effective material and manufacturing process to construct commercially viable composite bearings, again keeping in mind uses for towers. 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 bearings will have numerous applications for military and industrial communities, including replacements for steel bearings in many applications such as: electric motors, automotive applications, submarines, ocean oil platforms, drive shafts etc.

REFERENCES:
1. DoD Standard Family of Tactical Shelters, Natick Soldier Center, January 2000. Website http://www.sbccom.army.mil/hooah/pubs/jocotas.pdf

2. ASTM E238-84 (2002), Standard Test Method for Pin Type Bearing. Website http://www.astm.org

3. ASTM D2990-01, Standard Test Method for Tensile, Compressive, and Flexural Creep-Rupture of Plastics. Website http://www.astm.org

KEYWORDS: Ball Bearings, Roller Bearings, Composites, Low Cost, Long Life-Cycle, Axial Load, Radial Load

AF05-278 TITLE: Inorganic Materials for Production of Fire-Resistant Composite Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Provide a resin/matrix combination and a suitable manufacturing process to create durable, fire-resistant composite materials with low cost and high shear strength.

DESCRIPTION: Composites are generally constructed using a fiber reinforcement material and a matrix material. The typical fibrous reinforcement used is glass, and the typical matrix material used is thermosetting resin. The glass used is a strong and economical material with an acceptable modulus of elasticity. Thermosetting resins dominate composite fabrication because of their ease of processing. The two major types of thermoset materials are phenolic resins and unsaturated polyester resins (UPRs). Of the two, phenolics are more difficult to process and tend to form voids with low structural capability, but they have adequate fire resistance. Conversely, UPRs are easy to process and have very good structural properties, but the finished composite structure is susceptible to fire. The ideal solution to the lack of fire resistance in composite structures is to combine the fibrous reinforcement (i.e., glass) with a practical, manageable, and nonflammable inorganic matrix.

Inorganic composites can be found in nature as well as created in laboratories. Crab shells are an example of a natural inorganic composite, and glass-reinforced concrete or house siding (e.g. Hardiplank®) are examples of man-made inorganic composites. Such materials have excellent fire resistance, but these man-made composite systems have very low ductility and shear strength and are consequently not very durable.

It is proposed that suitable water-soluble polymers can be found that will interact with inorganic matrix materials to produce very durable and especially fire-resistant structures. An ideal solution would be to find or create a polymer that improves the processability of the aqueous mixture and then reacts with the inorganic matrix material to form strong chemical linkages (i.e. thermosetting). The following are examples of polymers that may serve this function: polyvinyl alcohol, polyvinyl acetate, polyvinylpyrolidone, metallic salts of polyethyleneacrylate copolymer, or polyacrylic acid (or its salts).

PHASE I: Design new materials or processes or research existing materials and processes that will allow thermosets to be durable and fire-resistant with low cost and high shear strength. A feasibility study will be required for this phase's completion.

PHASE II: Develop and test a cost-effective material and manufacturing process to construct commercially viable fire-resistant thermoset structures. Also, conduct structural analyses by computerized simulation and construct a prototype thermoset structure to ensure the structure will meet or exceed Air Force requirements.

DUAL USE COMMERCIALIZATION: The proposed process and resulting thermoset structures will have numerous applications for military and industrial communities including replacements for current thermoset composite structures as well as replacements for metal structures, which have corrosion problems.

REFERENCES:
1. ASTM Standard E1925, Specification for Engineering and Design Criteria for Rigid Wall Relocatable Structures. Website http://www.astm.org.

2. DoD Standard Family of Tactical Shelters, Natick Soldier Center, January 2000. Website http://www.sbccom.army.mil/hooah/jocotas.pdf.

3. ASTM D790, Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics. Website http://www.astm.org.

KEYWORDS: Composites, Inorganic, Thermosets, Low Cost, Structures, Fire-Resistant, Fire-Retardant

AF05-282 TITLE: Natural Gas and JP-8 Multi-fuel Reformer

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Research and develop a fuel reformer with multi-fuel capability, able to produce fuel cell quality hydrogen from JP-8 logistical fuel or methane natural gas, as a minimum, and other hydrocarbons.

DESCRIPTION: Concurrent with the development of fuel cell technology the reformer technologies necessary for producing hydrogen from methane gas and kerosene based JP-8 logistical fuel have been progressing. Reformers capable of producing fuel cell quality hydrogen using JP-8 have been developed as well as reformers which utilize methane natural gas as feedstock. Due to the requirement to reduce petroleum usage and pollution levels during peacetime, the Air Force has a need for a single reformer capable of utilizing both feed-stocks. While stateside, operation would utilize pipeline municipal natural gas, and during deployments, JP-8, the NATO single fuel for the battlefield, would be used. Furthermore, a true multi-fuel capability would be advantageous enabling the forces to utilize available host nation fuels.

PHASE I: Research and develop designs, evaluating feasibility and identify technical issues for a multi-fuel reformer. Performance goals would include conversion of 70 % of the methane and JP-8 bound hydrogen to hydrogen gas suitable for direct use, or, with clean-up, use in a PEM type fuel cell. Provide sufficient data and analysis to indicate minimum risk for continuation to Phase II.

PHASE II: Develop, demonstrate performance and deliver to the Air Force a prototype multi-fuel reformer for incorporation into an Air Force PEM fuel cell demonstration application.

DUEL USE COMMERCIALIZATION: A multi-fuel reformer would be useful in the commercial market enabling the consumer to utilize whatever fuel type was available in the city or remote locations.

REFERENCES:
http://www.eere.energy.gov/hydrogenandfuelcells/fuelcells/annual_review2002.html
Proceedings of the 4th Department of Defense, Logistic Fuel Reforming Conference, Oct 22, 2003. Philadelphia, PA.

KEYWORDS: Reformer, Hydrogen, Fuel cell, Methane, JP-8, Catalyst

AF05-283 TITLE: Compact Integrated Hub Traction Motor and Inverter

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Research and develop a design for in-hub inverter and traction motor suitable for use in aircraft ground support equipment.

DESCRIPTION: Advances in electric drive motors for vehicles has resulted in successful in-hub motor designs. In-hub drive motors allow the vehicle designer freedom to utilize cabin space for passengers and cargo. For the Air Force the in-hub motor allows the application of all wheel drive into all electric material handling equipment and other pieces of ground support equipment which otherwise would not be considered for self propulsion due to the complicated drive shafting, weight and space restrictions. The integration of the motor drive inverter into the hub will further simplify the design of the ground support equipment. Ideally an inverter-motor hub would be common to many pieces of ground support equipment, allowing for their rapid replacement in the field. The ease with which the drive system can be used will lead to self-propelled ground support equipment in cases which have traditionally been towed.

PHASE I: Research and perform feasibility assessments, identify technical challenges, and develop design solutions for an universal in-hub inverter and traction drive motor suitable for incorporation into the next generation of ground support equipment. For an all wheel drive system maximum continuous power might be 5 kW at a torque density of 20 to 30 N-m per Liter. Intermittent power levels would be approximately 50% higher. To satisfy safety requirements hub must include conventional friction and parking brake system in addition to any regenerative braking features possible. Trade offs of torque density with hub diameter are to be examined.

PHASE II: Build and deliver four Compact Integrated Drives suitable for incorporation into Air Force ground support equipment, possibly an all electric bomblift. Final selection of the type of GSE targeted of this new in-hub drive will depend on the Phase 1 findings.

DUEL USE COMMERCIALIZATION: Commercial aircraft ground support equipment is going towards all electric due to air pollution requirements. A universal drive system will provide cost savings for both the Air Force and commercial aircraft operators.

REFERENCES:
http://www.evs20.org/brochurepdfs/EVS20-auditoriumsessions.pdf
http://www.qtww.com/press_releases/pr_aug_11_2003.shtml
http://www.sinomotors.com/dcmotor/golf-caddy-e.htm

KEYWORDS: Hub Motors, Traction Motors, Electric Vehicle, Ground Support Equipment, Motor Drives, Inverters

AF05-285 TITLE: Advanced Lithium Ion Battery Manufacturing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Research advanced manufacturing techniques for Li-Ion batteries for use in various Air Force advanced vehicle applications such as; electric S-10 truck, hybrid electric step van and bus.

DESCRIPTION: The Air Force as several advanced power vehicles which utilize storage batteries as the primary energy source and in hybrid vehicles in which the storage batteries are the secondary source. In both cases, Li-Ion batteries promise to provide efficiency and range performance equal to or exceeding the conventional gasoline engine powered vehicle. Technical deficiencies of Li-Ion batteries which currently limit the widespread commercialization are the limited life of approximately 1000 charge recharge cycles and high cost which is attributed to manufacturing processes. The purpose of this work is to explore innovative manufacturing techniques for an all solid-state lithium ion battery with extremely high cycle life (> 10,000 charge/discharge cycles), a wide operating temperature range, a rapid recharge capability, and increased power densities that are a factor of 10-100 times greater than today's rechargeable lithium batteries. These batteries are expected to be inherently safer than

existing lithium-ion and lithium-polymer and better suited for recycling due to the precision manufacturing technology. This technology would represent an important breakthrough in battery manufacturing and performance, and is of critical significance in the drive to develop effective hybrid solutions for tomorrow's portable power requirements.

PHASE I: Conduct applied research into novel manufacturing processes for advanced Li-Ion batteries. Analysis will consider the projected cost of manufacture and performance of prototype modules.

PHASE II: Develop prototype battery module to prove improved cost and battery performance objectives. Deliver a battery pack suitable for testing and evaluation.

DUEL USE COMMERCIALIZATION: Widespread commercialization potential exists for civilian and military use anywhere rechargeable batteries are currently used.

REFERENCES:
http://www.arb.ca.gov/msprog/zevprog/2000review/BTAPsum.pdf
http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1024&context=itsdavis

KEYWORDS: Battery, Li-Ion, Electric Vehicles, Materials, Manufacturing, Processes

AF05-289 TITLE: Accurately Validated High-Speed Wear Prediction Code

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a highly validated prediction code that will accurately predict high-speed wear of test track vehicle slippers or shoes.

DESCRIPTION: Sled tracks are used for testing Department of Defense (DoD) weapon systems at various U.S. locations. Sled tests are conducted at speeds up to 10,000 feet per second. A sled is attached to the rail with a steel wrap-around shoe or slipper that holds the sled to the rail in the vertical and lateral direction while allowing the sled to slide in the down-track direction. These slippers are typically made of steel, thus creating a steel-on-steel wear environment. Currently, four problems limit obtainable sled test velocities. These problems are slipper wear, slipper and rail gouging, severity of slipper-to-rail impacts, and available rocket propulsion. Recent advances have been accomplished in rocket propulsion, understanding of rail gouging physics and of the prediction and avoidance of slipper and rail gouging, and improvements in sled design techniques that greatly reduce slipper rail impacts. The only limiting problem yet to be greatly understood and controlled is high speed-slipper wear. Current sled test hardware is plagued with adverse effects caused by excessive slipper wear. This slipper wear is currently unpredictable due to the complexity of the slipper-rail interaction. Many parameters could affect slipper wear including normal force, sled velocity, slipper material, rail material, slipper impact frequency, slipper-rail contact period, etc. Slipper wear models could be reasonably constructed but validation is the key. For track engineers to gain confidence in slipper wear models, a stringent validation procedure needs to be completed. This validation procedure must have closely controlled test parameters that can be varied to allow parametric studies.

PHASE I: Develop the slipper wear prediction code concepts and the supersonic wear test validation concepts. Assess the technical feasibility of the overall concepts.

PHASE II: Develop the slipper wear prediction code, design the supersonic wear test validation concepts, build an initial operational supersonic wear test validation capability, and conduct preliminary tests to validate the slipper wear prediction code.

DUAL USE COMMERCIALIZATION: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities to leverage the result of this effort in high-speed brake application, high-speed Wankel engine wear technology, and other applications wherein complex supersonic wear is a controlling problem. Potential commercial applications exist for the automobile industry, specifically rotary engines and for mass transit and train applications where break wear is of concern.

REFERENCES:
1. Slipper Wear/Gouging Analytical Tool, Final Scientific and Technical Report, AZ Technology Inc., Craig P. Schmitz, August 14, 2000.

2. www.rotaryengineillustrated.com/animationpages/an-RE4a.html.

3. Proceedings of the NATO Advanced Study Institute on Vibration and Wear Damage in High Speed Rotating Machinery, Tróia, Sebútal, April 10-22, 1989.

KEYWORDS: sled tracks, test tracks, slipper wear, high-speed wear, high-speed wear models

AF05-291 TITLE: Enhanced Focal Plane Array Technology

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a high spatial resolution laser imaging radiometer capable of making field measurements of high-energy laser (HEL) spot spatial distributions.

DESCRIPTION: In support of HEL testing, there are many requirements to measure the spatial distribution of laser energy reflected from test targets. During Phase I, this SBIR project is to develop the appropriate focal plane array(s) (FPA), design the radiometer system(s), predict the performance of the system(s), and estimate the cost and time required to produce follow-on system(s). During Phase II, a prototype system will be developed and tested, and the appropriate parameters will be quantified. In Phase III, a standard product will be developed. Only components that are near availability at the time of the design will be considered. The laser wavelengths of interest are at specific wavelengths between 1.0 and 1.5 micrometers. The system must have at least 1024x1024 pixels (goal of 2048x2048 pixels). It must respond to laser pulses as short as 10 nanoseconds and to continuous laser energy. The FPA integration period must include pulsed lasers; therefore, the integration time must be capable of being synchronized to an external trigger. To reduce the effect of background signals and other sources of infrared (including other HEL sources), the system must have very narrow spectral band pass filters (including near-zero response to all out-of-band sources). Since the reflected energy spatial distribution may have a wide dynamic range, the FPA system must have an adaptable radiance dynamic range of at least 1,000 (goal of 10,000). The FPA system will be used with various optical systems, some of the optical systems having diffraction limited resolution of 1 microradian. Although this SBIR topic does not anticipate the detailed design of the various optical systems, sufficient analysis is required to assure that the proposed FPA system can support this resolution. The system may be operated from surface tracking mounts or from aircraft platforms and must be designed to operate in these environments without degradation.

PHASE I: Develop appropriate FPA(s) and design a spatial laser radiometer based on the FPA(s). Radiometer descriptive parameters will be predicted. Phase I periodic reports and a final report will be required. The final report will document the expected radiometer performance parameters and relate the performance to the stated objective.

PHASE II: Develop and deliver a prototype radiometer based on the FPA developed during Phase I and the Phase I system design. The prototype descriptive parameters will be measured and compared to the predicted performance parameters. Any changes to the Phase I design will be fully documented prior to implementation. Full documentation of the system tests and the results of those tests will be required.

DUAL USE COMMERCIALIZATION: All military services have requirements for these radiometers. Nearly half of the shortfalls identified in the Tri-Service Directed Energy Test and Evaluation Capabilities (DETEC) study (References 1-4) required such radiometers. Test and evaluation of systems in development, such as the tactical high-energy laser (THEL), mobile tactical high-energy laser (MTHEL), airborne laser (ABL), and HELFighter, are but a few of the programs with stated requirements. Commercial developers of HEL weapon systems also require the radiometers.

REFERENCES:
1. DETEC Tri-Service Study Shortfall 2.15a – In-Band Reflected Energy Distribution Measurements.

2. DETEC Tri-Service Study Shortfall 2.18c – Target Imagery Measurements.

3. DETEC Tri-Service Study Shortfall 2.10a&b – Laser Irradiance Spatial Profile Distribution Measurement.

4. DETEC Tri-Service Study Shortfall 2.12b&c – Atmospheric Laser Transmissivity Measurement.

KEYWORDS: spatial resolution, imaging radiometer, focal plane array, pixels, energy, dynamic range, laser/wavelengths, dynamic range

AF05-293 TITLE: High Speed Target Acquisition and Tracking System

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a device capable of accurately locating and tracking multiple, small, high speed targets over a wide-field-of-regard, at short to intermediate ranges.

DESCRIPTION: Surveillance and tracking of large objects at long range has been performed using radar for well over 60 years. However, radar (MMW) wavelength is too large to individually locate and track small, closely spaced threat objects (cannot provide sufficient resolution to resolve multiple targets in small volumes) and some target coatings or target configurations may not be conducive to RF tracking . Therefore, a need exist for a device with the capability to simultaneously acquire and accurately track numerous, closely located, fast moving, small threat objects (targets) at short to intermediate ranges. This prototype device must be able to report tracking information in a real time manner (allowing for rapid response and/or preventative measures). In order to provide increased flexibility in deployment the device should be stand alone and transportable by no more than two persons. Based upon results of a recent literature search, subsystems and components exist which if properly integrated with the development of new subsystems may well provide a solution to the need stated.

PHASE I: In this phase, contractor will:

Produce a conceptual design and breadboard device which will demonstrate:

1. The ability to accurately detect and track time space position information for multiple, small (examples are 0.223, 0.30, and 0.50 caliber bullets and 40 mm rifle-launched grenade) targets moving at subsonic up to high supersonic speeds over a wide area at ranges out to 10 kilometers (km).

2. The ability to pass projectile's launch position, and hit-point location in sufficient time to allow for prompt and accurate response measures.

3. The ability to function in a stand alone mode and that is transportable by two persons.

4. The ability to deploy on Ground mobile and littoral platforms.

PHASE II: Using the results of phase I, Develop, test, and demonstrate a producible High Speed Target Acquisition and Tracking (HSTAT) device . This device will meet all technical requirements of Phase I. Documentation and demonstration of the design and the Concept of Operation shall be provided.

DUAL USE COMMERCIALIZATION: This effort has a direct relevance to an identified military need and upon successful completion should be available for transition. A High Speed Target Acquisition and Tracking (HSTAT) device will have application to both military and commercial sectors. Military applications include (as a minimum) defense of Dept. of Defense installations and Littoral (just off shore) water vessels. Commercial applications include security of airports and protection of high-value civilian industrial assets. There are numerous applications to US infrastructure protection from terrorist attack (e.g., Homeland Defense).

REFERENCES:
1. D. Leslie, H. Hyman, F. Moore, M. Squire "Surveillance, detection, and 3D infrared tracking of bullets, rockets, mortars, and artillery. Exponent Inc. . . 980 Park Center Drive, Vista, CA. 92083
2. M. Squire, F. Moore, M. Dunn, G. Houghton, H. Hyman, D. Leslie, "Detection and 3-D Tracking of Bullets for Sniper Location", Proceedings of the Military Sensor Symposium- Specialty Group on E-O Systems, Vol 1, p99-107(2000)
3. F. Moore, D. Leslie, H. Hyman, M. Squire, "Counter Sniper: A small projectile and gunfire localization system", Proceedings of SPIE 4232, Enabling Technologies for Law Enforcement and Security, p217-227(2000).
4. B. MacDonald, M. Dunn, D. Herr, H. Hyman, D. Leslie, "Missile and Aircraft Test Data Acquired With the Rapid Optical Beam Steering (ROBS) Sensor System," Proceedings SPIE-3065, Laser Radar Technology and Applications, p140-145(1997).
5. B. MacDonald, M. Dunn, D. Herr, H. Hyman, D. Leslie, "Recent laser radar field test results gathered With the Rapid Optical Beam Steering (ROBS) Sensor System," Proceedings SPIE-2748, Laser Radar Technology and Applications, p325-332(1996).

KEYWORDS: (Infrared search and track) and target and small, Rapid Optical Beam Steering System (ROBS), (Infrared Focal Plan Array) and small and portable, (Detect and Track) and bullets, (Infrared search and track) and instrumentation

AF05-294 TITLE: Data Mining and Knowledge Discovery Tools for Store Separation Engineering

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a software tool library for analyzing large store separation data sets generated by Monte Carlo and genetic algorithm methods.

DESCRIPTION: The engineering field of store safe separation is concerned with predicting the trajectory of a store (e.g., bomb, missile, fuel tank, etc.) in the aerodynamic flow field of the release aircraft and then assessing the safety and acceptability of that trajectory. Monte Carlo and genetic algorithm techniques are increasingly being applied to six degree of freedom store safe separation analysis problems. These techniques can routinely generate thousands of trajectories per flight condition for each aircraft configuration and/or weapon station analyzed. Analysis projects can have 40 or more flight conditions and/or up to 80 weapon stations that must analyzed. The resulting number of trajectories for the separations engineer to review and assess can be on the order of 100,000. This large number of trajectories can easily overwhelm the separations engineer's ability, with the use of traditional tools, to look through all the trajectories, determine the ones of concern, determine the root causes of problem trajectories, and then predict the likelihood of problem trajectories actually occurring. A new generation of store separation analysis tools is needed to rapidly sift through this large number of trajectories and extract the critical information necessary to perform a separations analysis. It is envisioned that the new analysis tools would employ advanced statistical and data mining techniques that will give the separations engineer computational and graphical tools and techniques to aid in data analysis. It is also envisioned that these computational tools would interface with existing graphical tools such as Tecplot, MATLAB, or Excel to prevent duplication of effort. Data mining and knowledge discovery in databases is a rapidly growing area that builds on theories and techniques from many fields including uncertainty modeling, pattern recognition and learning, and statistics. Databases, data warehousing, high-performance computing, data visualization, and online analytical processing can also be used in data mining. This program differs from many commercial sector efforts using this technology in that most commercial efforts are focused on directed marketing campaigns and this program seeks to employ these methods for solving engineering problems.

PHASE I: Analyze the data analysis problems of large store separation data sets and determine which data mining or knowledge discovery techniques, or combinations of techniques, would be most applicable to the store separation problem. Document the questions or problem statements the separations engineer may need to answer with a data mining system, and state how the recommended analysis techniques would accomplish determining the answers to these questions or problem statements. Demonstrate prototype elements of the final system on relatively small sets of data.

PHASE II: Code the complete software tool library and demonstrate the utility of the tools by searching for relationships in the data set that will give the separations engineer greater insight to the store separations problem. A separations data set will be provided for test use.

DUAL USE COMMERCIALIZATION: Commercial use of data mining techniques to date has primarily been focused on tailored marketing campaigns. This phase of the program would attempt to commercialize the library of software tools proven to work in an engineering application. The resulting library could then be marketed to other engineering groups as a new software tool or perhaps be incorporated as a toolbox into other existing commercial engineering tools such as MATLAB or MatrixX.

REFERENCES:
1. Grossman,R. L., Kamath, C., Kegelmeyer, P., Kumar, V., and Namburu, R.R., Data Mining for Scientific and Engineering Applications, Kluwer Academic Publishers, 2001

2. Wright, P., Knowledge Discovery in Database Tools and Techniques, ACM Crossroads, 2002

KEYWORDS: data mining, knowledge discovery, separation, trajectory, data extraction, information retrieval, information exploitation, aerodynamics

AF05-295 TITLE: Laser Hardening of Test Targets

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

OBJECTIVE: Develop hardening techniques and identify materials to protect test item instrumentation from degradation when exposed to High-Energy Laser (HEL) beams.

DESCRIPTION: Test items (including targets) are generally equipped with flight termination systems, telemetry systems, and other control systems requiring the receiving and/or transmitting of information via Radio Frequency (RF) links. These systems are not currently designed to operate in the destructive level high surface temperature environment produced by HEL beams. HEL survivable instrumentation has been identified as a high priority shortfall in the tri-service Directed Energy Test & Evaluation Capabilities (DETEC) study process. Exposed antennas are considered to be the most vulnerable components to damage by HEL beams. Prototype devices specifically designed to assure operation during and after a HEL engagement are required. This SBIR proposes to develop highly survivable antennas and associated signal transmission systems. It will characterize and quantify the HEL environment expected from HEL systems currently in development and develop materials/methods that will assure the operational integrity of the instrumentation systems to satisfy test data and range safety requirements.

PHASE I: Determination of the HEL irradiance environment expected to be produced at target surfaces by the various HEL systems and those currently in development will be required. Analyze the effects of HEL exposure on the operation of instrumentation and flight termination systems and develop detailed analysis of performance degradation under a HEL environment. Identify materials and develop methodology to protect and ensure proper operation of test systems during a HEL encounter. An optimum set of design parameters, for antenna design and heat shielding, will be identified and survivability estimates in expected test scenarios will be determined.

PHASE II: Using the results from phase I, design and produce prototype HEL hardened instrumentation and flight termination systems. Define field test objectives and conduct limited appropriate testing to verify system performance. During these tests, degradation parameters will measured to validate the estimates produced in the Phase I analysis and to directly determine the survivability of instrumentation systems. Results of these tests should identify further design refinements needed to increase the survivability of the systems during HEL testing encounters. A final system design will be produced and survivability parameters will be measured, analyzed, and reported.

DUAL USE COMMERCIALIZATION: The DETEC study concluded that all military services have a requirement for HEL survivable instrumentation systems and all will benefit from the results of this SBIR. HEL Weapon System

Contractors conduct developmental testing that require data transmission during HEL encounters and will also benefit.

REFERENCES:
1. Directed Energy Test and Evaluation Capabilities (DETEC) Tri-Service Study Shortfall 1.10.5 - Flight Termination System – Laser Protection Approach.

2. DETEC Tri-Service Study Shortfall 1.16 - Target Controller – Laser Protection Approach.

3. DETEC Tri-Service Study Shortfall 1.14b - Telemetry Package – Laser Protection Approach.

KEYWORDS: high-energy laser, irradiation, telemetry, antennas, control systems, shielding/hardening, degradation

AF05-296 TITLE: Dynamic Pressure Calibrator for Wind Tunnel Models

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a traceable dynamic pressure calibration for wind tunnel instrumentation.

DESCRIPTION: The primary hand-held pressure calibrators use a constant amplitude (134 dB) and constant frequency (250 Hz) to excite the dynamic pressure sensor. With the advent of compact electronics, the research and development of a full frequency and sound level hand-held dynamic pressure calibration appears to be feasible. We seek a novel approach to the development and demonstration of a dynamic calibration source for as -installed dynamic pressure transducers. Current static pressure calibrations are available by pressurizing the test chamber at significant cost to the wind tunnel customer or by accepting data based on laboratory calibration constants that pose moderate risks to data fidelity. Typical systems used to dynamically calibrate sensors are very large and cannot be used for field/test cell calibrations. These items include shock tubes and hydraulic impulse calibrators. Some calibrators require the use of helium to provide fast response times. This prototype should be small and adaptable to a number of transducer installations as small a military aircraft models 1-2 feet in span. Advances in sound generation technology and component miniaturization may enable the development of this hand-held dynamic pressure calibration system. The system should include automatic closed-loop control and compensation in order to generate constant amplitude signals at most frequencies in the audio range, 20-20 KHz. Application of the system is for surface-mount acoustic sensors which has a sound pressure level (SPL)from 120 dB to 170 dB and frequency control from 50 Hz to 30 KHz. Computer-controlled set points and closed-loop controls with a variety of displays and diagnostics through a graphical user interface would be valuable.

PHASE I: Demonstrate feasibility of a basic system that can be utilized to supply a dynamic pressure calibration source.

PHASE II: Demonstrate a prototype system that is capable of supplying a calibrated acoustic source to pressure sensors distributed on a test model in a transonic wind tunnel.

DUAL USE COMMERCIALIZATION: The portable dynamic pressure transducer verification source would verify the proper operation, configuration and data reduction of installed dynamic pressure transducers in wind tunnels and other industrial application where frequency spectrum sensing is required.

REFERENCES:
1. Maly, Joseph R., Kienholz, David A. (CSA Engineering, Inc.), "Development of a Dynamic Pressure Response Calibrator." International Instrumentation Symposium, 39th, Albuquerque, NM, May 2-6, 1993, Proceedings (A93-54351 24-35) Page: p. 185-201.

2. McLean, Andrew and Box, Phillip, "Calibrating Air Blast Transducers with the PCB Dynamic Pressure Pulse Calibrator." Defense Science and Technology Organization (Melbourne Australia, May 01, 2000.

3. Zuckerwar, Allan J., Cuomo, Frank W., Robbins, and William E. "Fiber optic microphone having a pressure sensing reflective membrane and a voltage source for calibration purpose." NASA Langley Research Center (Hampton, VA, United States)

KEYWORDS: calibration, microphone, controls

AF05-297 TITLE: Reduction of Effects of Support System Dynamics on Wind Tunnel Test Data

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop process tools and establish approaches for reducing system dynamics on wind tunnel test article data.

DESCRIPTION: Seek novel approaches to reduce effects of support system dynamics on wind tunnel data. Research model based approaches to dynamic data analysis and propose appropriate strategies to separate the dynamic from the “steady state” force measurements. The majority of aerodynamic data derived from wind tunnel testing is obtained from captively supported test articles, wind tunnel models, during steady-state "pitch-pause" or slowly moving "continuous-sweep" modes of operation. The test article and its support system, sting, can deflect statically and dynamically under aerodynamic and inertial loading during data acquisition. The dynamic component results from aerodynamic forces and inertial forces. Aerodynamic forces are derived from: time-varying change in reference test conditions, mean test article attitude (e.g., continuous sweep testing), aerodynamic self-excitation, and dynamic motion of the test article (geometric attitude and aerodynamic attitude resulting from motion- induced velocity). Static and dynamic deflections are of concern for both tunnel operational safety and data quality perspectives. Static support deflection effects are currently handled by data system corrections or on-board attitude measurement devices. Both data analysis methods and hardware implementations are encouraged to account for and minimize the detrimental effects of model and support system dynamics on wind tunnel data. The goal is to remove a minimum of 85% at a 90% confidence of all motions and inertial induced bias error.

PHASE I: Laboratory demonstration of feasibility.

PHASE II: Demonstrate feasibility to implement a hardware and/or software system to meet the data analysis needs of the wind tunnel testing environment.

DUAL USE COMMERCIALIZATION: Additional applications of the technology include automotive and flight system aerodynamic testing in wind tunnel and other ground test environments, steady-state data acquisition in dynamic environments, and in characterization of transient dynamics on aerodynamic load measurements in industrial flow systems.

REFERENCES:
1. Buehrle, R. D., “System Dynamic Analysis of a Wind Tunnel Model With Applications to Improve Aerodynamic Data Quality," Ph.D. Dissertation, College of Engineering, University of Cincinnati, 1997.

2. Tcheng, T. et al., "Effects of Yaw and Pitch Motion on Model Attitude Measurements," NASA Technical Memorandum 4641, February 1995.

3. Billingsley, J. P., "Sting Dynamics of Wind Tunnel Models," Arnold Engineering Development Center, AEDC-TR-76-41, May 1976.

KEYWORDS: aerodynamics, dynamic deflection, continuous sweep testing

AF05-298 TITLE: Throat and Wall Materials for Hypersonic Wind Tunnel

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Devise a hypersonic nozzle system that will withstand the extreme conditions typical of hypersonic facilities.

DESCRIPTION: New high strength, high temperature, oxide-resistance materials are required for hypersonic wind tunnel applications. Arc heaters and hypersonic propulsion testing facilities experience reservoir conditions pressure as 250 atm and temperatures as high 4500 K, and run times of multiple minutes. Shorter run time(less than 10 seconds)hypersonic facilities might benefit from the development of their technology, such as Air Force's Tunnel 9. Innovative nozzle design and fabrication technologies are sought including new alloys, ceramic inserts, composite materials, and high strength oxide-resistant coatings. Different facilities require different nozzle throat strategies. Long run time (minutes) facilities often employ some sort of active cooling. In this case a high thermal conductivity is important, as well as high strength at temperature. On the other hand, short run time facilities may be able to employ heat sink methods, where strength at temperature is most important. Ease of fabrication is important since the internal shape is contoured with throat diameter ranging from 0.5 inch to 2.5 inches.

PHASE I: Develop and demonstrate samples of one or more materials suitable for nozzle systems.

PHASE II: Demonstrate a prototype nozzle/nozzle system suitable for testing in arc heaters and hypersonic propulsion testing facilities.

DUAL USE COMMERCIALIZATION: Many industrial and military applications, e.g., combustors, require materials to survive at very high temperatures.

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KEYWORDS: nozzle throat materials, hypersonic wind tunnel, oxide-resistance materials

AF05-299 TITLE: Variable Electrochromic Devices (VEDs) for Space Simulation Testing

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a variable electrochromic system for a cryo-vacuum environment in the infrared spectral region.

DESCRIPTION: We are seeking novel approaches to the development of ground-based simulation of target scenarios for testing, acquisition, discrimination, and terminal phases of space-based sensor systems. The technical challenge is to combine various infrared projections, while minimizing significant radiometric losses, and transmitting the result to the aperture of the unit under test. Electrochromism is defined as a reversible color change of a material caused by the application of an electrical current or potential. Its potential applications include smart windows for the modulation of incoming light, as well as displays, a field in which competition with liquid crystal

display is possible. A prototype infrared beam combiner (at least 4” sq) that can be significantly varied in reflectance and transmission over a 5 µm band in the 2 to 25 µm region, or demonstration of a prototype mirror (at least 6” sq) is required. The device must be spectrally suppressed (minimal reflection beyond 14 µm)and must operate at 20K or less. Also, the nature of the test methodology limits possible swapping of components. A beam combiner, that could reflect/transmit 50:50 in one mode and 90:10 in another mode would be extremely useful or a mirror that could spectrally suppress the reflection beyond 14 µm when activated would be useful in normal testing, while the full spectrum would allow visualization of stray radiation and narcissus effects. Spectral filters with adjustable band pass would also be of great interest. Research an electrochromism device that can operate in a cryo-vacuum environment (~ 20 to 80K) while minimizing the radiometric background artifacts of the test chamber itself.

PHASE I: Demonstration feasibility of a prototype electrochromic beam combiner/mirror at a temperature of 120 K (or -153 deg C).

PHASE II: Demonstration a prototype beam combiner at 20 K (-253 C).

DUAL USE COMMERCIALIZATION: These devices would be used by cryogenic radiometric test facilities. Further, the devices would be usable for passive thermal control on satellites.

REFERENCES:
1. Studies of electrochromic devices based on thin films of PProDOT-Me2, Summer 2000 Research Program: Research Experiences for Undergraduates, 2000. Robert J. Clark1, Jungseek Hwang2, Irina Giurgiu3
David B. Tanner2, and John R. Reynolds3 --1) Departments of Physics and Chemistry, Ohio Northern University, Ada, OH 45810 --2) Department of Physics, University of Florida, Gainesville, FL 32611 --3) Department of Chemistry, Center for Macromolecular Science and Engineering,University of Florida, Gainesville, FL 32611

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KEYWORDS: stray radiation control, variable electrochromic devices, cryogenic optics, beam combiners

AF05-301 TITLE: Chemical Quick Quench Probe for Engine Emissions Measurements

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop an extractive probe that "freezes" the chemical composition of the sampled turbine engine exhaust gases.

DESCRIPTION: There is a need to determine the true molecular composition of high speed reacting gas flows - specifically the exhausts of aircraft turbine engines (augmented and non-augmented), turbine engine combustors, and rocket engines. These measurements are required for the determination of engine efficiency and for the understanding needed to reduce pollutants. Typically, extractive sampling is biased by reactions that occur as the gas sample travels through a sample line from the probe, located at the engine exist plane, to the analyzer. The composition that actually reaches the analyzer is different than that which enters the probe. A reliable method for quenching these reactions, thus freezing the molecular composition and removing this bias is required. Past approaches have included aerodynamically expanding the sample once it enters the probe, thus attempting to cool it sufficiently such that reactions cannot proceed, as well as the addition of a diluent gas (e.g. argon which also cools the sample). These approaches may be successful. The offeror is encouraged to research and develop alternatives to these extractive methods and to demonstrate feasibility of the new approach.

PHASE I: Demonstrate feasibility of a prototype system. The demonstration can be made in a laboratory environment with hot gases similar to a turbine engine.

PHASE II: Develop and demonstrate a prototype quench probe system which shall be capable of operation in the exhaust of an augmented turbine engine.

DUAL USE COMMERCIALIZATION: A quenching sampling probe capable of operating at turbine engine exit and combustor temperatures will find commercial and military application with the manufacturers of aircraft and stationary power-producing gas turbines.

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KEYWORDS: quench probe, gas sampling, engine exhaust gases

AF05-304 TITLE: Imaging Acoustic Signature Analyses for Plant Turbo-machinery

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a system that will acquire and monitor the acoustic signature of rotating machinery.

DESCRIPTION: Industrial plant equipment needs to be monitored for health status. A remote acoustic based system needs to be developed to detect rotating equipment health status. The system must operate properly without human intervention while targeting, and identifying developing faults. Acoustic spectral signature analysis has existed for many years, and is similar to vibration analysis using accelerometers with the advantage that nothing must be mounted on the machine. Acoustic imaging systems using phased arrays have also been existence for some time. The current state-of-the-art, however, requires an expert human operator to interpret the data from these devices, and therefore is not suitable for automated, online monitoring. The goal of this topic is to develop an automated acoustic monitoring system that includes the necessary filtering/data manipulation techniques and expert system/classification/anomaly detection algorithms to diagnose the health of plant equipment (compressors, electric motors, gear trains, fans, etc.), turbine engines, and other rotating machinery in an industrial high-bay area environment. The system will include an imaging array coupled with software that includes fault diagnosis/anomaly detection algorithms, the capability to learn and recall the acoustic signature of novel faults, and the capability to send an alarm output via a standard interface over distance to a facility control room.

PHASE I: Feasibility demonstration of acoustic imaging technologies, a design for a sensor array, an architecture and design of an intelligent, expandable fault identification/anomaly detection software package, and evidence of viability for the proposed system to function in the plant environment.

PHASE II: A prototype acoustic monitoring system will be demonstrated on rotating machinery representative of large-scale plant equipment. Acoustic variations on a demonstrator motor or other rotating machinery will be used to simulate and detect faults typical of that device.

DUAL USE COMMERCIALIZATION: Such a system has wide potential for the monitoring and diagnosis of plant equipment, aircraft/rotorcraft systems, generators, and other rotating machinery. Because the system would be non-contact, a single system could be used to monitor many types of rotating machinery/equipment simultaneously.

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KEYWORDS: Anomaly Detection, Expert System, Acoustic Array, Health Monitoring, Turbine Engine, Rotating Machinery, Beamforming

AF05-307 TITLE: High Temperature Endoscopic Particle Imaging Velocimetry (PIV) System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a high temperature endoscopic PIV system for turbine engine augmentors.

DESCRIPTION: A need exists to measure fuel spray characteristics inside turbine engine augmentors. Both velocity and size distributions are needed. PIV with the addition of a second, interferometrically coupled camera would allow simultaneous determination of both velocity and size. Endoscopic PIV systems exist for velocity measurements, but such endoscopic systems have not been demonstrated for simultaneous velocity and size distribution measurements. Also, the existing endoscopic systems are not sufficiently cooled to allow operation in turbine engine augmentors, where conditions can reach 3500 F and 75 psia. The endoscope(s) shall (or be scalable to) extend to at least two feet and be no more that 0.5-inch in diameter. Provision shall be made for adjusting the field-of-view and depth of focus. Optical access in a turbine engine environment requires not only cooling but optically clean components as well. Innovative approaches to determining the flow velocity distribution and simultaneous particle size distribution in adverse combustion environment are sought.

PHASE I: Demonstrate feasibility of an endoscopic system for the simultaneous measurement of particle velocity and size distributions in a laboratory environment.

PHASE II: Demonstrate a prototype endoscopic system for the simultaneous measurement of particle velocity and size distributions. The system shall be demonstrated at typical turbine engine environment.

DUAL USE COMMERCIALIZATION: A high temperature endoscopic PIV system has a high potential for research and development needs for combustor development in the military and commercial market.

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KEYWORDS: particle image velocimetry, particle sizing

AF05-309 TITLE: Automated Learning Video Analysis (ALVA)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Research the application of Neural Networks and other learning type algorithms for the purpose of automated identification and tracking of events captured on video.

DESCRIPTION: The collection of video data is transitioning from analog to digital. There are now Gigabytes of digital video collected during a single mission of an extended aircraft flight test program. This digital video comes from ground based systems, in-flight chase aircraft video, on-board video, and cockpit video. Currently, analog and digital video is used by engineers to identify key events during a test and then using the time of that event to index into other data streams for further analysis. This is an extremely time consuming process requiring intense concentration by the engineer as they search frame by frame for the expected event.

The intent of the research is to investigate learning algorithms that can be applied to processing digital video. Specifically, the algorithms should allow a user to identify a "training set" of images to be the basis for searching for matches and approximate matches in the video data. For example, the user should be able to select a video image and identify a sub-set of the image that would be watched for changes in the image, the text, or the color; this pattern recognition capability has found use in machine tool and manufacturing environments. Additionally, the algorithms should be able to "track" an identified image in the video as it "moves" within the frame and changes orientation without being distracted by similar but unwanted content. For example, if an aircraft is the identified image it may move within the video frame or change orientation and the algorithm should be able to continually identify the changing image as the same aircraft. This ability to find and track specified high speed events is not available.

All algorithms shall be prototyped and tested and will be important tools in the verification of the theoretical solutions. The results of these investigations should include all algorithms required for a prototype digital video analysis system including documentation of the prototype and the verification and testing processes. Hardware requirements to implement these algorithms shall be identified.

PHASE I: Investigate various "learning" algorithms to determine the best candidates for use with identifying events in digital video.

PHASE II: Develop and demonstrate prototype software capable of automated video data analysis using an algorithm that "learns" what key events look like and then is able to find those events in a video stream.

DUAL USE COMMERCIALIZATION: This research has potential applications in aerospace, Homeland Defense, security, and entertainment. Being able to automate the search through digital video data for specific events can be used to analyze security videos, test data, and movies.

REFERENCES:
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KEYWORDS: Digital Video Data Analysis, Learning Algorithms, Neural Networks.

AF05-310 TITLE: Multi-Spectral Projection Using Reflective Microelectromechanical Systems (MEMS)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop increases in frame rate, resolution, and spectral diversity of multi-spectral scene projection.

DESCRIPTION: Missile seeker heads employing imaging sensors are robust and resistant to directed energy countermeasures. Testing imaging seekers requires the ability to project virtual reality scenes that include a mix of simultaneous infrared (IR), visible, and ultraviolet (UV) objects that are registered and synchronized. Resistive arrays are currently the dominant technology used in the test process, but are limited to longer wavelength IR, pixel recovery times of milliseconds, and inhibited development due to narrow markets.

MEMS technology has shown up to 11 kHz pixel modulation rates and array sizes over one million pixels but Reflective MEMS suffer from diffraction interactions with the pixel constructs at longer IR wavelengths. Pulse width modulation intensity schemes reduce the modulation rate to lower frame rates and commercial versions are optimized to visible radiation. Fundamentally, reflective MEMs offer trade-space between dynamic range, spectral diversity, resolution, and frame rate that the Air Force desires. This SBIR solicits methods to develop suitable combinations using commercial or modified devices. This may include special optics or source modulation.

The technology challenge is to obtain frame rates of 80 - 100 Hz while retaining UV, visible, and IR efficiency in the optics and dynamic range approaching 12 bits. Research work may require knowledge of material science, pixel software control algorithms, and optical designs.

PHASE I: Research chemical and physical modifications to integrated circuits necessary to work across the desired spectral regions. Develop software concepts to project multi-wavelength scenes, using interfaces with scene generation software. Present design studies of optical systems that will integrate the necessary sources and performance parameters. Analyze the optimization of trade-space parameters for various scene projection needs and determine the feasibility of development in Phase II.

PHASE II: Develop prototype capable of multi-spectral scene projection. Demonstrate the ability to simulate the environment with sufficient fidelity to allow captured-missile (hardware in the loop) missile testing.

DUAL USE COMMERCIALIZATION: An advanced prototype scene generation projector using the Reflective MEMs technology will find applications in both military and commercial aircraft ground test operations. Additional applications will include use by security forces intent on defeating IR surveillance cameras. In addition to projecting “into” optics, this technology can be extended to project “onto” items, allowing camouflage radiation signatures for objects.

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KEYWORDS: Multi-Spectral Scene, Virtual Reality, Reflective Microelectromechanical Systems (MEMS), MEMS, Digital Light Processing (DLP), Aircraft Missile Defense, Missile Counter-Measures, Image Projection, Camouflage.

AF05-311 TITLE: Independently Controlled Extended Infrared Source Array

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop theoretical approaches to support infrared (IR) extended sources in testing.

DESCRIPTION: The testing of many defense and commercial applications requires the ability to generate extended IR scenes without flicker. The evaluation of critical performance parameters of algorithms, optics, and sensors rely on the ability to generate extended infrared sources that approximate typical targets, countermeasures and backgrounds. The goal of this topic is to develop an independently controlled extended IR emissive source array. The current technology is limited in temperature, crosstalk, refresh rate, controllability, heat dissipation, and packaging. The solution to this problem will require source technology advancements needed to create IR source elements that can be independently controlled in frequency, temperature, and emission duration. The IR emissive source elements must be arranged in an array to minimize the space between elements and to provide the observing IR sensor system with a controllable IR scene. A prototype array must present a nominal 4 by 4 inch area to the viewing sensor to demonstrate individual element control and isolation. The number of elements, temperature range, controllability, heat dissipation and other characteristics are to be addressed in a trade space identified by the following required characteristics:

1) Individually controllable source elements arranged in a contiguous two-dimensional (2-D) array
2) Maximum IR emissive element size: 1 inch x 1 inch with ¼ inch x ¼ inch as a goal (the array fill factor should be maximized – smaller IR emissive element size should mean more IR emissive sources to fill the array)
3) Temperature range: Ambient (about 20 degrees C) to 600 degrees C with 800 degrees C as a goal
4) Element temperature stability: 1 degree C with 1/10 degree C as a goal
5) Maximum cross talk between elements of: 1% with 1/10 % as a goal of commanded levels
6) Minimum temperature rise time from ambient to 90% of maximum in five milliseconds with one millisecond as a goal
7) Minimum temperature fall time from max temperature to ambient 10 seconds with 1/10 second as a goal
8) Refresh rate 200Hz with 1000 Hz as a goal
9) Element cooling must be self-contained and capable of cooling rates approaching the required fall time
10) The source emission should cover the 1.5 to 5.5 micron band

PHASE I: Develop an IR extended source concept by identifying the physics and device technology necessary to provide improved or significantly alternate approaches to the current state of the art. Perform critical component or technology proof of concept experiments and complete source preliminary design and trade-off analysis to determine the feasibility of the proposed technology.

PHASE II: Develop prototype IR extended source array 4 inches on a side with a minimum of 16 (4x4) elements and a goal of 64 (8x8) elements. The package, including all critical components, should be designed to be a building block for a larger array. This transition may include large 1024 by 1024 or 4096 by 4096 element arrays of 100 inches on a side. Conduct a demonstration and document the performance and limitations of the prototype array. The demonstration shall include critical experiments that define the limits of capability and define a fabrication process path to a core device that can transition to a production IR extended source capability.

DUAL USE COMMERCIALIZATION: The commercial infrared sensor and Department of Defense funded guided weapons development community would benefit directly from this development. All weapon programs relying on infrared sensors against high contrast targets would benefit. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. With the advent of a real time infrared system, infrared scene projection technology could easily move into the commercial sectors such as fire fighting, forest fire hotspot location, and night vision systems for personnel and commercial vehicles.

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KEYWORDS: High-contrast display, Infrared-extended-sources, Infrared-scene, real-time, Large-area-display

AF05-312 TITLE: Joint Tactical Radio System (JTRS) Wideband Network Waveform (WNW) Host Simulator

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Research and develop ground test and diagnostic tools to serve as a computer-based Host Platform Simulator for the Joint Tactical Radio System (JTRS) Wideband Network Waveform (WNW), or JTRS WNW.

DESCRIPTION: JTRS is the next generation radio system that will replace all current radio systems onboard military aircraft and in military ground stations. All Radio Frequency systems acquired by the Department of Defense (DOD) must meet the current standards for software and hardware configurations set forth by the JTRS Joint Program Office (JPO). All radios purchased by the DOD must be some variant (cluster) of the JTRS family of radios. JTRS will be capable of performing 32 different legacy radio functions, currently performed by separate radios, plus the new WNW function. Every platform in the DOD must integrate and field JTRS WNW.

The 32 legacy radio functions performed by JTRS can be tested using existing radio ground test equipment developed when that function was originally integrated into AF platforms. However, to test and evaluate the JTRS WNW functionality and interoperability onboard an aircraft, adequate ground stations and diagnostic tools must be developed and made available to the Test and Evaluation (T&E) community.

WNW is the next generation Tactical Digital Information Link (TADIL), a follow on to the Link 16 Waveform and an eventual replacement to all other radio waveforms. WNW will be a capability of the JTRS Cluster for Airborne-Maritime-Fixed (AMF) applications, to be utilized by all Air Force (AF) platforms. JTRS AMF hardware will have WNW capability that will require a controlling host platform to function and process data.

In AF applications the host platform would usually be the aircraft Mission Computer and Operational Flight Program (OFP). In a ground test and diagnostic station there is no aircraft; all of the OFP functions will need to be simulated to make the JTRS WNW function. The ground test and diagnostic stations would likely utilize a JTRS radio and a software program that interfaces with the JTRS radio to act as the OFP of a host platform. The technology challenge is to develop that software program while WNW is still in development. WNW is expected to be more advanced and complicated than any other form of communications systems ever used by the DOD.

PHASE I: Research the feasibility of developing a PC based software tool to provide basic control and communications of the JTRS WNW that will provide the minimal functionality needed to operate a JTRS WNW ground station and the JTRS AMF radio currently under development.

PHASE II: Develop a prototype Windows based PC based software tool that provides basic control and communications of the JTRS WNW to provide a JTRS WNW ground station. Incorporate JTRS WNW emulation of multiple host platforms (i.e., Airborne, Maritime, and Fixed) and test and diagnostic capabilities. Develop a reconfigurable ground test station that can emulate real platforms and monitor and analyze the JTRS WNW

functionality, heath and status real time down to the internal process level of the JTRS utilizing this software tool and a JTRS AMF radio.

DUAL USE COMMERCIALIZATION: This system can be duplicated and used at testing and evaluation (T&E) centers well as training and experimentation facilities DOD wide. The software tool will also find use within both academic and commercial environments supporting advanced communication system development.

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(all of these documents are available at http://jtrs.army.mil)

KEYWORDS: Joint Tactical Radio System (JTRS), Wideband Network Waveform (WNW), Host Simulator, Test Tools.

AF05-313 TITLE: Open-Air Range Scattered Laser Light Detectors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate a capability to monitor stray emissions generated by lasers on open air ranges.

DESCRIPTION: The Department of Defense is developing high energy laser (HEL) weapon systems (e.g. Tactical High Energy Laster [THEL], Airborne Laser [ABL]) for long range target destruction. A target engaged by a laser may scatter, specularly or diffusely, one or more secondary laser beams over an area approaching 100 square kilometers. When HEL weapons are used, these reflections could produce potentially damaging energy/power levels that may impact surrounding protected or occupied areas.

Currently, there are no means available to accurately monitor or detect scattered reflections from laser illuminated targets or laser light dispersed by particulates in the atmosphere over a large area that would identify potentially hazardous situations or areas during lasing operations. Staring arrays located in space can not be directed to change in a timely manner. Traditional Bidirectional Reflectance Distribution Function (BRDF) measuring devices are not suited for remote operation and are limited to making surface measurements on relatively small samples under controlled conditions. Portable BRDF measuring devices are also limited in operation to measuring the reflectance distribution off of a defined surface.

This effort will address the detection and monitoring shortfalls by developing and building a prototype sensor system to monitor stray reflections of laser light from dynamic and static targets. The technology challenge is to detect the presence of reflected (specular or diffuse) beams where there may be no identified incident beam and the presence of intense ambient background illumination. A detection system would need to be deployed in one or multiple locations to cover several hundred square miles during daylight or nighttime HEL testing. The remote operation will dictate a durable power supply and a communication scheme to transfer information to a remote annunciation facility be integrated into the system.

PHASE I: Define the proposed concept and develop key component technological milestones. Produce a conceptual design and provide a detailed analysis of the predicted performance to include modeling and simulation of the prototype device. Determine the technical feasibility of the prototype device and provide a plan for practical field deployment.

PHASE II: Develop a prototype system and demonstrate successful detection of non-incident laser beam reflections sensing only scattered light not intended for use by the primary laser system. Perform field trials and show sensitivity and interpretability of laser source and type, using a data mesh of monitors/detectors.

DUAL USE COMMERCIALIZATION: The proposed device can be used during live military engagements to detect foreign laser applications in hostile situations. These devices will find extensive use in industrial manufacturing sites and laboratories as well as in academic laboratory environments to protect employees from stray laser light applications reducing the number of laser induced eye injuries and the associated costs.

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KEYWORDS: Environmental Monitoring, Laser Eye Safety, Battlefield Laser Light, Range Finders, Target Designators, Directed Energy Weapons, Open Air Testing, Perimeter Security.

AF05-314 TITLE: Instrumentation Hardware Abstraction Support Tools

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Define a hardware abstraction language and develop supporting tools for the programming of instrumentation.

DESCRIPTION: Instrumentation support systems (ISSs) are used to program data acquisition instrumentation prior to a test in order to instruct the instrumentation as to what measurements to make and what format to put the acquired data in. There is an increasing requirement for ISSs to interface with and program myriad instruments produced by myriad vendors. A common language for interfacing between these various ISSs and instruments would significantly reduce the overall interface development and integration efforts as well as increase interoperability. The development of such a language needs to abstract hardware characteristics in order to establish a useful foundation for support tool development. A conceptual approach to this language is to consider it as similar to an intermediate language used in compiler design (ref 1.). Companies that support different programming languages (e.g., C++, Ada, Visual Basic, etc.) usually compile source code into an intermediate language. Vendors that support specific computers (e.g., Sun, Intel, IBM, etc.) then compile this intermediate language into their specific machine code. A similar concept can be applied to ISSs and instrumentation. The different ISSs play the role of the different programming languages and the different instrumentation suites play the role of the machines utilizing different machine code.

This effort is to develop a hardware abstraction language to be used by different ISSs (e.g., Iliad, Vista, OMEGA, etc.). The ISSs would translate the data acquisition programming requirements into this language and then the vendors supporting specific devices (e.g., SCI, TTC, Veridian, L3 Com, etc.) would provide programs that translate this language into their hardware specific languages. This eliminates the need for every support system to develop interfaces to every device. There are on the order of 1000 existing devices that potentially require support. Each device can take $5K to $50K or more to integrate. Further, more devices are constantly being put on the market. The current structure makes it cost prohibitive to support all such devices. The cost savings involved is the classic reduction from N*(N-1) to 2N interfaces. Instead of interfacing from every ISS to every instrument, every ISS and every instrument interfaces with the intermediate language.

Test and evaluation (T&E) cannot take place without the programming of data acquisition systems. The instrumentation community is distinctly moving towards multi-vendor interoperability. The significant reduction in interface development accomplished by this effort would be a key component in the reduction of both time and cost of T&E programs.

PHASE I: Research existing techniques for supporting multiple vendor hardware in programming environments. Research and analyze instrumentation programming languages used by various vendors. Research existing instrumentation support systems and the types of data they use. Develop a hardware abstraction of commands, parameters, and attributes of different instrumentation devices. An initial description of the intermediate language should be provided. Mappings between support system data and device specific commands via the intermediate language should be provided. A software design of translators and other appropriate support tools should be provided.

PHASE II: Develop software designed in Phase I. Update and improve the hardware abstraction and the associated language. Provide demonstrations that the language captures a large percent of commands, parameters, and attributes required to program a variety of devices from different vendors. Demonstrate that the software tools facilitate the addition of devices to instrumentation support systems. Work towards having the language adopted as a formal standard.

DUAL USE COMMERCIALIZATION: The hardware abstraction language and translator software technology can be used to significantly reduce the lifecycle cost of ISS for diverse T&E applications, data collection and monitoring systems. In addition to the weapons testing field, it can be used to support critical applications in process monitoring, facilities and equipment health monitoring, and mission-critical applications for industry segments such as aerospace, automobile, shipbuilding, and health-care. Broad applications include commercial marketplaces requiring real-time data monitoring and surveillance such as airports, weather services, traffic-control (land, air, and sea), and stock markets.

REFERENCES:
1. Compilers: Principles, Techniques and Tools, Aho, Sethi, and Ullman, ISBN: 0201100886, 1986.

2. Telemetry Group, Range Commanders Council, IRIG Standard 106-01, Telemetry Standards, Secretariat, Range Commanders Council, U.S. Army White Sands Missile Range, NM, (2001).

KEYWORDS: Test Equipment, Computer Sciences, Instrumentation, Data Acquisition, Compiler Design, Hardware Abstraction

AF05-316 TITLE: Health and Environmental Simulation

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop an algorithmic model for dispersal in air of hazardous chemicals released two to 25 feet from a potential receiver(s).

DESCRIPTION: In order to improve efficiency in identifying health and environmental concerns from hazardous chemicals over various periods of time, there is a need for a realistic multidiscipline modeling and simulation capability. Evaluating health and environmental risks from hazardous materials exposure is a new discipline within the test and evaluation community that meets the customers' requirements in providing a more flexible maintenance concept of operations in various environments. In order to provide valuable information that is translated into actionable assessments for the warfighter on health and environmental risks, the Air Force requires a tool that will use actual test results to anchor a broad area dispersal simulation for several realistic scenarios. As a result, this capability will enable the Commanders and the warfighters to understand and know the health and environmental risks from maintaining and operating these weapon systems.

Current models from the Environmental Protection Agency (EPA) provide some general use for health and environmental exposure to hazardous chemicals. However, because of the nature of test and evaluation, these

models are only useful on a macro-level to determine human exposure and can only be used in a limited capacity. Simulation models such as Computer-Aided Management of Emergency Operations (CAMEO) or Hazard Prediction & Assessment Capability (HPAC) provide only limited use in this endeavor. CAMEO is used to access, store, and evaluate information critical for developing emergency plans. HPAC can be used to predict hazards from nuclear, biological, chemical, and radiological (NBCR) weapons and facilities. Thus, the Air Force needs an algorithmic model to use in identifying chemical hazards in the air for health and environmental assessments.

The solution should be implemented into a simulation capability focused on hazardous chemicals, typically found in a flight test center or industrial maintenance environment, released into the air. The simulation capability will be used to predict scenario outcomes. The validity of this simulation should be verified with test measurements. In addition, the simulation of hazardous chemicals dispersement should be over various elapsed periods of time to show exposure levels in environments from these hazards to the human and surrounding environment.

PHASE I: Investigate similar algorithms where hazardous chemicals are dispersed in the air and the receiver is two to 25 feet from the release of the chemical. Determine the gaps in current algorithms and implementation for this Health and Environmental (H&E) risk measurements prototype. Develop an initial conceptual design and model the key elements needed for the simulation.

PHASE II: Develop the H&E simulation prototype and demonstrate it by forecasting a potential chemical release and then compare these predictions using actual data from similar operations or other fate and transport models.

DUAL USE COMMERCIALIZATION: This research will ultimately find use within the Department of Defense, and Homeland Defense for assisting in identifying the micro-level effects and risks from chemical and biological agents dispersed in the air to the both the warfighter and general population. It will also be suitable for use in a variety of industrial emissions measurement applications.

REFERENCES:
1. Current modeling capability at EPA is located at http://www.epa.gov/oppt/exposure/

2. Current health standards at OSHA (Occupational Safety and Health Administration) are located at http://www.osha.gov/

3. Exposure Report from Center for Disease Control, “Hazardous Report on Human Exposure to Environmental Chemicals,” http://www.cdc.gov/exposurereport/

4. Air Force Occupational Safety and Health Standard (AFOSH) 48-8, “Controlling Exposures to Hazardous Materials,” dated 01 Sep 97, currently being revised to additional chemicals of concern

5. Air Force Instruction (AFI) 48-119, Medical Service Environmental Quality Programs, dated 25 Jul 95, currently being revised to go to risk based evaluations of environmental factors

KEYWORDS: health, environmental, chemical exposure, hazardous materials, human, risks, chemical agents, toxic industrial chemicals

AF05-318 TITLE: Buffet and Dynamic Loads Analysis

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Improve the reliability and accuracy of aircraft simulations where fluid structure interaction is of prime concern.

DESCRIPTION: Modern military aircraft often carry external stores, operate at high angles of attack, and perform aggressive maneuvers. This leads to flow separation, turbulence, buffet, and high dynamic loads. Traditionally it has been impractical to sufficiently model these effects and get reliable simulation results. Recent advances in computer performance and algorithm efficiencies now make it possible to more accurately analyze these issues.

At high-speed flight and moderate angles of attack, or at low-speed flight and high-angles of attack, the aerodynamic flow over the aircraft can become separated causing turbulence and vortex bursting in the vicinity of an aircraft. When the turbulent flow and/or vortices impact downstream portions of the aircraft structure (the horizontal or vertical tail for example) the result is buffeting which can cause a severe vibration environment in the aircraft. Predicting these aeroelastic phenomena from model-based simulations is challenging.

Several Computational Fluid Dynamics (CPD) -based aeroelastic simulation technologies have emerged for this purpose but have been utilized mainly on classical flutter problems, where flow that is laminar and inviscid is assumed. Increasing the usefulness of these tools in the area of buffet simulations requires paying careful attention to turbulence modeling within a fluid structure interaction framework. This in turn requires developing robust algorithms for modeling moving fluid-grids and updating their motion, particularly in the boundary layer where viscosity becomes dominate. Recent developments in CFD on moving grids and structural-analogy-based methods for constructing dynamic meshes provide a possible path for developing the much needed technology.

Dynamic loads resulting from rapid maneuvers depend on the non-linear control surface effectiveness in a dynamic (time dependent) flow environment. In order to capture these dynamic loads it is necessary to model the control surface motion. Current research is exploring methods of emulating the control surface motion in an aeroelastic simulation using meshless algorithms in the area near the control surface to provide a means of accurately capturing dynamic loads due to aggressive maneuvering.

Although many of the technologies discussed in this proposal have been developed for use as fluid dynamic analysis tools, incorporating them into a fluid structure interaction framework will require advanced development of the requisite algorithms to ensure the order of accuracy of the simulation is not lost in the message passing between the fluid dynamic algorithms and the structural dynamic algorithms that must take place in order to capture the interaction between the fluid and structure. Ultimately, this predictive capability can be exploited to significantly expedite structural clearance flight testing for new military and commercial aircraft.

PHASE I: Identify and define advanced technologies for modeling moving grids and turbulence on these grids. Identify pathways for integrating them with CFD-based aeroelastic software. The viability of directly modeling the control surface motion in an aeroelastic simulation also needs to be explored. The benefits and technical implementation approach will be demonstrated.

PHASE II: Using the results from Phase I, the modeling technologies addressed 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 fighter aircraft configuration in the subsonic, transonic, and early supersonic flight regimes.

DUAL USE COMMERCIALIZATION: Commercial and military aviation will benefit from this research since both segments of the aircraft industry are equally affected by non-linear aeroelastic phenomenon, buffet and dynamic loads. In addition, there is potential for use in any case where unsteady aerodynamics and structures interact. Examples of this are parachute dynamics in the aircraft wake, civil engineering structures in the wake of mountains, or other structures, or turbine dynamics.

REFERENCES:

1. 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)

2. C. Farhat, B. Koobus and M. Lesoinne, ``A High Fidelity and High Performance Computational Methodology for the Solution of Viscous Aeroelastic Response Problems," Proceedings of the First AFOSR Conference on Dynamic Motion CFD, Rutgers, June 3-5, pp. 159-187 (1996)

KEYWORDS: Fluid Structure Interaction, Aeroelasticity, Buffet, Dynamic Loads

AF05-319 TITLE: Control Systems for Data Relay Stations

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative means to relay data at extreme altitudes and distance.

DESCRIPTION: Data relay stations at high altitudes (approximately 70K ft.) will be used in the future to communicate data to/from various locations. The ability to have stations positioned at extreme altitudes will provide greater mission coverage and frequency reuse capability. This will also provide the capability of performing simultaneous mission operations using the same mission frequency, preventing cancellation of missions due to requirements for different missions to use the identical frequency.

Data relay stations will be unmanned dirigibles and therefore, must be remotely controlled from a command & control facility. Such a system must be able to control various systems including data relay and navigation and do so under extreme environmental conditions. Existing control systems do not provide these highly specialized capabilities. These conditions include: extremely low air-pressure, low humidity, extremely low temperatures, etc. The extreme environmental conditions can increase the risk of decomposition of the station and have negative impacts on reliability and usability of data systems. Without a control system, maintainability of a station will be negatively affected.

Navigational control of a station must provide the capability of changing the stations ground coordinate location altitude. This capability will effect both coverage and frequency reuse. It will also be required to launch and return a station for various maintenance actions. Without the control system a station would tend to 'drift' from its required location possibly reducing the coverage footprint therefore making multiple missions using the same frequency impossible.

PHASE I: Research innovative technologies to identify the risks associated with remotely controlling a relay station at high altitude under extreme environmental conditions and provide a conceptual top level design of an extreme distance remote control system.

PHASE II: Design and develop a prototype control system that performs the requisite station keeping and relay functions. Analyze end-to-end performance and capability of a relay station to perform correctly under extreme conditions.

DUAL USE COMMERCIALIZATION: In addition to military data relay applications, this technology will find extensive applications by the commercial weather tracking industry. This research also has potential applications in the entertainment and communication industries.

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1. "High Altitude Platforms for Wireless Communications," T. C . Dozer and D. Grace, Electronics and Communications Journal, June 2001

2. "Commercial High-Altitude Unpiloted Aerial Remote Sensing: Some Legal Considerations," Joanne Irene Gabrynowicz, Photogrammetric Engineering & Remote Sensing,Vol. 62, No. 3, March 1996, pp. 275-278.

3. Design of Mission Operations Systems for Scientific Remote Sensing by Stephen D. Wall Publisher: Taylor & Francis; (December 1991), ISBN: 0850668603

4. High Altitude Airship (HAA), http://www.globalsecurity.org/intell/systems/haa.htm

KEYWORDS: unmanned, control system, navigation, environmental conditions, reliability, frequency reuse.

AF05-320 TITLE: Personal Issue Flight Test Data Recorder with Display

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop validated software capable of generating, in real-time, report quality flight-test results.

DESCRIPTION: Aircraft flight testing has previously been done using data collection systems integral to the airframe, incurring significant costs. Instrumenting a military aircraft for data collection costs upwards of a half million dollars. A device, that incorporates Personal Digital Assistant (PDA), tablet computers, or similar technology, that is usable on-board ejection-seat equipped aircraft is needed; size, weight, and freedom from entanglement requirements are considerations. A device that can collect, display, analyze and report test data in real time, and make recommendations in real-time to fly more efficient test profiles is needed.

This SBIR project entails compensating for less precise data with more intelligent use of it, giving acceptably similar test results. It leverages off other advances in sensors. The technology challenge is to accommodate hardware that will press the limits of low resolution, sampling rate, and variable installations. Sensors may be low dynamic range, mounted temporarily, unaligned to aircraft axes, or even reside in a pilot's clothing. This needs to be mitigated with intelligent software, capable of learning, adapting to new environments, and performing dynamic calibrations.

Packaging needs to be inexpensive and modular enough for individual pilot or flight test engineer issue, hand carried to varied aircraft for sorties. Connection to an airframe must be kept to an absolute minimum. Early tests may use MIL-1553 data, but the desire to be free from aircraft modifications will drive toward sensor packages as part of the new system. Later versions will be capable of wireless sensor-reporting from remote airframe locations (wingtip, bomb rack, etc). Cockpit displays of data will allow knowledge of sensor drop outs, flight test technique (FTT) feedback, and sufficiency of data. Changing the balance between data quality and intelligent handling of data must directly decrease the operational cost of flight test without mitigating safety. The cockpit display will show data in formats ranging from raw data (strip charts) all the way to reduced, calibrated, and normalized graphs typically seen in final test reports. Graphs will be populated interactively as a pilot flies a flight profile and the software will advise on how to more efficiently fill in data voids.

Battery time must allow more than 90 minutes of operation, preferable up to 10 hours, and allow in-flight battery exchanges with no impact to other pilot duties. Software must accommodate sensors providing 6 axis acceleration, air data, control deflection, control forces, engine data, and other parameters. Open Source solutions are preferred if they offer competitive performance. Sample rates may exceed 1 Hz for performance testing, 80-100 Hz for flight handling qualities and 4 KHz for vibration and flutter testing. The user interface should include changeable modular objects such as those seen in airplane cockpits, plus engineering items such as strip charts, G-meters, rate gauges, annunciators, etc. These should be changeable manually or automatically for different FTTs. Recording and presenting data is a mandatory, but not sufficient, foundation. The heart of this SBIR is innovative and effective ways of developing the pilot/information interface to more efficiently get results that match traditional methods.

PHASE I: Research the feasibility of developing a design for software that includes, as a minimum, a concept definition, software architecture, subsystem modules for testing, and technical studies to bound the data needs of dynamically learning software. Report the effect data-quality has on expected test results, and any regimes of data sensitivity. Report on potential flight program savings using the proposed system to guide individual flight profiles, and other benefits to program participants (pilots, engineers, managers, and customers).

PHASE II: Develop a prototype system and demonstrate proper operation. Integrate the prototype onto a flight vehicle and demonstrate the numerical results and precisions compared to traditional systems. Highlight and document any disparities, with mitigating operational options. Report any disparities from Phase I reports.

DUAL USE COMMERCIALIZATION: This effort will provide military and commercial flight engineers with systems to reduce customer support cost. Both military and commercial test pilot and flight test engineer schools have an immediate need for this system. The product can be modified for use by commercial airplane manufactures to meet Federally mandated standards, supporting type certification of Unmanned Aerial Vehicles (UAV),

Experimental aircraft, Sport Class, Recreational Class, and other aircraft. Inexpensive options will be an enabling technology to increase flight safety by allowing analysis of airframes that have never been tested.

REFERENCES:

1. "Testing of Low Cost Aircraft Reporting System (LCARS) and Intelligent Collision Detection and Warning System (ICDWS) (Project Have Bubble)", USAF Test Pilot School, AFFTC-TIM-03-05, Maj J Schott, et al, December 2003.

2. “Preliminary Dynamic Soaring Research Using a Radio Control Glider”, James Parle, AIAA Paper 2004-132, 42nd AIAA Sciences Meeting & Exhibit, Univ So. Cal., Los Angeles, CA, Jan 5-8, 2004.

3. Data sensing packages, marketed toward autopilot use: http://www.o-navi.com/phoenix_ax.htm

KEYWORDS: Test Pilot Equipment, Flight Test Data Reduction, Personal Digital Assistant (PDA), Flight Test Engineer