AIR FORCE
SBIR 08.1 Proposal Submission Instructions

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

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

The Air Force Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. For general inquires or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (13 Nov through 09 Dec 07), contact the Topic Authors listed for each topic on the website. For information on obtaining answers to your technical questions during the formal solicitation period (10 Dec 07 through 09 Jan 08), go to **http://www.dodsbir.net/sitis/.**

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

PHASE I PROPOSAL SUBMISSION

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

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

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

Limitations on Length of Proposal

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

Phase I Proposal Format

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

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

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

Key Personnel

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

Phase I Work Plan Outline

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

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

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

Cost Proposal

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

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

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

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

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

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

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

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

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

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

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

PHASE I PROPOSAL SUBMISSION CHECKLIST

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

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

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

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

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST, 9 January 2008 deadline.** A hardcopy **will not** be accepted. Signatures are not required at proposal submission when submitting electronically. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

The Air Force recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and could slow down the system. **Do not wait until the last minute.** The Air Force will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of 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.

Article I.

Section 1.01 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..

Article II. 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.

Article III. On-Line Proposal Status and Debriefings

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

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

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

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

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

PHASE II PROPOSAL SUBMISSIONS

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

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

FAST TRACK

Detailed instructions on the Air Force Phase II program and notification of the opportunity to submit a FAST TRACK application will be forwarded with all AF Phase I selection E-Mail notifications. The Air Force encourages businesses to consider a FAST TRACK application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract.

NOTE:

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

For FAST TRACK applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offeror will not be considered for any Phase II award. FAST TRACK applicants may submit a Phase II proposal prior to receiving a formal invitation letter. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including FAST TRACK applicants.

Article IV. AIR FORCE PHASE II ENHANCEMENT PROGRAM

On active Phase II awards, the Air Force will select a limited number of Phase II awardees for the Enhancement Program to address new unforeseen technology barriers that were discovered during the Phase II work. The selected enhancements will extend the existing Phase II contract award for up to one year and the Air Force will match dollar-for-dollar up to $500,000 of non-SBIR government matching funds. Contact the local awarding organization SBIR Manager for more information. (See Air Force SBIR Organization Listing) . If selected for a Phase II enhancement, the company must submit a Phase II Enhancement application through the DoD Submission Website at www.dodsbir.net/submission.

Article V. 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.

Section 5.01 PHASE I SUMMARY REPORTS

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

Article VI. AIR FORCE SUBMISSION OF FINAL REPORTS

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

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SPECIAL INSTRUCTIONS
For Topics AF081C-016, AF081C-042, and AF081C-043

These special instructions apply only to topic AF081C-016 and are in addition to the regular instructions listed at the beginning of the Air Force section of the solicitation.

The Air Force plans on awarding multiple Phase I contracts on this topic. Each Phase I contract will be limited to $100K. We anticipate that these phase I contract awards will be normal 9 month efforts with six months planned for the technical effort and an additional three months allowed for reporting.

The Air Force plans on awarding one Phase II contract worth up to $3+M. Phase II proposals will be by invitation only. At that time, special instructions will be provided for the Phase II proposals. Examples of the additional information needed in the Phase II proposal invitation package include the following: a business plan, a transition plan addressing the specific requirements of the platform for success implementation, and implementation plan. All these plans will document the offeror's ability to address all aspects necessary to ensure implementation of the innovative approach to produce and deliver reduced cost, high performance active noise reduction earplugs upon completion of the Phase II award.

The following additional evaluation criteria will be utilized in conjunction with the criteria set forth in Section 4.3 of the solicitation in determining the Phase II award:

a. The ability of the offeror to identify and address the critical high cost/ long cycle time processes from their specific materials processing and fabrication detailed value stream analysis. The offeror must identify innovative technical approaches to address the critical processes, and the associated return-on-investment (ROI) of those approaches assuming successful implementation.

b. The business plan will be reviewed and a sensitivity analysis will be performed on their business plan based on various levels of implementation.

c. The transition plan will be reviewed for completeness in addressing the specific requirements of the platform for successful implementation.

d. The implementation plan will be reviewed for assessment of risk and the business case for insuring cost and throughput competitiveness.

We anticipate that the phase II effort will be a traditional two years technical effort with an additional three months allowed for reporting.

These special instructions apply only to topics AF081C-042, and AF081C-043 and are in addition to the regular instructions listed at the beginning of the Air Force section of the solicitation.

The Air Force plans on awarding multiple Phase I contracts for these topics. Each Phase I effort will be limited to $100K. We anticipate that these phase I efforts will be accelerated to less than our traditional nine months with four months planned for the technical effort and an additional two months allowed for reporting (total: 6 months).

The Air Force plans on awarding one Phase II contract worth up to $3+M. Phase II proposals will be by invitation only. At that time, special instruction will be provided for the Phase II proposals. Examples of the additional information needed in the Phase II proposal package include the following: critical high cost/ long cycle time processes from their specific manufacturing detailed value stream analysis (VSA), innovative technical approaches to address the critical processes and associated return on investment (ROI). Also, it is expected that the Phase II proposal will include both a business plan and a transition plan. These plans will document the offerors ability to address all aspects necessary to ensure implementation of the innovative approach to manufacture upon completion of the Phase II award.

We anticipate that the phase II effort will be a traditional two years technical effort with an additional three months allowed for reporting.

AirForce SBIR 08.1 Topic Index

AF081-064	Health Management Tools for Rocket Engine Turbomachinery
AF081-065	Multi-Mode Propulsion for Orbit Transfer, Maneuvering, Station Keeping and Attitude Control
AF081-066	Highly Reliable, Reusable, Non-Toxic Rocket Engine Ignition Systems
AF081-067	Experimental Characterization of Particle Dynamics Within Solid Rocket Motors
AF081-068	Combined GPS & Comm Antenna Technology
AF081-069	Improvements to Sense and Avoid (SAA) Systems for Unmanned Aircraft Systems (UAS)
AF081-070	Automated Pixel Geo-Registration for Precise Imaging
AF081-071	Hyperspectral Persistent Surveillance Exploitation Algorithms
AF081-074	Electronic Bumper for Rotorcraft Brownout Approach and Landing
AF081-077	Innovative Micro Air Vehicles & Control Techniques for Urban Environments
AF081-078	Airborne Palliative for Helicopter Brownout Dust Abatement
AF081-079	Algorithm to Emulate RF Signal of Multiple Targets for Countermeasures Technique Assessment
AF081-082	Fiber-optic RF Distribution (FORD)&digital control signals network across a PCB in GPS User Eqpt
AF081-085	Two-Beam Transmit Satellite Antenna for Limited Field-of-View (FOV)
AF081-086	Distributed Control Actuator Aeroservoelasticity Methodology
AF081-087	Due Regard Technology for Unmanned Aerial Systems
AF081-088	Verification of Cold Working and Interference Levels at Fastener Holes
AF081-089	Design/Life Prediction Tools for Aircraft Structural Components with Engineered Residual Stresses
AF081-090	Distributed Satellite Resource Management for Defensive Counterspace
AF081-091	Optical Transmitter for Inter-satellite Communications
AF081-092	Lightweight Solar Array Structure for Thin Multijunction Solar Cells
AF081-093	Agile IR Filters
AF081-094	Novel Mitigation Techniques for Reconfigurable Computers for Space Based Applications
AF081-095	Advanced Cryogenic Refrigeration Technologies
AF081-096	Modeling, Simulation and Analysis Tools for Collaborative Systems
AF081-097	Secure Active Global Radio Frequency Identification (RFID) System.
AF081-100	Real-Time, Remote Electronics Test Capability
AF081-101	Development of Cad Plating Replacement with Alkaline Zinc-Nickel Electroplating for Threaded Fasteners/Components
AF081C-016	Affordable High-Performance Hearing Protection/Communication System
AF081C-042	Mold-in-Place Coatings
AF081C-043	Direct Part Manufacturing (DPM) for Nonstructural Components

AF081-001 TITLE: 3D Magnetic Field Modeling

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop greatly increased ability to model 3D magnetic fields by addressing the wave effects of Maxwell's equations.

DESCRIPTION: Develop ability to model 3D magnetic fields in a way that addressers the wave effects in Maxwell's equations. Almost all high-current pulsed power application systems are three-dimensional. While several well-benchmarked magnetohydrodynamics (MHD) codes, such as Mach2, exist for two-dimensional problems, three-dimensional capability is still sorely lacking. For example, Mach3 is still in its early stages of actual use, as opposed to initial development. One of the biggest problems with these codes is the magnetic field solver in three dimensions. The finite-difference, finite-volume, or finite-element approaches typically treat problems as quasi-stationary, that is, they ignore wave effects in Maxwell's equations because the time scales for propagation of electromagnetic waves over typical device distances are much shorter than the MHD time scales. Therefore, nonlinear diffusion equations apply, and they are solved. In vacuum, there is no physical conduction, and dielectric media are generally approximated by using a very high, but artificial, magnetic diffusion coefficient for them, so that the same equations are solved everywhere. This approach is intractable for most real problems, where the physical domain of the problem (that necessarily extends out to boundaries where the fields become negligible) is very much larger than typical diffusion scale lengths (skin depths), which must be accurately resolved. This problem is also referred to in the computational physics community as solving the vacuum field problem in a more computationally tractable way. This more tractable way could include massively parallel processing approaches, but should not simply use the brute force approach of very small time steps. Defense uses of this technology include simulation and virtual prototyping of very high current devices, such as intense radiation sources. This could be used, for example, for extending the detection range for explosives and other materials of concern, prompt sterilization of biological agents, and testing effects on electronics and materials. This could also be used to advance the technology and compactness of charged particle beam or hypervelocity projectile devices.

PHASE I: Requires innovative R&D of modeling 3D magnetic fields in a way that addresses wave effects of Maxwell's equations. Solutions to test problems with other topologies should be calculated and compared with their known analytic solutions to fully demonstrate the validity of the proposed approach.

PHASE II: Extend to complex geometries, integrate with 3D-MHD code like Mach3 and implement major part, e.g., make automated mesh generator for convenient problem setup. Examples: baffled vacuum current feeds, varying thickness or shaped high current armatures (imploding liners, converging/diverging electrode gaps for propagating current discharges or magnetic pressure driven solid or plasma armatures).

PHASE III / DUAL USE: Military application: Military uses of this technology include simulation and virtual prototyping of very high current devices, such as intense radiation sources. Commercial application: More efficient and increased radiation sources, seismic probes, lightning simulators for Homeland Defense, law enforcement, public safety, oil prospecting, and counter mine systems.

REFERENCES:
1. H.Knoepfel, ""Pulsed High Magnetic Fields,"" North Holland Publishing Co, Amsterdam, London, p.87 (1970).

2. H. Knoepfel, Magnetic Fields: A Comprehensive Theoretical Treatise for Practical Use, John Wiley and Sons, Inc, NY, 2000.

3. R.E.Peterkin,Jr, M.H.Frese, and C.R.Sovinec, "Transport of magnetic flux in an arbitrary co-ordinate ALE code," J.Comp.Phys. 140, 148 (1998).

4. Megagauss Conference Proceedings (every several years since 1980).

5. IEEE Pulsed Power Conference Proceedings (every odd year since 1970's; e.g., 2007, 2005, 2003, etc, easy to find at www.ieee.org).

KEYWORDS: 3D modeling, magnetic fields, wave effects, Maxwell's equations, 3D-MHD, magnetohydrodynamics; vacuum field problem, field diffusion

AF081-003 TITLE: Innovative Research for Crashworthy Stowable Troop Seating for Helicopters

TECHNOLOGY AREAS: Air Platform, Biomedical, Human Systems

OBJECTIVE: Develop innovative technology concepts for a crashworthy, lightweight, and rapidly stowable/removable helicopter troop seat with crash protection equivalent to the flight crew.

DESCRIPTION: Large Special Operations or Search & Rescue Helicopters are required to perform a variety of missions. The seats used to carry troops in these aircraft provide limited protection to the occupants as they do not adequately attenuate the energy during a crash pulse or restrain the crewmember during impact and roll-over events. Current cabin seating systems are installed prior to flight with little modification possible during the flight due to changing mission needs. The seats themselves do not provide a clear path for crewmember movement during flight. Crashworthy, light-weight, and movable/stowable seating is required that allows safe transportation for troops, rapid egress/ingress, and stowing of the seats as necessary to allow for changing mission needs. Such mission needs include the addition of litter patients and payload insertion/extraction. The seating system shall safely secure the full anthropological range of the troop population, with or without full combat gear (body armor, life vest, helmet, 90-lb back pack, etc), but allow the crewmembers quick transition to a standing position for ingress/egress and secure stowage/removal of the seat to an unobtrusive area. The seating system should provide adequate troop protection and restraint during a crash pulse at least equivalent to the flight crew seats. To achieve acceptable troop seating performance levels for the varied missions, the solution should address crew anthropometry, ergonomics, restraint systems, equipment design, workload, human-seating interface issues, Human Systems Integration (HSI) and crash protection strategies.

This topic differs from AFI081-005, " Mobile Aircrew Crashworthy Seating Systems for Helicopters" in it focuses solely on the troop seating systems. Troops need to be able to quickly get into their seats, strap in, stay there until they reach their destination, and then be able to quickly leave their seats and egress the aircraft, whereas mobile crewmembers need to be just that – mobile, in order to perform their duties. Troop seats must not block doors and only need to be moved/repositioned during mission changeovers such as going from troop transport to cargo transport, whereas the mobile crewmember work areas are in the aircraft door areas, which means that the seats need to be able to be easily and quickly moved out of the way for ingress/egress, hoist operations, aerial troop deployments, etc., Troop seating may be able to accommodate many using a single system, whereas the mobile crew seat needs to accommodate one individual at each position. Mobile crewmembers also have a set of life support equipment that is completely different from the troops that typically carry large and heavy backpacks, so troop seats need to be "deeper" to accommodate the backpacks and have a greater weight capacity than the mobile crew seats.

The Human Effectiveness Directorate of the Air Force Research Laboratory and Air Combat Command anticipates hosting an Open House Workshop during the last week in November or first week of December 2007 at Langley AFB and Ft. Eustis, VA that will provide additional information and address issues related to this SBIR topic. This Open House Workshop is open to prospective bidders on this topic, but the attendees must be US Citizens or permanent residents. The briefing information will also be available to prospective bidders who are not able to attend the Workshop. For additional information, please check for updates on the SBIR website or contact the topic author.

PHASE I: Develop innovative technology concepts for a crashworthy, lightweight, and rapidly stowable/removable troop seat that provides maximum protection to transported troops in full gear by attenuating the energy during a crash pulse and adequately restraining the crewmember during impact and roll-over events. Propose specific seat designs based on technology concepts.

PHASE II: Validate the solution(s) identified in Phase I to include modeling, testing, prototypes, and initial operational assessment to assure aircrew equipment/aircraft compatibility. Demonstrate the crashworthy aspects of the design. Finalize the design of a prototype device, and identify necessary aircraft structural requirements and potential modifications to accommodate the prototype.

PHASE III DUAL USE COMMERCIALIZATION: Military: Can be used in troop transport aircraft to provide crashworthy seating.
Civilian: Can be used in civilian rescue aircraft and for ground vehicles for firefighters and other rescuer transport vehicles. Troop seats are also used for civilians during mass evacuations in support of national disasters such as hurricanes.

REFERENCES:
1. JSSG-2010-7, DEPARTMENT OF DEFENSE JOINT SERVICE SPECIFICATION GUIDE: CREW SYSTEMS CRASH PROTECTION HANDBOOK, 30 October 1998.

2. ENGINEERING ANALYSIS OF CRASH INJURY IN ARMY CH-47 AIRCRAFT, USAAAVS Technical Report TR 78-4, Directorate for Investigation, Research & Analysis U.S. Army Agency for Aviation Safety, Fort Rucker, Alabama 36362, June 1978.

3. Hudson, Jeffrey A., Gregory F. Zehner, Kathleen M. Robinette. JSF CAESAR: Construction of a 3-D Anthropometric Sample for Design and Sizing of Joint Strike Fighter Pilot Clothing and Protective Equipment. AFRL-HE-WP-TR-2003-0142, 2003.

4. Life Cycle Systems Engineering, Air Force Instruction 63-1201, Secretary of the Air Force, 23 July 2007.

KEYWORDS: Helicopter seating, energy absorbing, troop seat, crash protection, impact protection

AF081-005 TITLE: <u>Mobile Aircrew Crashworthy Seating Systems for Helicopters</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop innovative technologies that can be incorporated into a lightweight, crashworthy, and movable helicopter seating system for aircrew that require mobility during flight to perform their duties.

DESCRIPTION: Helicopter mobile aircrew members (e.g. gunners, flight engineers, load masters) located in the aircraft cabin need mobility to give flexibility to perform their mission duties while still being provided with adequate protection in the event of a severe maneuver, crash, or other impact event. These duties often involve reaching outside the aircraft while providing ground suppression fire using a .50 caliber or minigun, scanning for survivors, operating a rescue hoist, providing medical care, or conducting airdrop operations. Current crew cabin seating systems are either non-existent or installed for the entire mission prior to flight, and provide very limited impact/crash protection. Since these systems cannot easily be moved or removed during flight or they limit crewmember full range of motion which hinders them with their duties during troop transport and cargo loading/unloading. Many crew stations currently do not have any type of seating system which results in limited or no impact protection..

A crashworthy, light-weight, and movable/stowable seating prototype is required that allows the cabin crewmembers the freedom to perform the majority of his airborne tasks from the seat but also allows for easy and rapid repositioning or stowing of the seat to accommodate cargo/troop ingress/egress, hoist operations, etc. The prototype will also allow the crewmember quick transition to a standing position. The seating system should provide adequate crew protection and restraint during a crash pulse at least equivalent to the flight crew seats. The seating system also needs to accommodate the entire aircrew population while wearing all the necessary crew equipment (body armor, life vest, helmet, etc). To achieve acceptable seating system performance levels for the varied duties, the solution should address crew anthropometry, ergonomics, restraint systems, equipment design, workload, human-seating interface issues, Human Systems Integration (HSI) and crash protection strategies.

This topic differs from AF081-003, "Innovative Research for Crashworthy Stowable Troop Seating for Helicopters" in it focuses solely on the mobile aircrew seating systems. Mobile crewmembers need to be just that – mobile, in order to perform their current duties (frequently and rapidly be able to get in and out of the seats), whereas troops need to be able to quickly get into their seats, strap in, and stay there until they reach their destination, and then be able to quickly leave their seats and egress the aircraft. The mobile crewmember work areas are right in the aircraft door areas, which means that the seats need to be able to be easily and quickly moved out of the way for ingress/egress, hoist operations, aerial troop deployments, etc., whereas the troop seats are not blocking doors and only need to be moved/repositioned during mission changeovers such as going from troop transport to cargo transport. The mobile crew seat needs to accommodate one individual at each position whereas troop seating may be able to accommodate many using a single system. Mobile crewmembers have a set of life support equipment that is completely different from the troops that typically carry large and heavy backpacks, so troop seats need to be "deeper" to accommodate the backpacks and have a greater weight capacity than the mobile crew seats.

The Human Effectiveness Directorate of the Air Force Research Laboratory and Air Combat Command anticipates hosting an Open House Workshop during the least week in November or first week of December 2007 at Langley AFB and Ft. Eustis, VA that will provide additional information and address issues related to this SBIR topic. This Open House Workshop is open to prospective bidders on this topic, but the attendees must be US Citizens or permanent residents. The briefing information will also be available to prospective bidders who are not able to attend the Workshop. For additional information, please check for updates on the SBIR website or contact the topic author.

PHASE I: Develop lightweight and mobile seating system concepts to provide maximum protection to the aircrew by attenuating crash energy by adequately restraining the crewmembers, yet provide adequate mobility to allow crewmembers to perform a majority of their airborne duties from the seated position.

PHASE II: Validate the solution(s) identified in Phase I to include modeling, testing, prototypes, and initial operational assessment to assure aircrew equipment/aircraft compatibility. Demonstrate the crashworthy aspects of the system. Identify aircraft structural requirements and potential modifications necessary to accommodate the system.

PHASE III DUAL USE COMMERCIALIZATION: Military: Use in fixed wing aircraft such as AC-130 where crew need mobility. Possible use in ground vehicles such as Humvees which can provide protection against accelerations from IEDs and crashes.

Commercial: Use in civilian rescue, law enforcement, life-flight, fire-fighting, and aerial cinematography aircraft. Seating systems for medical personnel in ambulances.

REFERENCES:
1. JSSG-2010-7, DEPARTMENT OF DEFENSE JOINT SERVICE SPECIFICATION GUIDE: CREW SYSTEMS CRASH PROTECTION HANDBOOK, 30 October 1998.
http://products.ihserc.com/Specs3j/controller?event=VIEW_DOC&prod=SPECS3&sess=277295949&linkSource=SEARCH&docId=LPRIIAAAAAAAAAAA

2. HH-47 Combat Search and Rescue (CSAR-X), GlobalSecurity.com,
http://www.globalsecurity.org/military/systems/aircraft/hh-47.htm

3. ENGINEERING ANALYSIS OF CRASH INJURY IN ARMY CH-47 AIRCRAFT, USAAAVS Technical Report TR 78-4, Directorate for Investigation, Research & Analysis U.S. Army Agency for Aviation Safety, Fort Rucker, Alabama 36362, June 1978.

4. Hudson, Jeffrey A., Gregory F. Zehner, Kathleen M. Robinette. JSF CAESAR: Construction of a 3-D Anthropometric Sample for Design and Sizing of Joint Strike Fighter Pilot Clothing and Protective Equipment. AFRL-HE-WP-TR-2003-0142, 2003.

5. Life Cycle Systems Engineering, Air Force Instruction 63-1201, Secretary of the Air Force, 23 July 2007.

KEYWORDS: Helicopter seating, energy absorbing, troop seat, crash protection, impact protection

AF081-006 TITLE: Advanced Fabric Technology Materials for Future Aircrew Life Support Equipment

TECHNOLOGY AREAS: Materials/Processes, Human Systems

OBJECTIVE: Develop advanced fabric technology materials for the Integrated Aircrew Ensemble (IAE).

DESCRIPTION: Legacy aircrew life support equipment (ALSE) uses older material technology that is often uncomfortable and distracting to aircrews. Current constant-wear anti-exposure suits are often unbearably hot while on the ground. Even standard ALSE configurations are unbearably hot. In addition, ALSE configurations are often bulky. The Air Force desires new fabric technology that prevents heat build-up, protects against cold weather, and provides water immersion protection while affording equal or better protection as legacy ALSE. Maintaining aircrew comfort is key in developing new materials. In addition, these fabric technology materials should improve durability while decreasing bulk.The emergence of new threats, expansion of operating environments and sortie duration, and the requirement to accommodate a broader user population has widened the gap between available flight equipment and needed capability. The current multilayered ensemble consists of poorly-integrated subcomponents which impair aircrew capability and performance, and are based on dated technologies and materials that are increasingly difficult to support. As a result, user surveys indicate that aircrews do not use their mandatory equipment in many instances because of real or perceived deficiencies with regard to bulk, thermal burden, and other distractions.

In June 07, the Joint Program Executive Office for Chemical Biological Defense and Joint Program Manager for Individual Protection agreed to revise the chemical warfare protection requirement for IAE downward from previous cold war levels to a more realistic standard consistent with the updated USAF Chemical Warfare Continental US Operations (CONOPS). This development will enable the IAE program to provide aircrew a thinner, less burdensome chemical warfare solution. Fabric analysis is required to determine if an exposure suit or flight suit (with lightweight liner) could provide the required protection. A positive result will significantly increase aircrew performance/endurance during flight operations and eliminate the cost and manpower burden of maintaining stand alone chemical-warfare ensembles.

A key limiting factor of the current flight ensemble is the weight/bulk of the antiquated torso harness required for fighter aircraft. The harness's fabric components and hardware date back to the Vietnam War, and program office engineers cannot validate the source or operational relevance of its stringent performance specifications. Meanwhile, commercial parachutists employ systems that weigh significantly less.

The current exposure suit is bulky, difficult to don/doff, reduces mobility, and causes significant thermal burden. The suit also has a history of requiring extensive repairs and developing pinholes that allow water to enter the suit. The neck and wrist seals are uncomfortable, easily damaged, and cause chaffing. In addition, aircrew wearers have limited capability for bladder relief when wearing the suit. The IAE requires a tailorable, scalable, cold-water immersion solution to enable the aircrew, with gloved hands, to survive exposure for up to 6 hours in water temperatures between 60 °F and 32 °F (Ref 4). The IAE material will enable the aircrew to safely withstand ejection at up to 600 Knots Equivalent Air Speed (KEAS). (Ref 4) The IAE material will provide heat and flame protection equal to the equipment it replaces; the materials will neither melt nor drip when exposed to heat and flame (Ref 4).The IAE material will be field modifiable to provide ballistic protection (Ref 4). The performing contractor will be encouraged to generate creative, innovative approaches to discover a novel fabric solution capable of achieving the qualified improvements in the technical parameters of interest.

PHASE I: The offerer will investigate one or more materials that are capable of meeting the above requirements. Those materials shall undergo testing and demonstrate improvement over those in use today. The offerer should choose the most promising to carry forward for further testing and fabrication.

PHASE II: Implement the Phase II Test Plan submitted at the end of Phase I. Fabricate a prototype IAE using the materials to be tested. Perform testing to reveal how well materails under test meet the objectively quantified technical parameters of interest. Deliver test results to the government along with the prototype IAE for further testing by the USAF.

PHASE III / DUAL USE: Military application: Air Force use will be for the Integrated Aircrew Ensemble. Commercial application: Dual use applications include commercial fabric technology for fabrics that provide cold weather protection while preventing heat build-up.

REFERENCES:
1. MIL-C-83429B Cloth, Plain, and Basket Weave, Aramid

2. Industry Day IAE Briefing, 10 Jan 07 San Antonio, albert.burnett@brooks.af.mil, 648 AESS/TAM

3. Integrated Aircrew Ensemble Initial Capabilities Document (18 May 06), randolph.loving@langley.af.mil, ACC/A8SR

4. Capability Development Document for the Integrated Aircrew Ensemble, 26 Jun 07, ACC/A8SR, Langley AFB VA, request document thru randolph.loving@langley.af.mil

KEYWORDS: aircrew,life support equipment,cold weather gear

AF081-007 TITLE: Solid State Night Vision Sensor

TECHNOLOGY AREAS: Sensors, Human Systems

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

OBJECTIVE: Develop a compact and high performance sensor that will replace the image intensifier tube in night vision goggles.

DESCRIPTION: To support night combat missions throughout the world and meet the requirements for warfighter readiness and mission performance a new generation of headmounted digital night-vision technology is envisioned. The critical, limiting factor of this technology is the sensor. Current sensor technology for head-mounted systems cannot provide the same performance, particularly at the lowest light levels, as compared to the latest image intensification technology. A high performance sensor could be integrated into a head-mounted night-vision optical system to truly provide a digital capability.

The limitations of the present analog approach (i.e. image-intensifier-based night-vision goggles) are the: size and weight, cost of the image intensifier tube, lack of processing capability, limited image transmission capability for sharing the visual image, limited imagery/symbology insertion capability, limited ways to obtain a polychromatic display, and limited spectrum.

Specific requirements for this effort are: light sensitivity, noise resolution (sensor element size), format size, total number of sensor elements, size, weight, power consumption, and cost shall be equivalent to or better than the current generation of image intensifier tube. Additionally, this effort requires potential for a standardized format signal output to feed a miniature display.

Desired spectral sensitivity range should be visible, near infrared, and short wave infrared (up to about 2 microns)

PHASE I: This phase shall require the vendor to design and demonstrate the technical feasibility of an innovative approach to sensor technology that will improve the image quality while reducing the size and overall power requirements of the NVGs.

PHASE II: Four prototypes of the optimized design shall be fabricated and delivered for incorporation into a yet-to-be determined head-mounted digital night-vision system for both laboratory testing and field demonstrations.

PHASE III / DUAL USE: Military application: Pilots, loadmasters, special operations ground personnel, base security Commercial application: Law enforcement, border patrol, fire-fighting, security, and crop dusting. Under certain conditions, the commercial pilots may also benefit from the implementation of such technology.

REFERENCES:

1. Craig, J.L. (2000). Integrated panoramic night vision goggle. Proceedings of the 38th Annual Symposium SAFE Association, http:www.safeassociation.com

2. Task, H.L. (2000). Integrated panoramic night vision goggles fixed-focus eyepieces: selecting a diopter setting. Proceedings of the 38th SAFE Association, http://www.safeassociation.com

3. J.W. Landry and N.B. Stetson (1997). Infrared imaging systems: Design, analysis, modeling, and testing VIII; Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 3063), Orlando, FL, APR. 23-24, 1997, (A97-34579 09-35), p. 257-268.

4. B.P. Butler and N.M. Allen (1997). Long-Duration Exposure Criteria for Head-Supported Mass; Army Aeromedical Research Lab., Fort Rucker, AL. (AD-A329484)

5. D. Kent and J. Jewell (1995). Lightweight helmet mounted night vision and FLIR imagery display systems. Helmet- and head-mounted displays and symbology design requirements II; Bellingham, WA, Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 2465), Orlando, FL, Apr 18-19, 1995, (A95-33965 08-54), p. 68-80.

KEYWORDS: night vision, image intensification, solid state sensor, miniature camera, CCD, CMOS, flat panel display

AF081-008 TITLE: Optical Limiters Without Focal Planes

TECHNOLOGY AREAS: Sensors, Human Systems

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

OBJECTIVE: To develop an optical limiter without a focusing lens that provides sufficient attenuation to prevent eye damage at incident radiation levels that would otherwise cause retinal injury.

DESCRIPTION: Laser eye protection (LEP) for military applications incorporates cutting edge technologies (reflective coatings and advanced absorbing dyes) to protect against lasers at wavelengths in the near-infrared (NIR) and visible portions of the electromagnetic spectrum. However, these technologies produce filters that always block the light for which they are designed whether under laser illumination or not. When these filters block visible light they have a negative impact on combat performance; this even happens with some filters intended only for NIR protection. These negative effects increase proportionally with the number of visible wavelengths blocked until the filter becomes opaque. Active filters, i.e. those blocking light only when illuminated with a laser, are a conceptual solution to this problem, however they currently do not respond fast enough to protect against pulsed laser systems (nsec time domain). Pulsed emissions can be created at numerous wavelengths, and the high peak power in very short pulses can cause retinal injury at average energy outputs that would not be injurious for a continuous wave emitter. A promising technology currently under development for protecting against pulsed lasers is optical limiters (OL). These materials absorb or scatter laser illumination in a nonlinear manner. At lower incident energy they let the light pass through but once the incident energy reaches a threshold, the amount of radiation blocked by these materials increases by an amount greater than subsequent increases in incident energy. For example, once the threshold energy is reached an OL may show a four-fold increase in protection in response to a doubling of incident energy. The very rapid response time with no need for a sensing and control system make optical limiters an attractive technology option for LEP. The problem with current OL technology for LEP is that the threshold for nonlinear behavior is much higher than the threshold for retinal injury. Because of this, current OL materials require a lens system to collect and focus the incident energy on the OL in order to create a nonlinear behavior at incident energies relevant to retinal protection. This requirement translates into heavy and bulky LEP devices. From a human factors standpoint, an OL that doesn't require a focal plane would result in LEP that is significantly smaller and lighter than current OL allow. The goal of this topic is to develop a lightweight, low profile optical limiter that provides an optical density (OD) >=4 at incident radiation levels sufficient to cause retinal injury and doesn't require focusing lenses. The response region of interest is 400 nm to 1400 nm and it must provide at least 15 percent ground state luminous transmittance in the visible spectrum. Innovative and creative approaches are highly encouraged in meeting these outlined objectives. Since this concept has never been attempted before, there is a degree of technical risk which the proposal submitters must be aware of and willing to accept.

PHASE I: Perform a technology feasibility assessment. Deliver a concept design for the OL prototype and data to support the feasibility assessment in a technical report. A market analysis for potential civilian applications as part of the Phase I technical report is encouraged.

PHASE II: Execute the technology development plan described in a Phase II proposal. Fabricate, demonstrate and deliver a prototype of the proposed solution in addition to validating, measured performance data in a final technical report. The Phase II deliverable is not expected to be production ready but some discussion of remaining development work required to achieve that end is encouraged.

PHASE III / DUAL USE: Military application: The Air Force, Army, and Navy all have operational requirements for LEP for combat personnel. The Air Force requirements are not releasable to the general public. Commercial application: Potentially any field that employs lasers/laser eye protection (e.g. medical laser surgery, dental laser surgery, laser operators, lab technicians, welding, manufacturing, and laser researchers).

REFERENCES:
1. Sheehy, James B. and Morway, Phyllis E. “Laser-protective technologies and their impact on low-light level visual performance.” in Laser-Inflicted Eye Injuries: Epidemiology, Prevention, and Treatment, SPIE Proceedings Vol. 2674, pp 208-218, (1996).

2. Aircrew visor performance specification, MIL-V-43511C. Google ""MIL-V-43511C Specification.""

3. ANSI Standard Z136.1. American National Standard for the Safe Use of Lasers. American National Standards Institute, Inc., (2000).

4. K. Mansour, M. J. Soileau, and E. W. Van Stryland, ""Nonlinear optical properties of carbon-black suspensions (ink),"" J. Opt. Soc. Am. B 9, 1100- (1992).

5. D. Vincent, S. Petit, and S. L. Chin, ""Optical Limiting Studies in a Carbon-Black Suspension for Subnanosecond and Subpicosecond Laser Pulses ,"" Appl. Opt. 41, 2944-2946 (2002).

KEYWORDS: Laser eye protection (LEP), optical limiter, luminous transmittance, optical density, near-infrared radiation, visible radiation, retinal injury

AF081-009 TITLE: Low-Power Direct-View Flexible Displays

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop non-glass, ejection-safe digital display to replace printed paper maps and checklists on pilots’ knees in tactical cockpits and enable a large display to be rolled up for stowage.

DESCRIPTION: Displays are an important part of the warfighter-to-global information grid (GIG) interface and have a major impact on the situational awareness of pilots, crews, and ground-based operators. There are situations where portable and wearable displays are needed that are flexible (i.e. conformable or rollable), exhibit resistance to breakage, and have low space-weight-and-power (SWaP) while simultaneously meeting performance requirements such as environmental, sunlight-readability, and night vision compatibility. Currently fielded displays tend to break because they are fabricated on glass and do not have low-enough SWaP for applications in which the display must be worn or carried. Flexible displays have an electronic backplane fabricated on plastic or steel foil that drives an electro-optical frontplane based on any of several technologies, each of which has limitations. These frontplane technologies and their limitations include electronic inks (problem: lack of color and video operation), cholesteric liquid crystals (problem: low frame rate and color saturation), and organic light emitting diodes (problem: low lifetime and lack of efficient blue emitter). The backplanes comprise thin-film transistor (TFT) pixel drive circuitry (~ 10-μm thick) that is difficult to fabricate on plastic or metal foil and may be easily broken or degraded by flexing. The intent of this Flexible Displays SBIR topic is to provide the warfighter wearable direct-view information capability with a 3-4 in. diagonal image size for wrist worn usage, a 7-8 in. size for knee-top, and 8-10 in. for hand-held, with the larger sizes being rollable for stowage in small form factor.
Threshold (minimum) performance features to achieve these uses are as follows: conformable (4-in. radius of curvature) 3-4 in. diagonal black-white image size having spatial, grayscale, and temporal resolution of 320x240 pixels/image, 4-bits/pixel, and 2 Hz frame rate. The objective (goal) performance features are: repetitive (10,000 times) rollability (1-in. radius of curvature), 7-10 in. diagonal full-color image size having resolution of 1024x768 pixels/image, 24-bits/pixel, and 30 Hz video frame rate.

The currently fielded displays are built on glass substrates. The glass makes the displays rigid & easily breakable, has a large size and weight. This research will address these problems and will result in a display that can be used for many applications that require flexibility.

Non-glass display technology has not been developed for cockpit man-machine interfaces. To use it for knee-top mounted display will provide a human system perspective.

This topic is soliciting science & technology (S&T) proposals to develop flexible display technology (current TRL = 3) for cockpit and other aerospace applications (threshold TRL = 6: objective TRL = 7). The project involves a degree of technical risk and is not intended for procurement.

PHASE I: Develop an innovative approach to flexible displays and demonstrate its technical feasibility. The intended application of such a flexible display is for knee-top mounted or hand-held usage.

PHASE II: Fabricate, demonstrate, and deliver four flexible display breadboard subsystems at Technology Readiness Level (TRL) 5, as defined in the DoD Defense Acquisition Handbook. TRL 5 requires that all basic technological components be integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment

PHASE III / DUAL USE: Military application: Pilots, cockpits, command center, flight line maintenance, Special Forces, electronic map.
Use DoD Technology Readiness Level (TRL) 6 corresponding to system/subsystem demonstration. Commercial application: An electronic flight bag for commercial aviation pilots that provides a large display when needed but that rolls up for stowage when not.

Laptop computers & portable devices with displays.

REFERENCES:
1. Seung-Han Paek, et al., "10.1 inch SVGA Ultra Thin and Flexible Active Matrix Electrophoretic Display," SID 2006 Intl Symposium Digest of Technical Papers, Volume XXXVII, paper 62.3, pp. 1834-1837 (2006).

2. Dong Un Jin, et al., "5.6-inch Flexible Full Color Top Emission AMOLED Display on Stainless Steel Foil," SID 2006 Intl Symposium Digest of Technical Papers, Volume XXXVII, paper 64.1, pp. 1855-1857 (2006).

3.“Technology Maturity and Technology Readiness Assessments,” DoD Defense Acquisition Guidebook, DoDD 5000.1, DoDI 5000.2, Table 10.5.2.1
https://akss.dau.mil/dag/DoD5000.asp?view=document&rf=GuideBook_c10.5.2.asp

4. K. R. Sarma, et al., “Active Matrix OLED Using 150 oC a-Si TFT Backplane Built on Flexible Plastic Substrate,” Proceedings of SPIE Vol. 5080, Cockpit Displays X,Edited by Darrel G. Hopper (SPIE, Bellingham WA, April 2003), paper 5080-24.

5. “Status and Opportunities of Electronic Paper Display,” Jacques Noels, SID Business Conference, (www.sid.org), 21 May 07.

KEYWORDS: flexible displays, light weight, low power, shatterproof, conformal, flat panel display

AF081-010 TITLE: High-Resolution Wide-Field Night Vision Goggle

TECHNOLOGY AREAS: Sensors, Human Systems

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

OBJECTIVE: To develop an enhanced wide field of view (FOV) night vision goggle (NVG) with improved image resolution enabling the pilot to carry out missions more effectively under a variety of operating conditions.

DESCRIPTION: While wide field of view NVGs enable pilots to carry out missions more effectively under a variety of operating conditions, they also have known performance and human factor design limitations. Among the limitations are NVG system resolution and head supported size/weight concerns. The Air Force’s current Panoramic Night-Vision Goggles (PNVGs) present a wide field of view (FOV) using smaller format image intensifier tubes. The PNVGs mount to a standard HGU-55/P Air Force helmet via a special “banana clip” connector. The use of four channels results in a panoramic view while still allowing the pilot to look down under their goggles at the instrument panel or up at their overhead panel without having to first refocus the NVG for near distance. Side viewing while wearing the PNVG allows pilots peripheral vision to pick up peripheral visual cues without having to turn their head. The PNVG is a Type I imaging system, which means the image of a scene is in the user’s direct line of sight. Type II systems are those where the intensified image of a scene is projected on a see through medium in the user’s line of sight.

Designing and assembling an innovative enhanced wide FOV NVG prototype with a magnitude improvement in resolution (a 20% higher resolution than currently fielded systems) is made even more technically challenging by the requirement to also minimize system weight. An enhanced wide FOV NVG must satisfy a number of challenging human systems interface issues as well as having a horizontal field of view of at least 80 degrees, lighter in weight than currently fielded NVGs and an extensive adjustment capability to precisely adjust the NVG for maximum viewing and comfort. Additionally, the enhanced wide FOV NVG must meet all human safety-of-flight criteria including maximum head borne weight, center-of-gravity, wind-blast, etc.

A helmet mounting connector to replace the current “banana clip” connector that is both lighter weight and rigid when induced to high accelerations/vibrations will also be designed and prototyped. The mounting connector will include a flip-up capability to move the NVG away from the pilots line of vision and a quick detach mechanism that enables the NVG to be detached from the helmet quickly using only one hand and shall permit one-handed (either hand with equal facility) operation of adjustments. The mounting connector will also be required to separate the NVG from the helmet during the catapult phase of emergency aircraft ejection to minimize injury to the pilot. Separation shall not occur during normal flight maneuvers.

All final designs should consider ease of maintenance by life support personnel.

PHASE I: A preliminary enhanced wide FOV NVG design will be completed. Also, a preliminary design of a new mounting connector is required.

PHASE II: This phase involves the design and prototyping of an enhanced wide FOV NVG and one mounting connector. The prototype will be completely self-contained (i.e. batteries on the helmet or mounting area) and attached to the standard Air Force HGU-55/P helmet. Prototype hardware will be sufficiently robust to undergo laboratory and field testing.

PHASE III / DUAL USE: Military application: Applications are primarily for the pilots of aircraft that currently fly with the standard 40-degree FOV NVGs. Special operations ground use is also anticipated. Commercial application: The applications of an enhanced wide FOV NVG are many and include such areas as surveillance and law enforcement. Additionally, homeland security applications also are relevant (border patrol, etc.).

REFERENCES:
1. Pinkus, A.R., Task, H.L., Dixon, S.A., Barbato, M.H., Hausmann, M.A., Twenty-Plus Years of Night Vision Technology: Publications And Patents From The Crew System Interface Division of the Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, AFRL-HE-WP-TR-2003-0048. http://www.hec.afrl.af.mil/Publications/night/index.html

2. MacMillan, R. T., Brown, R. W., Wiley, L. L., Safety-of-Flight Testing for Advanced Fighter Helmets, Helmet and Head-Mounted Displays and Symbology Design Requirements II, Proceedings SPIE 2465, pp 122 - 129 (1995).

KEYWORDS: night vision goggle, image-intensifier tube, solid-state imaging, electronic image intensifier tube, panoramic night-vision goggle, near-infrared, night vision device, miniature flat panel display, night operations

AF081-011 TITLE: <u>Head Mounting Device for Advanced Night Vision Goggle (NVG) Systems</u>

TECHNOLOGY AREAS: Sensors, Human Systems

OBJECTIVE: Develop a design concept for a lightweight, durable head mounting system to allow the use of Night Vision Goggles (NVG) without a bulky helmet. Demonstrate the technological feasibility of the concept with prototype devices.

DESCRIPTION: Current NVGs such as Aviator’s Night Vision Imaging System (ANVIS) and Panoramic Night Vision Goggle (PNVG) attach securely to a flight helmet's outer shell enabling aircrew to use them in flight. However, aircrew members flying air mobility and air refueling aircraft do not wear flyers’ helmets although they must be able to effectively use these devices during portions of their mission. Ground crews performing night operations such as Aeromedical Evacuation loading/unloading, aircraft refueling, basic maintenance, and weapons loading in forward areas may also require use of NVGs. In addition, warfighter's in terrain vehicles may also require the use of NVG's while operating the vehicle. While in operation, the NVGs must remain correctly positioned within a small tolerance with respect to the wearer’s eyes to optimize their function. This tolerance needs to be maintained while the crewmember is moving his head or is being exposed to turbulence, aircraft vibrations, ground vehicle vibrations, and environmental extremes such as high winds. This tolerance also needs to be maintained without compromising comfort and long term use.

There is a need for a robust concept that allow NVGs to be mounted on a crewmember's head and keep them in the proper position during operation, while being exposed to the accelerations, vibrations, and other environmental conditions onboard flying aircraft and during ground operations. The design concept and prototype should allow for proper optical alignment to maximize functionality. The design should include investigation on minimizing concentrated forces on the crew’s head and minimize fatigue on the crew's neck [1,2] due to weight and Center-of-Gravity (CG) location. This design concept prototype should minimize hotspots on the head, and provide a secured fit to ensure adequate NVG stability for 99 percent of the male and 99% of the female crewmembers as defined in the JSF CAESAR population [3] using the minimal number of device sizes, taking into account the variations in the crewmember head shapes [4]. This device must hold both the NVG and a battery pack (an alternate NVG power source). It must also be able to be compatible with the inter-plane communications system and must allow proper wear and operation of the MBU-19/P and other chemical-biological mask/hood assemblies [5].

PHASE I: The contractor will investigate one or more designs using the above guidelines, and present a preliminary analysis that demonstrates minimal force stressors on the head and minimal fatigue on the neck for a variety of crew head shapes and sizes.

PHASE II: Finalize a design, build one or more prototype devices, and conduct an evaluation on individuals covering a wide range of crew anthropometric variations to ascertain the proper fit and to identify any potential force concentrations on the head and any neck fatigue issues. Verify adequate stability of the NVG devices and fatigue due to CG balance on individuals in simulated work conditions.

PHASE III / DUAL USE: Military application: Air Force personnel will use for air mobility and air refueling aircraft during mission periods when NVGs are required. Ground support personnel will use when dark operations are required. Commercial application: Dual use applications for this technology are for law enforcement, search and rescue operations, hunting, wildlife observation, surveillance, security, navigation, hidden-object detection, and exploration of caves.

REFERENCES:
1. Phillips, Chandler A. and Jerrold S. Petrofsky. Neck Muscle Loading and Fatigue: Systematic Variation of Headgear Weight and Center-of-Gravity, Aviation, Space, and Environmental Medicine, October 1983.

2. Gallagher, Hilary and Erin Caldwell. Neck Muscle Fatigue Resulting from Prolonged Wear of Weighted Helmets, Aviation, Space, and Environmental Medicine, March 2007.

3. Hudson, Jeffrey A., Gregory F. Zehner, Kathleen M. Robinette. JSF CAESAR: Construction of a 3-D Anthropometric Sample for Design and Sizing of Joint Strike Fighter Pilot Clothing and Protective Equipment. AFRL-HE-WP-TR-2003-0142, 2003.

4. Plaga, John A., et al. Design and Development of Anthropometrically Correct Head Forms for Joint Strike Fighter Ejection Seat Testing, AFRL-HE-WP-TR-2005-0044, February 2005.

5. O'Hern, Michael R., et al. Chemical Defense Equipment, https://ccc.apgea.army.mil/sarea/products/textbook/Web_Version/chapters/chapter_16.htm

KEYWORDS: night vision, head mounted device, helmet mounted device, head harness

AF081-013 TITLE: Intelligent Scenario Generation Tools for Distributed Mission Operations (DMO) Training and Rehearsal

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop tools to automatically generate simulation-based training scenarios to meet individual/team requirements by targeting deficient, skills, and competencies.

DESCRIPTION: This effort will demonstrate technologies and tools that generate scenario content for training in simulation based environments. Today, scenarios developed in current simulation systems are hand-crafted and static representations of training and mission contexts. Further, when an instructor wants to modify the scenario characteristics for specific learning events, or to target specific observed performance deficiencies, this cannot be done in real time in an ongoing training event. Finally, there is no current method to facilitate the instantiation of good instructional principles and practice in each scenario and to package the scenario in a way that permits routine application of the scenario and adaptations to the scenario based on learner needs in simulation-based environments. In summary, there is no current capability to dynamically generate and delivery scenarios that permits scenario design and execution, adapting to learner needs, within a specific scenario in real time, and that incorporates good instructional practice. The scientific and technical challenge in this effort is the development and demonstration of versatile and adaptive scenario generation and delivery that supports learning for both individual students and teams operating in both local and distributed training environments. As part of this effort, expert judgments based on their experiences with diagnosing complex skill performance and deficits will be delineated and modeled using cognitive task analysis methods. The resulting "expert diagnostician" model will be embedded in software that can assist scenario developers in determining the appropriate content and sequence of training and rehearsal scenarios for enhanced learning and performance. Additionally this effort will identify critical trigger experiences within the scenario structure for various missions, broken down by team and position and that are needed to develop requisite knowledge and skills for successful accomplishment of the mission. The work to be accomplished in this effort directly supports the Air Force Distributed Mission Operations (DMO) training transformation initiative with tailorable, semi-automated simulation-based training tools for individuals and teams.

PHASE I: Develop a proof-of concept design and feasibility assessment for dynamic scenario generation and adaptation for individual and team learning in simulation-based environments. Results from the design and assessment will be documented for Phase II.

PHASE II: Based on PHI design and assessment, develop prototype methods for diagnostic assessment and demonstrate the efficacy of the assessment to identify deficiencies and match deficiencies with training scenario characteristics to target the deficient skills or competencies.

PHASE III / DUAL USE: Military application: Dynamic scenario development is a critical need for simulation-based environments and learners in those environments to increase the efficiency and effectiveness of distributed training events. Commercial application: Commercial scenarios exist where communications could be monitored to assess cognitive readiness or lapses in team situation awareness (incident command, commercial air crews, emergency response).

REFERENCES:
1. Burgeson, J.C., et al. Natural effects in military models and simulations: Part III - Analysis of requirements versus capabilities. Report No., STC-TR-2970, PL-TR-96-2039, (DTIC accession number AD-A317 289), August 1996.

2. Aerospace Operations Center Concept of Operations, ACC/AC2ISRC/A-31, 9 March 2001.

3. Defense Modeling and Simulation Office homepage: www.dmso.mil

4. Crane, P. Designing Training Scenarios for Distributed Mission Training. Presented at: 10th International Symposium on Aviation Psychology, Columbus, OH, April 1999.

KEYWORDS: aerospace operations, affordability, command and control training, distributed mission operation, readiness evaluation, team effectiveness, workgroup effectiveness

AF081-014 TITLE: Live, Virtual, and Constructive (LVC) Common Performance Measurement Development, Tracking, and Warehousing System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop methods to identify, generate, format, extract and track performance data from live aircraft, instrumented ranges, and distributed mission operations simulation environments.

DESCRIPTION: This effort will develop methods for identifying and capturing human performance data in complex combat environments. It will also identify alternative approaches for increasing cross-systems collection and sharing of human performance data from live aircraft, range instrumentation systems, and distributed simulation networks. There is currently no common or integrated data tagging specification or warehousing and tracking capability to support routine evaluations and sharing of data across a variety of training, rehearsal, exercise, test, or evaluation environments. There is currently nothing like a Shareable Courseware Object Reference Model (SCORM) like there is for Advanced Distributed Learning, for performance measurement and readiness assessment. There are several existing standards and capabilities in operation today, but they are not directly compatible with each other and it is currently impossible to share data from different environments/systems in order to assess human performance within and across them. The simulation community generally follows a Distributed Interactive Simulation (DIS) protocol or High Level Architecture (HLA). Live ranges use Test and Training Enabling Architecture (TENA) and exercises use systems such as the Nellis Air Combat Training System (NACTS). Each of these can provide data individually, but there is no accepted approach to identifying and capturing useable data and for defining performance “objects” and for formatting data from each system such that important criteria can be defined, tracked, and shared. As the merger of live, virtual, and constructive (LVC) systems becomes more commonplace, these incompatibilities represent a significant shortfall in our capacity to assess the payoff of integrated and joint training and exercise concepts like LVC as readiness solutions. Further, we cannot demonstrate the longitudinal impact of these concepts because we cannot routinely evaluate performance and readiness across training, exercise, test and evaluation contexts over time. To solve the shortfall, this effort will develop and demonstrate a method for developing reliable and valid performance and readiness measures that are useable within and across live and virtual environments. A major part of this effort will examine existing data formats and structures within and across LVC environments and will develop and demonstrate capabilities to identify and extract data and common formats and data standards compatible across environments and systems. The successful effort will develop and demonstrate a toolset and methods to facilitate data collection and measurement development and to extract, format tag, and warehouse human performance data for a variety of sources in a common data format to permit sharing of common data for routine performance evaluation and management. Developing a common methodology and system for data sharing and warehousing represent a unique and critical capability for the development, analysis - and most importantly - usability of source data from different environments and systems for training and operational readiness assessments.

PHASE I: Phase I is a feasibility concept to identify/integrate metrics from different data formats and from live ranges, actual aircraft, and simulation-based systems and provides recommendations for formats to facilitate data sharing, warehousing, routine extraction and tracking across environments.

PHASE II: Phase II is a prototype demonstration of common interfaces, extraction tools, data tagging, and reporting methods for data from ranges, actual aircraft, operational exercise events, and simulation-based training and rehearsal environments. The Phase II prototype also includes data warehousing tools to permit routine measurement and tracking of performance “objects” across these environments.

PHASE III / DUAL USE: Military application: Existing systems are proprietary with limited data sharing across systems and contexts. Integrated civilian and military systems requires shared data to support common performance and readiness needs Commercial application: This effort addresses the growing need for common formats and tags and the need for sharing, tracking and warehousing human performance data across military and commercial environments and systems.

REFERENCES:
1. Defense Modeling and Simulation Office homepage: www.dmso.mil

2. Dwyer, D.J., Fowlkes, J.E., Oser, R.L., Salas, E., & Lane, N.E. (1997). Team performance measurement in distributed environments: The TARGETS methodology. In M.T. Brannick, E. Salas, & C. Prince (Eds.), Team performance assessment and measurement: Theory, methods, and applications. Mahwah, NJ: Lawrence Erlbaum Associates.

3. Serfaty, D., MacMillan, J., Entin, E.B., Entin, E.E. (1997). The decision-making expertise of battle commanders. In C.E. Zsambok & G. Klein (Eds.), Naturalistic decision making. Mahwah, NJ: Lawrence Erlbaum Associates.

KEYWORDS: developmental test and evaluation assessment, training and rehearsal, distributed mission operations, distributed mission training, performance measurement, distributed interactive simulation (DIS),high level architecture (HLA),live training

AF081-015 TITLE: Binaural Capture and Synthesis of Ambient Soundscapes

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Create a technique for capturing and replicating ambient soundscapes, and use the technique to statistically model ambient soundscapes for a wide range of listening environments.

DESCRIPTION: Many military applications require an accurate assessment of the probability that sounds propagating from a particular weapon system will be detectable by an adversary or annoying to the surrounding civilian population (for example, the likelihood that a new aircraft system will generate complaints about flyover noise near an air force base). Such assessments are impossible without a reasonably well validated model of the typical ambient auditory scenes that might occur at the location of the listener during that time of day for that time of year. Since detection and annoyance can depend on binaural factors such as dynamic head movements as well as the spectral similarities between the target and masking sounds, monaural recordings alone are unlikely to be useful for accurately modeling acoustic detection. This effort will focus on the development of a technique for accurately capturing low-level ambient sound fields in real-world environments over long periods of time, and accurately resynthesizing those sound fields in the laboratory for human listeners. The resynthesized sounds should match the absolute levels of the original sound field in each ear within +-1 dB (down to the absolute threshold of human hearing, 0 dB SPL). A change in head orientation in the laboratory setting should accurately reproduce same dynamic changes in the binaural sound field that would occur for an identical head movement in the original environment. This should allow listeners to identify the azimuthal locations of sound isolated sound sources captured in a free-field environment within 15 degrees. However, the most important attribute of the system is that it should accurately capture the masking that would occur in the original sound field for any combination of target sound location and listener head orientation. Thus, if an aircraft sound is superimposed on the resynthesized soundscape, the probability that a listener will be able to detect the target sound in the resynthesized environment should be the same as the probability of detection in the original environment. One example of a related technology is the Motion-Tracked Binaural (MTB) system developed at UC Davis, which uses a specialized microphone array for the auditory capture and a headphone-based system with a for resynthesis. However, this system does not currently work for very low-level ambient sounds, and many other implementations are possible both for the auditory capture and resynthesis systems. Once in place, the binaural audio capture technique can be used to build a database of a large number of ambient listening environments that can be used in modeling representative soundscapes for a wide range of environments based on information that might be available in a typical geographic database. This database should make it possible to synthesize a ""typical"" ambient field (or a best and worst case estimate) and for almost any ambient environment on the basis of such factors as population density, wind speed, time of day, terrain type, time of year, biological sources, transportation sources, etc.

PHASE I: Demonstrate a prototype technique capable of acquiring urban (city) and rural (desert) soundscapes and develop a concept to resynthesize the soundscape.

PHASE II: Demonstrate a synthesis technique that is capable of replicating the soundscape down to the same absolute level in a laboratory setting. Expand the technique to statistically model a wide range of environments based on environmental factors (e.g. time of day, terrain type, weather conditions, and population density).

PHASE III / DUAL USE: Military application: Assessing the detectability/annoyance of weapons systems in a variety of ambient listening environments, and providing realistic background sounds in military simulators for dismounted soldiers. Commercial application: The system has great potential for use in the video gaming industry, where realistic background sounds currently require a great deal of customization.

REFERENCES:
1. V. R. Algazi, R. O. Duda, and D. M. Thompson. "Motion-tracked binaural sound", Proc. AES 116th conv., Berlin, Germany, preprint 6015, (2004)

2.R.C. Maher, J. Gregoire, and Z. Chen, ""Acoustical monitoring research for national parks and wilderness areas,"" Preprint 6609, Proc. 119th Audio Engineering Society Convention, New York, NY, October 2005.

KEYWORDS: soundscapes, audio detection, sound synthesis, auditory scenes, binaural factors

AF081-017 TITLE: Space Environment Visualization

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

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

OBJECTIVE: Develop visualizations to communicate situational awareness of the space environment--especially naturally occurring space environment phenomena.

DESCRIPTION: A key capability needed to counter threats to the nation's satellite systems is accurate and decisive space situational awareness (SSA). An important aspect of SSA is the ability to predict and assess the effects of the space environment. Air Force Space Command's (AFSPC's) SSA Environmental Effects Fusion System (SEEFS) is one major information source for space environmental impacts and decision aids. SEEFS attempts to improve the capabilities of operators, analysts, system engineers, weather support personnel, and decision makers to distinguish natural from hostile or unintentional space system effects. SEEFS provides the ability to assess environmental effects on satellite operations, surveillance, missile warning, and on communication and navigation systems.

What is lacking is the ability for all with space protection responsibilities to make full use of space weather tools like SEEFS. Therefore a major goal of this effort is to seamlessly integrate space weather into the SSA and defensive counterspace workflow. Analysts are clear that they do not want more tools. The Work-Centered Support System technology developed by AFRL/HE is a good example of how such a system can be developed [5].This integration should consider compatibility issues with the space environment visualization and other new programs for managing, protecting, and defending space systems (e.g., the Integrated SSA program and the Rapid Attack, Identification, Detection, and Reporting System [RAIDRS]). Furthermore, considering the vast domain of space, the items in space, and the multitude of environmental and man-produced effects on these items, intelligent agents might be required for certain tasks. The levels of data fusion and fusion architectures need to be explored with these agents.

In addition to work-flow considerations, the visualizations are also important to ensure all analysts can understand the information. Visualizing patterns in heterogeneous data including weather and related systems effects will be particularly challenging. The end product should complement the user's thought processes by (1) increasing cognitive resources (e.g., offload work from cognitive to perceptual system), (2) providing efficient search capabilities, (3) facilitating the recognition of patterns, perceptual inference (visual representation make some problems more obvious), and perceptual monitoring (visualizations can allow for the monitoring of a large number of potential events and indicators/warnings), and (4) providing a medium for exploration and selection. The method must support traversing levels of detail, providing drill-down capability, as well as back-out capabilities.

PHASE I: Determine concept feasibility, and, if determined feasible, create a plan to develop technology. The plan needs enough detail to allow the government to assess the technology's merit.

PHASE II: Determine to what extent this functionality should interact with (or overlay over) existing space environment tracking systems and other SSA systems. Prototype the software, including functional intelligent agents, to allow the government to assess the technology's viability in operational use.

PHASE III / DUAL USE: Military application: With a network-centric approach being applied, build a system that the Air Force can test at an operational facility such as the Space Warfare Center or suitable alternative. Commercial application: Commercial satellite industry can be impacted greatly by the space environment. Better visibility of effects can reap a considerable savings and facilitate satellite insurance claim assessments.

REFERENCES:
1. Lawyer, D., Hand, M. and Higley, L., "Space situation awareness environmental effects fusion system (SEEFS)", Proceedings of 2nd Symposium on Space Weather, American Meteorological Society, Jan 2005. http://ams.confex.com/ams/Annual2005/techprogram/paper_83589.htm

2. Bryn, J. and Jones, L, “Integrating Space Weather information into global aviation operations”, J L Jones, Proceedings of 2nd Symposium on Space Weather, American Meteorological Society, Jan 2005. http://ams.confex.com/ams/Annual2005/techprogram/paper_83589.htm

3. Hansen, Charles D. and Johnson, Christopher R (Eds). The Visualization Handbook. Elsevier, Amsterdam 2005.

4. Ziarnick, B., “The Space Campaign: Space-Power Theory Applied to Counterspace Operations,"" Air and Space Power Journal, Volume XVIII, No. 2 AFRP 10-1, Summer 2004 http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/sum04.pdf

5. Roth, E.M., ""Work-Centered Support Systems: A Framework for Design and Evaluation of Computer Support Systems,"" MIT Humans and Technology Symposium, Jan 2006

KEYWORDS: display, space situational awareness, space weather, environmental effects, satellite and radar systems, data visualization

AF081-019 TITLE: Interdomain routing for mobile ad hoc networks (MANETs)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a routing capability to provide internetworking between Mobile ad hoc Network (MANETS) as well as between a MANET and more stable networks.

DESCRIPTION: MANET protocols have been proposed to address the dynamic information distribution needed in Air Force missions where nodes join and leave tactical networks. Network infrastructure is not always available for tactical units and the ability to exchange information within a group can be supported by MANET protocols. In addition to requirements of networking among mobile group members, tactical units must also connect to the larger military network when possible. This problem applies whether the tactical unit in question is a team of special operations forces on the ground, a group of fighter aircraft, or a cluster of unmanned aerial vehicles (UAVs), (although the airborne applications are certainly the most stressing). The reasons for this are discussed below. To provide a fully connected tactical environment, internetworking among MANETs and from MANETs to the GIG, either directly or via an Airborne Network backbone, is essential.

Most MANET research has focused on interior protocols with little research on the exterior connectivity of the mobile group. (MANET protocols provide solutions for mobile users that need to network among themselves, rather than providing exterior networking from the mobile group.) In terrestrial networks, connectivity between different routing domains is typically provided by the exterior gateway protocol, BGP (Border Gateway Protocol). The BGP is the de facto standard protocol of its type despite well known problems. The BGP’s capability to handle large numbers of routes makes it valuable, however it tends to experience long convergence times after routing changes. This is generally not considered to be a significant issue in terrestrial networks, since the links involved are generally very stable and the basic network topology is essentially fixed. However, this is a significant issue in a mobile environment since the links tend to be much less stable and the network topology is subject to change. These problems are intensified in an airborne environment. Communications links in aircraft will experience intermittent and varying quality radio signals due to banking, interference, and Doppler effects. Frequent network topology changes are possible due to the sheer speed of the aircraft involved. Links can appear and disappear very quickly in this environment. Furthermore, the BGP is also not extensible to a mobile environment since it does not support dynamic discovery of members, relies on Transmission Control Protocol (TCP) connections among members, and cannot support multiple attachments from a domain. Innovation is required to develop a means of providing networking among MANET and terrestrial domains, each of which may use a different routing protocol and different routing metrics, for a seamless tactical network environment.

PHASE I: Define and develop an internetworking capability for MANETs. This capability will provide internetworking among MANET domains as well as internetworking of MANET domains with non-MANET domains. Phase I will include a high level system design and a proof-of-concept implementation with lab demos.

PHASE II: Complete the design, development, and demonstration of the exterior MANET routing capability.

PHASE III / DUAL USE: Military application: Enables extension of GIG connectivity to the airborne domain by enabling the Airborne Network via internetworked platforms such as F-22, F-15, F-16, Global Hawk, JSTARS, AWACS, etc. Commercial application: Enables connectivity between commercial aircraft and between commercial aircraft and terrestrial networks to enable automated collision avoidance, fuel level reporting, emergency communications, etc

REFERENCES:

1. J. L. Burbank, et al, “Key Challenges of Military Tactical Networking and the Elusive Promise of MANET Technology”, IEEE Communications Magazine, November 2006.

2. R.K. Butler, et al, “Considerations of Connecting MANETs Through an Airborne Network”, IEEE Military Communications Conference Proceedings, MILCOM 2006.

3. ESC HERBB Airborne Networking web site, http://www.herbb.hanscom.af.mil/Hot_Buttons/Airborne_Networking/index.htm

4. The Mitre Digest, http://www.mitre.org/news/digest/defense_intelligence/12_02/di_global_grid.html

KEYWORDS: MANET, Airborne Network, Routing, MANET Internetworking, border protocols, exterior gateway protocols

AF081-021 TITLE: <u>Modeling the Behavior of Terrorist Networks</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

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

OBJECTIVE: Model a complex terrorist network and automatically identify its key operational nodes

DESCRIPTION: Recent attempts to model the activities of terrorist networks were primarily based on formal predictive methodologies that related the terrorist network to a simple system whose future state could be determined from its past behavior. These models tended to be of two basic types: (1) those which attempted to predict the behavior of individual terrorists and thus make the behavior of the entire network highly predictable and (2) those which hypothesized that terrorist behavior was essentially chaotic and that the best solution was to identify and eliminate the network leadership. Few results of value were obtained from such analyses. A mid-range approach, which considers the dynamics of the terrorist network at the organizational level, promises greater success. This type of associational modeling draws on the application of social network analysis: mapping knowledge networks within and across the boundaries of an organization. The approach focuses on individual network centrality which reveals, by quantitative analysis, the key individuals in the information flow and knowledge exchanges that are intrinsic to the function of the terrorist network. Three metrics are commonly used to define centrality: (1) the number of direct connections a node (in this case, an individual terrorist) has to other nodes (degrees)); (2) the ability of a node to link to important constituencies within the network (betweenness, see Wikipedia) and (3) a node’s ability to monitor the network to discern what is happening (closeness).

PHASE I: Develop a concept that can reasonably model an interactive social network. Focus on the feasibility of identifying key operational nodes by evaluating metrics such as closeness, degrees, and betweenness.

PHASE II: Demonstrate a prototype, in an operational environment, by introducing historical and social contexts into the analysis of the model. The process of refining the network will be performed by the model using a knowledge base of observed verified information. The analyst/user enters this information into the model using a simple query-based.

PHASE III / DUAL USE: Military application: Transition the model in coordination with the Navy counter-IED program & the Joint IED Defeat Organization. The Combat Terrorism Technology Task Force is a possible transition path for the tool. Commercial application: Homeland security and law enforcement applications.

REFERENCES:
1. Corbin, Jane, Al Qaeda: The Terror Network That Threatens the World, Thunder's Mouth Press, New York, 2002.

2. Davis, Paul K., Effects-Based Operations (EBO): A Grand Challenge for the Analytical Community, Santa Monica, Calif.: RAND Corporation, 2001

3. Jenkins, Brian, Countering al-Qaeda: An Appreciation of the Situation and Suggestions for Strategy, Santa Monica, Calif.: RAND Corporation, 2002

4. Levitt, Matthew, "The Zarqawi Node in the Terror Matrix," National Review Online, February 6, 2003a, http://www.nationalreview.com/comment/
comment-levitt020603.asp (as of February 28, 2006)

5. Ochmanek, David, Military Operations Against Terrorist Groups Abroad: Implications for the United States Air Force, Santa Monica, Calif.: RAND
Corporation, MR-1738-AF, 2003

6. Paz, Reuven, "Arab Volunteers in Iraq: an Analysis," The Project for the Research of Islamist Movements (PRISM), Herzliya, Israel: Global Research in International Affairs (GLORIA) Center, Occasional Papers, Vol. 3, No. 1, March 2005a

KEYWORDS: Counter Terrorism; Terrorist Networks; Modeling and Simulation, Executable Mission Content, Architecture

AF081-022 TITLE: <u>Real Time Dynamic Network Topology Management</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an approach for dynamic network topology management and control.

DESCRIPTION: The Department of Defense (DoD) is engaged in efforts to develop an IP-based Airborne Network (AN) which interconnects airborne platforms and provides interconnectivity with space and terrestrial networks. This AN will provide the DoD with the capability to extend mission information threads beyond the original constraints imposed by legacy (non-IP) data links, but its development involves many technical challenges. For additional information regarding the DoD's efforts to develop this IP-based Airborne Network, see reference 1. Topology is the interconnecting pattern of nodes in a network. In a wired network, the topology is essentially static, determined by physical connections between nodes. In most commercial wireless networks, the topology is largely static as well. Since Cellular and WiFi users are mobile, their point of connection may change, but the underlying network is typically a fixed set of cellular towers or WiFi access points. Emerging commercial ad-hoc or mesh based wireless networks are self-forming by nature, and active topology management can provide improved overall network performance, efficiency, and scalability. Topology management and control in airborne networks are more critical due to the high degree of platform dynamics involved. The RF links that form an airborne network must be capable of being established and changed rapidly in response to aircraft joining and leaving the network, aircraft changing flight paths, the changes in mission information flows, etc. These changes must be implemented in such a way as to minimize impacts to the performance of the network and with little or no operator involvement. There are two basic forms of topology control: control by changing transmit power or by redirecting antennas. In networks which utilize omni-directional antennas, which would typically be the case in networks of tactical aircraft, the only means of controlling the topology is by varying the transmit power. While keeping a high transmit power may improve connectivity and reduce the number of hops required through a network, it also causes increased interference and complexity of routing. In networks which utilize a fixed number of directional antennas, which would typically be the case in high bandwidth backbone portions of the airborne network, the only way of controlling the topology is to redirect one or more of the available antennas. Innovative solutions are required for topology management in airborne networks. Proposed mechanisms must dynamically identify, select, establish, adapt, and manage communication links. In conducting these functions, the proposed approach should consider computation overhead, levels of hierarchical organization, node power, desired connectivity, link data rate, jamming, network survivability, and graceful performance degradation under dynamic changes. Link selection criteria should consider traffic loading, link availability and status, and overall network topology. The optimum topology management mechanism will select a set of links that forms a stable and robust topology and provides optimal network performance.

PHASE I: Identify and/or develop potential mechanisms for managing the network topology in a dynamic mobile environment. Use simulation or prototype techniques to analyze performance and robustness of solution(s). Develop a system architecture design of the proposed topology management and control approach.

PHASE II: Complete the design, development, and demonstration of prototype systems that implement a topology management and control system for a dynamic airborne network environment.

PHASE III / DUAL USE: Military application: Efficient management of network resources is critical in limited bandwidth conditions present in a large number of military networks, both airborne and terrestrial based. Commercial application: Topology management and control is a technical issue that cuts across a broad array of wireless networks, including the growing number of commercial wireless metropolitan networks.

REFERENCES:
1. ESC HERBB Airborne Networking web site,
http://www.herbb.hanscom.af.mil/Hot_Buttons/Airborne_Networking/index.htm

2. MIT's Technology Review Magazine,
http://www.technologyreview.com/read_article.aspx?id=14407&ch=infotech

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

4. Topology Control in Wireless Ad-hoc and Sensor Networks, Paolo Santi, Wiley, 2006

5. Link Management in the Air Force Airborne Network, R. Ramirez, Proceedings of MILCOM 2005. 2005 IEEE Military Communications Conference

KEYWORDS: Airborne Network, Topology, Topology Management, MANET, topology control

AF081-023 TITLE: Unconventional Sensor Data Access and Integration

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Demonstrate a prototype that efficiently aggregates emerging sensor data with conventional Intelligence, Surveillance and Reconnaissance (ISR) sensor systems.

DESCRIPTION: New information concepts and technologies are needed to fully utilize unconventional ISR resources to augment current conventional ISR assets in our Global War on Terrorism. Each ISR asset provides a unique collection capability that when integrated together offers a common, shared, situational awareness of the battlespace for the Air Operations Centers and the Distributed Common Ground Systems. As a recent example, the Air Force successfully demonstrated the utility of supplementing conventional ISR platforms (e.g. JSTARS, AWACS and U-2) with unconventional sensor data provided by combat aircraft (F-15, F-18). In the near-future, new combat aircraft (e.g. F-22, F-35) will provide an array of even more robust, high-fidelity sensors that will access internet protocol based networks. Augmenting this airborne sensor suite are ground based sensors, such as, unattended ground sensors and man-portable target designation sensors. The goal of this research topic is to apply web service (e.g. metadata, mediation) and semantic web technologies (e.g. ontologies), data representation and interchange schemes (e.g. topic maps) and service oriented architecture design principles to integrate these diverse sensor data capabilities to create a rich information environment that is responsive to warfighter requirements. The primary focus will be on accessing and integrating imagery-based sensor data from disparate and heterogeneous sources that were previously separated or stove-piped. The key technical challenges are: (1) providing an automated ability to ingest unstructured data from each sensor suite, (2) make that sensor data accessible, understandable, and retrievable and (3) quickly perform format mediation and translation needed to create common data formats. This will facilitate down-stream correlation processes needed for the generation of a common operating picture and accurate combat assessments. The ability to combine and integrate sensor data may require the development of computer-assisted reasoning or inferencing abilities to aggregate data from dissimilar data sources into a meaningful and coherent form. The technical approach proposed should maintain compatibility with the Department of Defense's emphasis on network centric warfare.

PHASE I: Perform the initial research necessary to identify and assess potential technical approaches. Develop an approach and assess the feasibility of implementing an experimental prototype.

PHASE II: Develop the required technologies leading to a prototype demonstration. The prototype will demonstrate data access and integration using candidate ISR products consisting of imagery and video data from unclassified, open sources to the extent possible.

PHASE III / DUAL USE: Military application: This capability will provide the Air Force with the ability to discover and use all available ISR data to improved information management in a net-centric environment Commercial application: This capability will prove useful to retail, law enforcement and homeland defense applications.

REFERENCES:
1. "Connectivity, Persistent Surveillance Model Future Combat" Henry S. Kenyon, Signal magazine, May 2004

2. "The Network Way of War: Data flowing to and from all Air Force elements will cause a dramatic new form of combat", John A. Tirpak, Air Force magazine, March 2005

3. "ISR Integration: Essential Step toward Network-Centric Operations" Glenn Goodman, ISR Integration 2003 Conference: The Net-Centric Vision

4. "Networked Vision Moves Closer to Reality", Henry S. Kenyon, Signal magazine, July 2004

KEYWORDS: Situational Awareness, Integrated Sensor and Surveillance Data, Interoperability, Metadata, Data Discovery, Semantic Web

AF081-024 TITLE: <u>Defeating Emplaced Improvised Explosive Devices (IED) Using Fusion Algorithms</u>

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Pursue innovative R&D to provide algorithms that can successfully combine various data sources with a focus on recognizing patterns/cues necessary to move from being reactive to Improvised Explosive Device (IED) events to a proactive/predictive posture.

DESCRIPTION: The IED Defeat Program Office (ESC/EISG/XRD) of the Air Force Electronic Systems Center is interested in innovative techniques for the proactive usage of collected intelligence. Two major aspects of defeating the use of IEDs have evolved – defeating the device itself and defeating the network that provides the support to enable IED warfare. A great deal of effort has been applied towards combining sensor reports of various types in order to find those who emplace these devices after they are used. The emphasis of this research will be on the automatic prediction of where these devices may be placed in the future based upon collected intelligence and IED event reporting. The work that has been done in this area has been largely dependent on the man in the loop doing the historical pattern analysis and recognition. Innovative algorithms or are desired that will bring to bear all potential data sources (geospatial and temporal event info, coalition traffic patterns, multi-spectral sources of sensor data, etc) on the prediction of IED emplacements in an autonomous or semi-autonomous manner. Using historical data, algorithms should be analyzed for their ability to predict future emplacements from a point in time – e.g., given what patterns exist to date, could we have predicted the IED device from last week? Algorithmic results are required that provide quantitative estimates of both spatial and temporal locations of IED placement, or that enhance current counter-ambush/IED techniques.

PHASE I: Identify and define prototype approaches & evaluate applicability of innovative algorithms to meet the stated objective. Develop criteria & measures for evaluating effectiveness and performance. Conduct analyses using realistic data to evaluate approach. Demonstrate autonomous or semiautonomous prototype.

PHASE II: Develop, implement, and demonstrate a prototype of the Phase I approach using data sets provided by the Government. Perform detailed analyses and demonstrate the efficiency of candidate algorithms. Conduct tests, as required, to assess the effectiveness of the algorithms. Deliverables: Software algorithms, test data description and documentation; test and evaluation reports.

PHASE III / DUAL USE: Military application: The algorithms & processing techniques developed will be useful in fielded military systems supporting autonomous or semi autonomous detection of potential IED emplacements and/or IED devices. Commercial application: Law enforcement/homeland security where diverse data (geospatial, temporal events, multi-spectral sources of sensor data, etc) are combined to look for patterns in crime scenes, smuggling ops, etc.

REFERENCES:
1. Air Strike Targets Terrorist Safe Haven in Husaybah, www.defenselink.mil/

2. Improvised Explosive Devices, http://en.wikipedia.org/wiki/Improvised_explosive_device

3. IEDs – Iraq, http://www.globalsecurity.org/military/intro/ied-iraq.htm

4. Joint Improvised Explosive Device Defeat Organization (JIEDDO), Tactical Successes Mired in Organizational Chaos: Roadblock in the Counter-IED Fight, LTC Richard F. Ellis, USA, Joint Forces Staff College, Joint and Combined Warfighting School, 13 March 2007

5. GMTI-tracking and information fusion for ground surveillance, Koch, W. FGAN-FKIE, Wachtberg, Germany Journal: Proceedings of the SPIE - The International Society for Optical Engineering Conference Title: Proc. SPIE - Int. Soc. Opt. Eng. (USA) vol.4473 p.381-925.

KEYWORDS: Prediction, behavior analysis, improvised explosive device, multi-sensor fusion, pattern analysis, trends

AF081-025 TITLE: Multilayer approach for Efficient Distribution of Information over Wireless Networks

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop intelligent, efficient, and robust data distribution approaches for one-to-many and many-to-many data exchanges over airborne networks.

DESCRIPTION: The DoD is developing an Airborne Network methodology for exchanging information among airborne, surface, and space nodes. (A background to the AN effort can be found at [1]). In contrast to the terrestrial based Internet -- in which data exchanges are primarily point-to-point -- the majority of traffic exchanges over the Airborne Network is a “one-to-many” or “many-to-many” traffic exchange. For example, in the “one-to-many” exchange, a sensor hosted within an airborne platform may distribute situational awareness data (e.g., radar “tracks”) to a set of many receivers. In “many-to-many” exchange, multiple sensors distribute raw sensor data to multiple receivers. Obviously, using Internet point-to-point protocols to distribute data for a one-to-many pattern is inefficient. While various approaches have addressed the problem for stable, wire-line networks -- e.g., peer-to-peer application overlays (BitTorrent) -- there are no approaches that address the challenges of robust data distribution specific to dynamic, wireless networks such as the Airborne Network. Indeed, airborne networks pose a significant challenge due to the many differences they exhibit relative to the Internet:

- Bandwidth constrained links require very efficient solutions;
- Lossy and/or intermittent links due to the inherent nature of wireless media and effects of airborne platform mobility dynamics (pitch, yaw, and roll);
- Dynamic network topologies due to nodal mobility and lossy/intermittent links;
- Multiple, heterogeneous transmission systems (including directional, and omni-directional links) are often employed by aircraft;
- Heterogeneous node capabilities in terms of the number of transceivers and their bandwidth; and
- The potential to leverage physical layer broadcast in the wireless environment – an opportunity that does not exist in the wired environment.

While many potential approaches to developing intelligent, efficient, and robust data distribution exist (e.g., content-based routing, application layer peer-to-peer overlays, MANET routing multi-cast protocols, Network Coding [ref 1]), the breadth of the challenges posed by dynamic, wireless networks may require the problem be addressed in a multi-layer approach. For example, can a synergistic application of network layer (e.g., Network Coding) and application layer (e.g., Peer-to-peer Application Overlays) be applied to more efficiently address the problem than would be possible in separately (and perhaps redundantly) applied single-layer solutions? In summary, new approaches are required to developan intelligent, efficient, and robust data distribution at multiple layers to address the challenges particular to the Airborne Network.

PHASE I: Propose potential means of addressing data exchanges over dynamic, wireless networks in a multilayer and/or synergistic approach. Evaluate approaches using simulations and/or prototype techniques to assess the performance of the multi-layer/synergistic approach relative to independent applications.

PHASE II: Complete the design, development and demonstration of a prototype of the selected approach in a simulated dynamic, wireless airborne network.

PHASE III / DUAL USE: Military application: Technology in this area would be an enabler for many applications (such as Single Integrated Air Picture (SIAP) and other military situational awareness capabilities. Commercial application: As the Internet and its applications extend into the bandwidth constrained wireless domain, a more efficient approach for information distribution is needed for these emerging wireless networks.

REFERENCES:
1. Network Coding for Wireless Applications: A Brief Tutorial; http://www.mit.edu/~dslun/publications/iwwan2005.pdf

2. On the Utility of Network Coding in Dynamic Environments; http://web.mit.edu/trace/www/iwwan-final.pdf

3. T. Ho, J. Jin and H. Viswanathan, ""On network coding and routing in dynamic wireless multicast networks"", Workshop on Information Theory and its Applications, UCSD, 2006

4. Performance Issues of P2P File Sharing Over Asymmetric and Wireless Networks; Yao-Nan Lien, Computer Science Department, National Chengchi University, Taipei, Taiwan

5. An integrated approach for P2P file sharing on multi-hop wireless networks; http://www.cs.sunysb.edu/~bintang/papers/wimob_05.pdf

6. Wireless And Mobile Computing, Networking And Communications, 2005. (WiMob'2005), IEEE International Conference on Publication Date: 22-24 Aug. 2005, Volume: 3, On page(s): 268- 274 Vol. 3

7. Comprehensive View of a Live Network Coding P2P System; Microsoft Research; http://www.imconf.net/imc-2006/papers/p18-rodriguez.pdf

8. Internet Measurement Conference archive
Proceedings of the 6th ACM SIGCOMM on Internet measurement table of contents

Rio de Janeriro, Brazil
SESSION: Peer to peer table of contents

Pages: 177 - 188
Year of Publication: 2006 "

KEYWORDS: Multicast, network coding, peer-to-peer, common operational picture, situational awareness, data distribution, data exchange, file sharing

AF081-027 TITLE: Mitigate IED threat by Leveraging an Effect-based Approach

TECHNOLOGY AREAS: Information Systems, Battlespace

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

OBJECTIVE: Pursue innovative R&D techniques to develop tools and techniques that apply effect-based approach to mitigate improvised explosive device (IED) threat.

DESCRIPTION: The 21st century threat that has emerged is more complicated and dynamic than the Cold War strategic threat. The threat of terrorism is not limited to a singular nation state or affiliated group of people. This effort is focused on the analysis of the root causes of terrorism and the development of models and simulations that can exhibit the evolution to terrorist behavior given those root causes. Researchers should investigate cultural, motivational, historical, political and economic data to determine if there are mathematical and statistical models that can be used to predict the formation of terrorist activities. The models and simulations developed should also allow for an exploration of courses of action that can be taken to predict/anticipate the formation of terrorist activity based on those root causes. The end goal is to determine sets of actions that can influence the root cause behaviors and cultivate a culture that does not support the development of criminal activity.

PHASE I: Perform initial research necessary to identify/develop mathematical & statistical methods that incorporate use of computational social science within quantitative algorithms. Demonstrate in a simulated context how the use of these models can influence the actions of U.S. COAs and Terrorist activity

PHASE II: Develop a prototype implementation that includes the algorithms, models, and supporting infrastructure that demonstrates how U.S/coalition actions affect IED deployment. Solutions must be aligned with the DoD Net-Centric Data Strategy, as well as inclusion of Commercial Off The Shelf (COTS) / Government Off The Shelf (GOTS) capabilities where applicable.

PHASE III / DUAL USE: Military application: IED threat mitigation. The same technology can be applied to other military domains where evaluating the effects of policy on unique groups is critical, e.g., threat prediction, indications & warning. Commercial application: Applications to law enforcement include homeland security issues. The capability to evaluate how groups (demographics) react to external forces is critical to large scale marketing and R&D.

REFERENCES:

1. Adaptive Foe Thwarts Counter-IED Efforts, National Defense, January 2006, http://www.nationaldefensemagazine.org/issues/2006/jan/adaptive_foe.htm

2. DoD Taps Industry Know-How in Ongoing Counter-IED Efforts, American Forces Press Service, http://www.defenselink.mil/news/Jan2006/20060124_4000.htm

3. http://www.smallwarsjournal.com/documents/swjmag/v8/swanson-swjvol8-excerpt.pdf

4. http://dspace.dsto.defence.gov.au/dspace/bitstream/1947/4684/1/DSTO-TR-1955.PR.pdf

KEYWORDS: Counter-IED, prediction, modeling and simulation, improvised explosive device, terrosism modeling

AF081-028 TITLE: Information Sharing between the Global Information Grid (GIG) and the System Wide Information Management (SWIM) system

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Protype the exchange of a radar target report exchange between the GIG and FAA System Wide Information Management(SWIM)network from the radar detection to display at the FAA in less than 2.3 seconds

DESCRIPTION: Develop a real-time net-centric concept for sharing radar data in a multi-level security environment between the Global Information Grid (GIG) and the Federal Aviation Administration (FAA) System Wide Information Management System (SWIM). Accurate, reliable, and timely radar and Airborne Dependent Surveillance - Broadcast (ADS_B) position data with very high integrity is critical to ensure aircraft collisions are prevented. Timeliness and accuracy will be even more important to maintaining safety in the FAA NextGen Air Transportation System being put in place. The NextGen is being designed to handle three times as much air traffic as today. Many more aircraft will be squeezed into the same airspace as today. This means that blunder detection and resolution loop times will be greatly reduced. Exchange of aircraft position data must be reliable, timely and accurate with very high integrity to ensure safety. This SBIR will strive to propose a way to guarantee that the position information can enter the GIG and be received by SWIM and processed for display with high confidence in less than 2.3 seconds from detection to display. The quality of Service of both networks must be defined to ensure that position data (radar and ADS-B) reliably reaches its destination with high integrity.

Background: Information must be exchanged between aircraft, ground radars and ground ATM facilities to ensure safe and efficient operation of the aviation system. These same aircraft, radars and ATM facilities will be sending and receiving position and flight change information between the GIG to the SWIM network using internet protocol technology (IPV6).

The GIG will be used to share real-time position information (including radar and ADS-B position data), issue and acknowledge controller instructions, update flight plans, provide threat information, etc. Critical flight information must pass both ways to ensure safety of flight and to allow military aircraft to fly through civil airspace to accomplish their missions.

It is envisioned that control instructions and other information will be transmitted from the FAA ATM facility over SWIM to an appropriate gateway with the GIG then to the aircraft via data link and vice versa. The airborne transmission path can be direct to a SWIM gateway or via data link between the aircraft and military ground station directly or by using military satellites, thence from the GIG to the SWIM.
Both GIG and SWIM are IP based and use XML, however they cannot be used for flight critical information until the appropriate quality of service for the information to be transferred is assured. This exchange is necessary to enable information to be shared across civil and military enterprises in the interest of air transportation safety and the expeditious coordinated movement of air traffic worldwide. The data to be exchanged varies from near real-time radar data in Asterix over IP with strict latency requirements, (0.3 sec for transmission and a total of 2.3 seconds from detection to display) to flight plan information that can tolerate much longer latencies. A priority system and a Quality of Service (QoS) scheme must be developed to insure that time critical information such as radar, ADS-B

and control instructions are received without delay. The exchange of data using the GIG and SWIM has the potential to minimize the unique avionics necessary on board military aircraft to achieve access to civil airspace worldwide.

PHASE I: Develop a priority scheme and Quality of Service plan that will ensure the exchange of radar, ADS-B and air traffic control data between the GIG and SWIM on networks that also carry data with varying levels of criticality. Deliver plan with sucess criteria for building prototype software/hardware

PHASE II: Build the prototype described in Phase I and demonstrate that the prototype provides real-time transfer of position information and air traffic control instructions using the criteria developed in Phase I. Insure quality of service considerations are addressed.

PHASE III / DUAL USE: Military application: Allow DoD to provide information over GIG to civilian ATC using existing avionics. Allows civil agencies to track & control aircraft in civil airspace using information over the GIG/SWIM interface. Commercial application: The resulting interface can be used by civil aviation authorities worldwide to provide service to US military aircraft without having to equip their facilities with special equipment unique to handle

REFERENCES:
1. Quality of service requirements for system wide information management (SWIM), Smith, T.,Digital Avionics Systems Conference, 2005. DASC 2005. The 24th
Volume 1, Issue , 30 Oct.-3 Nov. 2005 Page(s): 1.A.2 - 1.1-8 Vol. 1 Digital Object Identifier 0.1109/DASC.2005.1563291

2. Transport of flight critical data over Internet protocol Ragothaman, V.; Baloch, F.; Pendse, R.
Digital Avionics Systems Conference, 2005. DASC 2005. The 24th Volume 1, Issue , 30 Oct.-3 Nov. 2005 Page(s): 1.D.2 - 1.1-8 Vol. 1,Digital Object Identifier 10.1109/DASC.2005.1563307

3. Security architecture for system wide information management, Stephens, B.,Digital Avionics Systems Conference, 2005. DASC 2005. The 24th,Volume 2, Issue , 30 Oct.-3 Nov. 2005 Page(s): 10 pp. Vol. 2 - Digital Object Identifier 10.1109/DASC.2005.1563474

4. FAA Order 7110.65, Handbook – Air Traffic Controller.

KEYWORDS: GIG, SWIM, ATC, military data link , gateway, QoS,latency

AF081-029 TITLE: Multi-Sensor Tracking and Fusion for Space Radar Application

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

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

OBJECTIVE: To develop multi-sensor tracking and fusion (TAF) algorithms for Space Radar (SR) applications and to Optimize the use of SR-TAF algorithms.

DESCRIPTION: Space Radar (SR) sensors provide the capability to assist in the tracking and fusion (TAF) of surface moving targets in various clutter and background environments – including open ocean and in littoral areas. Littoral areas provide difficult challenges due to the overall radar scattering inhomogeneity and presence of large discrete spikes in sea clutter radar detections. This effort will incorporate the extraction of target characterization information via High Range Resolution and Inverse Synthetic Aperture Radar modes into TAF algorithms. These modes extract target profile data or produce Synthetic Aperture Radar/Moving Target Indication co-products in order to obtain a two dimensional mover signature. The methodology for assessing the predicted performance will include a comparison of an SR processor/simulator with the applied TAF algorithms to an SR processor/simulator without the applied TAF algorithms and use fundamental detection and tracking methods (such as constant false alarm rate techniques and monopulse tracking). Any TAF algorithms under consideration will be assessed under practical real-world SR constellation operational scenarios and constraints within realistic radar clutter background environments. Scenarios should include Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellite constellations [e.g. 24 LEO satellites, and 8 MEO satellites] operating radar sensors at various grazing angles [e.g. between 10 and 60 degrees] and various radar parameters [e.g. between 8 and 18 gigahertz transmit frequency] with ground moving targets operating at various real-world velocities [e.g. 5-60 miles per hour] within various terrain environments [e.g. mountainous, hilly, urban, littoral, open ocean (between sea states 0 to 9)]. TAF algorithm modules should be developed such that they could easily be inserted into SR processors and simulators to support an end-to-end SR constellation system assessment and help the SR program office assess the ability to meet requirements essential for key decision point determination to transition from concept definition to design/development acquisition phase.

PHASE I: Conduct feasibility demonstration of novel TAF algorithms for SR constellation employment. Mature concepts, define methodology for assessing predicted performance and comparison to fundamental tracking methods. Provide validated set of performance measures and techniques/tools for utility assessment

PHASE II: Evaluate novel TAF algorithm modules within a real-world SR operational scenario that includes realistic radar clutter background environments. Incorporate other applications to support testing (e.g. displays). Conduct tests to characterize algorithm performance and utility. Validate algorithm(s) effectiveness. Deliver TAF algorithm description, test results, and detailed Phase III transition plan

PHASE III / DUAL USE: Military application: These new TAF algorithms, tools, and methodology will optimize the utility of SR sensors for robust multi-sensor and multi-target tracking of military targets in any region of interest & environment. Commercial application: These advanced TAF algorithms could be incorporated in commercial sensors for robust target tracking to support civil air, sea, ground traffic control, collision avoidance, and navigation.

REFERENCES:
1. D. L. Hall, Mathematical Techniques in Multi-sensor Data Fusion, Artech House, Norward, Ma, 1992.

2. Bar-Shalom, and T.E. Fortmann, Tracking and Data Association, Academic Press, New York, 1998.

3. J.W. Guan, and D.A. Bell, Evidence Theory and It's Applications, vol 1. Studies in Computer Science and Artificial Intelligence

4. R.P.S. Mahler, Statistical Multisource-Multitarget: Information Fusion, Artech House, Massachusetts, 2007.

KEYWORDS: space-radar, multi-sensor, multi-target, tracking, fusion, algorithm, moving-targets

AF081-031 TITLE: Wideband,Lightweight, Beamformer

TECHNOLOGY AREAS: Sensors, Electronics

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

OBJECTIVE: To develop steerable wideband beams by developing a thin 0.5-18 GHz Wideband. Lightweight Power Combiner/Beamformer Capable of Beam Steering

DESCRIPTION: As wideband apertures come into use, the ability of transmit and receive systems to fully utilize this bandwidth is limited by the passive network behind the aperture. Wideband systems have the potential for concurrent multifunctional operation, such as operating in multiple radar modes simultaneously and/or performing both radar and communications functions simultaneously. Such systems require steerable wideband beams. The goal of this effort will be to develop a lightweight, thin beamformer that can scan a minimum of +/- 60 degrees with a maximum of 7.5 degrees resolution in at least one plane. Novel architectures will be considered. Historically, true time delay and hybrid (true time delay plus discrete phase shifters) have been investigated. A minimum of 16 elements is to be considered for this array, although any architecture that is to be pursued must be scalable to larger numbers of elements. The thinness and weight of the beamformer will be dictated by the technology choice and overall design architecture but as a goal the 16 element array will be no deeper than 1 inch and weigh no more than 1 pound. Trade space analyses of candidate implementation technologies will be performed. The implementation strategy will be verified through software simulation of architectures/techniques developed during phase I.

PHASE I: Perform trade space analyses of candidate implementation technologies. Identify and design candidate beamformer architectures and prototype proof - of - concept devices that will give an indication for the success of Phase II.

PHASE II: Perform detailed design, simulation and implementation of a wideband, thin, lightweight 0.5 to 18 GHz beamformer that implements at least 16 channels of the architecture developed during Phase I. The implementation strategy will be verified through software simulation of architectures/techniques developed during Phase I.

PHASE III / DUAL USE: Military application: The contractor will develop wideband beamformer antennas for military/commercial aircraft and other platforms. Affordability will be a key focus for this application. This includes installation cost. Commercial application: The frequency band for a commercial application will be a subset of the 0.5 to 18 GHz frequency band. A partnering with a commercial supplier can be established to ensure the transition.

REFERENCES:

1. Hansen, R.C., Phased Array Antennas, Wiley and Co., Hoboken, NJ, 1998.

2. Mailloux, R.J., Phased Array Antenna Handbook, Artech House, Norwood, MA, 1994.

3. Key Circuits for a Reconfigurable and Bi-directional Beamformer for Ultra wideband Applications
T. Nilsson, C. Samuelsson, M. Alfredson and A. Ouacha
Swedish Defence Research Agency (FOI)
Department of Microwave Technology, SE-581 11; Linköping, Sweden; tonnil@foi.se, , matal@foi.se, azizcarsam@foi.se@foi.se

4. Optical Engineering - Jan 2003 - Vol 42, Issue 1, pp. 239-244, Continuous true-time-delay beamforming employing a tunable multiwavelength fiber ring laser source with equally increased or decreased wavelength spacing; Jianliang Yang, Jianping Yao, Yunqi Liu, and Swee Chuan Tjin; Nanyang Technological University, School of Electrical and Electronic Engineering, Photonics Research Group, Nanyang Avenue, Singapore 639798; (Received Mar. 21, 2002; revised Jul. 1, 2002; accepted Jul. 8, 2002)

KEYWORDS: Topic Keywords: Beamformer, phased array antenna, true time delay, phase shifter, planar transmission lines.

AF081-032 TITLE: Material Process Improvement for High-Performance Optical Ceramic Transparent Armor

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop and demonstrate advanced, low-cost processing methods for optical ceramic transparent armor.

DESCRIPTION: High-performance optical ceramic transparent armor materials such as aluminum oxynitride (ALON) have demonstrated the greatest improved performance against armor-piercing ballistic threats over that for conventional materials, but with poorly developed processing methods. The unclassified definition of the ballistic performance improvement of these new materials is that of no more than half the aerial density compared to conventional materials. The goals of this program include eventual processing and successful ballistic testing of minimum size 1-by-2-foot panels for protection against the 0.50-caliber armor piercing threat. Additionally, these new materials are prohibitively more costly to fabricate to required configurations due to the large number of low-yield, labor-intensive processing steps required for them to achieve optical transparency and excellent ballistic resistance. More cost-effective, high-rate processing methods are needed to make these materials more readily available in product sizes required for current applications in aircraft and vehicles.

PHASE I: Develop innovative processing methods for new optical ceramic materials to reduce processing time and increasing product yield by 50 percent while retaining ballistic performance. Demonstration of one optical 12-by-12-inch panel. Initial cost analysis performed with process yields and rates defined.

PHASE II: Minimum of 12 prototype optical panels shall be fabricated to 14 by 20 inches or greater with processing methods of Phase I. Product feasibility demonstrated with no significant deterioration in optical quality of product, successfully meeting ballistic performance against 0.50-caliber armor-piercing threats. Detailed cost analysis shall be performed defining size, process rate, and product yield.

PHASE III / DUAL USE: Military application: Transport aircraft, gunships, and personnel ground-armored vehicles will benefit from this development. Transparent armor is needed for protection of important personnel in civilian environments. Commercial application: Police SWAT team applications, VIP vehicles, and VIP speaker podium protection are potential commercial applications.

REFERENCES:
1. Wahl, J., and Hartnett, T., “Recent advances in ALON optical ceramic,"" Proceedings of SPIE Windows and Domes, Volume 5786, March 2005.

2. Cook, R., Kochis, M., Reimanis, I., and Kleebe, H., “A new powder production route for transparent spinel windows,"" Proceedings of SPIE Windows and Domes, Volume 5786, March 2005.

KEYWORDS: aluminum oxynitride, ALON, ballistic testing, optical ceramic materials, transparent armor

AF081-033 TITLE: Modeling of Nondestructive Evaluation (NDE) Processes for Reliability Assessment

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop application-optimized methods to validate the sensitivity of NDE processes using model-based methods to determine probability of detection (POD).

DESCRIPTION: Reliability of nondestructive inspection (NDI) techniques and NDE processes can be determined through rigorous POD studies. Difficult-to-inspect aerospace components, which include materials such as titanium, steel, aluminum, or a combination of all three; structures with limited access; and advanced inspection techniques, such as automated methods, phased array methods, and other new developments in the field of NDE, require validation before they are deployed as a new inspection process or technique. The requirements for a POD study are defined in MIL-HDBK-1823. These studies typically include a statistically significant number of samples prepared with the geometry of the part being inspected. A statistically significant number of representative flaws are introduced into these samples, preferably with the same characteristics as the flaws naturally occurring in the geometry of interest. The time and cost to perform such a comprehensive POD study are significant and burdensome to the process of deploying new inspection methods and techniques. The complexity and cost of this effort require the development of model-assisted methods to determine the POD of new inspection methods and techniques as they are introduced and maintained as part of a cost-effective maintenance process. Validation processes can include limited component trial analyses and verification studies or the completion of a full, rigorous POD study. The number of samples required for a full POD study following the guidance in MIL-HDBK-1823 can be substantial when considering such assemblies as large titanium structural parts. In these large titanium structures, the cost to manufacture multiple sets of representative samples is prohibitive. However, the inspection of these structures is a mandatory element before and during their use on aircraft structures. Therefore, research is needed to develop the process for evaluating the reliability of the inspection process using model-based methods. Utilizing transfer functions between various structures with similar material, geometry, or inspection scenarios, these models present an opportunity to validate a new inspection process within defined parameters. Preliminary work in this area has been accomplished as indicated in the references for this topic. However, the full integration of generic model-based approaches for ultrasonic inspection of large, nonaluminum structures has not been performed. Additional research required in this topic includes the development and/or integration of modeling of ultrasonic waves in titanium and other materials for the detection of fatigue cracks within specific geometric configurations. The integration of these modeling efforts must include the variations anticipated in the response from a defect such as fatigue crack to determine the sensitivity and reliability of the inspection process for these types of materials.

PHASE I: Demonstrate the feasibility of using a model-based approach to assess the reliability of an ultrasonic inspection of a titanium casting and/or forging that includes response from fatigue cracks.

PHASE II: The output of the feasibility product from Phase I would be further developed to include the variations observed in manufactured parts and would support a comprehensive validation effort for representative inspection scenarios.

PHASE III / DUAL USE: Military application: Model-assisted reliability methods developed under this topic should have extensive government and commercial applications, including aerospace, nuclear, and civil structure inspection applications. Commercial application: Inspection processes detecting damage in aircraft is highly important. This process will aid in development and application of inspection techniques for components requiring high fidelity examination.

REFERENCES:

1. Model-Assisted POD Working Group: http://www.cnde.iastate.edu/MAPOD

2. Lindgren, E.A., Aldrin, J.C., Knopp, J., Buynak, C.F., and Malas, J., ""Practical Methods to Simplify the Probability of Detection Process," Proceedings of the 2006 ASIP Conference, San Antonio TX, December 2006.

KEYWORDS: aerospace structures, fatigue cracks, nondestructive evaluation, NDE, nondestructive inspection, NDI, probability of detection, POD, titanium, ultrasound

AF081-034 TITLE: Nondestructive Evaluation (NDE) Techniques for Repaired Integrally Bladed Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop and demonstrate the feasibility of inspection techniques for the nondestructive evaluation (NDE) of repaired airfoils of integrally bladed rotors of modern gas turbine engines.

DESCRIPTION: Some modern gas turbine engines utilize integrally bladed rotors (IBR), sometimes called blisks (bladed disks), in the design of the fan and compressor. IBRs are unique because during fabrication the airfoil blades are bonded to a hub to form an integral structure, which offers performance benefits over the conventional dovetail design. There are many instances in operation when foreign object damage (FOD) to airfoils leads to the need for a partial or blend repair process. In some cases, material is added to restore lost strength and subsequently ground away to reshape the airfoil; and in other cases, the integrity can be restored by simply grinding out the FOD and rebalancing the component. Small damage is repaired using various patch-repair techniques. There are strict limits for which partial repair may be used, driven by the location and extent of the damage; and when the limits are exceeded, a decision must be made to condemn the component or apply a full-blade repair process. A full-blade repair requires the airfoil to be cut off and a new full-blade reattached, reattached using a solid-state joining process. The critical nature of these components requires that the new joint of the full-blade repair be free of defects such as internal porosity, planar low-density defects, and surface nonconformities. Good joining procedures and statistical process control are effective in producing defect-free joints; however, NDE techniques must still be employed on a periodic basis to ensure that the structural integrity of the repaired joint is acceptable. The main challenges are that the inspection area has limited accessibility, the object varies in contour, and it has a changing cross section. It is likely that multiple NDE techniques will be needed to assure full coverage, detect the different defect types, and provide the required sensitivity. This Phase I effort shall develop an inspection technique for the detection of subsurface and surface defects. Development and demonstration of the technique shall be on simple coupons fabricated by solid-state and fusion-joining techniques representative of current aerospace practices for a full-blade repair. For the Phase I effort, coupons shall be fabricated to evaluate NDE capability with limited access constraints but with a constant contour and cross section. The offeror is responsible for obtaining calibration samples representative of the joining process consistent with IBR design. Working with a gas turbine engine original equipment manufacturer is encouraged to define material and specimen requirements and obtain calibration samples.

PHASE I: The effort shall develop an inspection technique for detection of subsurface and surface defects in wrought Ti6Al-4V. Defect detection requirements include a 10-mil surface flaw and a 10-by-10-mil planar subsurface low-density flaw. Thickness of the inspection zone shall be one-half inch.

PHASE II: The Phase II effort will scale up the technique to include varying cross section and changing contour in addition to limited access. Scale up shall also demonstrate that the NDE technique is economical, production implementable, and reliable. A preliminary probability of detection analysis shall be included as part of this effort.

PHASE III / DUAL USE: Military application: This technology will benefit any military engine of integral rotor design where limited access and complex geometry constraints exists and where small surface or subsurface flaws must be detected. Commercial application: This technology will benefit any commercial engine of integral rotor design for which limited access, complex geometry constraints exist and where small surface or subsurface flaws must be detected.

REFERENCES:
1. O'Brien, R.L., Editor, ""Welding Handbook,"" Eighth Edition, Vol 2, pp 672-710, 714-738, and 740-762, 1998.

KEYWORDS: fusion joining, gas turbine engines, integrally bladed rotor, nondestructive evaluation, NDE, nondestructive inspection, NDI, solid-state joining

AF081-035 TITLE: Low Cost Titanium Refinement and Processing

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Based on existing commercial titanium alloys, determine the limits of alloy modifications possible using next generation chemical or electrolytic refinement processes and quantify the business case.

DESCRIPTION: Viable approaches to produce Ti alloys with chemical or electrolytic refinement processes have been demonstrated in recent government programs. The processes offer the possibility of producing titanium and its alloys at a much reduced cost from conventional production routes. Knowledge is, however, sparse about the limits to the type and amount of alloying elements (Al, V, Sn, Zr, Mo, Fe, Cr, etc) that can be added during these reduction processes. Build upon recent advances in direct conversion of ores or intermediate compounds to determine the types and amounts of alloying elements that can be added during the refinement/reduction process to cost-effectively produce desirable alloys of Ti containing Al, V, Sn, Zr, Mo, Fe, Cr, etc.

PHASE I: The initial effort will identify and define a method to chemically or electrochemically produce titanium alloys. The limits of the selected process route will be probed to define the limits of alloy content and alloying elements that the method can deliver. Preliminary experiments may be required.

PHASE II: The Phase II effort will demonstrate the production of existing and novel alloys in sufficient quantity that consolidated and/or melted product can be evaluated for mechanical performance. A detailed business case will be developed that quantifies the cost savings in aerospace systems.

PHASE III / DUAL USE: Military application: All future military aerospace vehicles need high strength titanium alloys. This project will aim at reducing both the price and the lead time for delivery of mill product. Commercial application: The increased importance of Ti in commercial aircraft, e.g. B-787, will ensure commercial spinoff by lowering the cost of aerospace grade titanium alloys.

REFERENCES:
1. ""Cost Affordable Titanium"", eds F.H. Froes, M. Ashraf Imam and D. Fray, TMS 2004; multiple papers.

2. TMS Annual Meeting, 25 Feb - 1 Mar 2007, Orlando FL, ""Innovations in Titanium Technology Symposium""

KEYWORDS: titanium, electrochemical reduction, chemical reduction, mechanical properties

AF081-036 TITLE: Development of Rapid Prototyping Process for Ceramic Cores for Investment Castings

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop rapid prototyping processes to use for the production of detailed, geometrically stable cores for investment castings.

DESCRIPTION: Stereo lithography has enabled the casting industry to rapidly fabricate and iterate molds for shells used for investment casting. A similar decrease in processing time for the rapid fabrication of ceramic cores is sought by this solicitation. While some lessons learned from the development of stereo lithography may be useful, the solicitation is open to any rapid fabrication process. The rapid fabrication process must overcome the limitations of stereo lithography such as surface roughness and result in a core that will not be degraded by contact with molten metal.

Current practice for the production of cores is an injection molding of ceramic into a metal die. Due to the high pressure within the die, a fine level of detail can be incorporated into the core without degradation of geometric stability at metal pour temperatures.

However, the metal dies are costly to machine and require a long lead time, hindering the ability to optimize core design. There is a definite need to develop a relatively inexpensive, short lead-time process to produce prototype cores for iteration of design while minimizing distortion and instability at high temperatures.

The project will develop a process that provides efficient production of investment casting cores to allow short-turnaround design changes for testing without sacrificing core stability and integrity, specifically for investment casting of titanium and nickel alloys. It will be important to consider both the geometric instabilities generated during the production of the core and also the instabilities associated with high-temperature behavior. Consideration will also be given to core removal following the casting process. It is desirable to use methods for core removal that are currently used in industry.

The Air Force (AF) is soliciting proposals to develop a process for the production of cores for investment casting of nickel and titanium components that shortens the cycle time while maintaining the rigidity of the core during the casting process. Current components that could utilize this process include hollow blades. Select the rapid prototyping process and its required processing parameters and produce a feasibility demonstration component for validation testing. Determine the required control of processing parameters to satisfy the use of titanium/nickel-alloy investment castings. Compare the feasibility results with a current art baseline. It is desired that the report and prototype cores be delivered to the AF for further testing and evaluation.

The proposers should consult the ASM Metals Handbook referenced below for typical constraints on the investment casting process used in the fabrication of turbine engine components.

PHASE I: Design the process and validation testing plans, in principle, and carry out basic test articles to compare, and then choose the more promising processing parameters.

PHASE II: Using the rapid prototype process of choice, produce the prototype core and test its rigidity based on environment conditions during typical titanium/nickel-alloy investment casting processes. It is desired that the model be delivered to the AF at the end of the effort for further evaluation and testing.

PHASE III / DUAL USE: Military application: The developed process could be used with modification across all aerospace materials, including aluminum, titanium, and nickel metals. Commercial application: The developed process could be used with modification across all aerospace materials, including aluminum, titanium, and nickel metals.

REFERENCES:
1. Boyer, Howard and Gall, Timothy, Editors, ""Metals Handbook,"" Ninth Edition, Vol. 15, Casting, ASM International, 1988.

KEYWORDS: casting, ceramic core, investment, rapid prototyping

AF081-037 TITLE: High-Temperature, Abrasion-Resistant Coating

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a high-temperature, abrasion-resistant coating with 450°F continuous use temperature for aircraft outer mold-line applications.

DESCRIPTION: Abrasion-resistant coatings are often used to protect composite surfaces of aircraft, more specifically, when metallic blade seals are in contact with the composite surface. These coatings are thin and usually spray applied. However, existing products typically do not perform above 350°F without some degradation of performance. These materials wear through after exposure to high temperatures, causing extensive damage to the underlying composite substrate. Therefore, an abrasion-resistant coating that can withstand temperatures up to 650°F for short durations with 450°F continuous use is required. General material requirements include abrasion-resistance greater than 1,000 cycles using taber abrasion, resistance to various aircraft fluids, and a spray application thickness limitation of 0.010 inch. Current test methods are not adequate for predicting the abrasive response of a material at high temperatures and should be taken into consideration during development. A test method may need to be derived to validate coating performance.

PHASE I: The contractor shall identify candidate materials to develop an abrasion-resistant coating that can withstand temperatures up to 650°F. The contractor shall demonstrate thermal stability, abrasion resistance at temperature, and compatibility with high-temperature structure substrates.

PHASE II: Further development of candidate materials for improved thermal stability, color, and coating performance. Processing techniques shall be developed with the assumption that individual parts will be coated. Large-scale coating processes for entire aircraft are not to be pursued.

PHASE III / DUAL USE: Military application: Similar high-temperature components for a wide vairiety of military and commercial aircraft. Commercial application: Industrial and automotive components will also benefit from these high-temperature protective coatings.

REFERENCES:
1. Shipway, P.H. and Ngao, N.K., ""Microscale Abrasive Wear of Polymeric Materials,"" Wear Journal, Vol. 255, Issues 1-6, August-September 2003, pp. 742-750.

2. Allsopp, D.N. and Hutchings, I.M., ""Micro-scale Abrasion and Scatch Response of PVD Coatings at Elevated Temperatures,"" Wear Journal, Vol. 251, Issues 1-12, October 2001, pp. 1308-1314.

3. Rutherford, K.L., Trezona, R.I., Ramamurthy, A.C., and Hutchings, I.M., ""The Abrasive and Erosive Wear of Polymeric Paint Films,"" Wear Journal, Vol. 203-204, March 1997, pp. 325-334.

KEYWORDS: abrasion resistance, coating, composite protection, high temperature, polymeric, wear

AF081-038 TITLE: Modeling and Simulation for Robust Ceramic Matrix Composite (CMC) Manufacturing Processes

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop modeling and simulation tools for the melt-infiltration process to facilitate robust ceramic matrix composite (CMC) manufacturing processes.DESCRIPTION: As the power density of modern propulsion systems increases, the need for new materials capable of higher operating temperatures is essential for turbine hot section components. SiC/SiC CMC, by virtue of low-density and high-temperature capability, are prime candidates for turbine applications. To be cost effective, the development cycle time and cost for CMCs must be reduced significantly. Modeling and simulation-driven optimization of manufacturing techniques can reduce the cost and cycle time to implement advanced CMCs in gas turbine engines. This approach will also reduce the manufacturing trials required to optimize the process for making specific components. One particular area of interest is the development of simulation tools to model the melt-infiltration process used to densify certain CMC components. Key mechanisms to be included in a physics-based modeling approach are flow through porous media, chemical reaction mechanisms, volumetric and temperature changes, the impact of surface characteristics on capillary flow, and residual stress effects. A simulation-based approach will help achieve full densification of parts with minimal defects, dimensional distortions, and residual stress. The offeror should conduct a detailed literature search to help identify models that can represent the physics of the melt-infiltration process. Development of the model in Phase I will be strongly influenced by the details of the melt-infiltration process; teaming with a CMC manufacturer is highly recommended. The potential cost savings and cycle time reductions of the simulation-based approach should be validated in Phase II; one or more engine components should be identified as test cases. Validation will be extremely dependent on detailed component geometry; teaming with an engine original equipment manufacturer (OEM) is also highly recommended. Commercialization plans and qualification requirements should be established to offer these new techniques to the aerospace industry for evaluation and qualification in Phase III.

PHASE I: Demonstrate the feasibility of simulating the melt-infiltration process for CMCs using a physics-based modeling approach that includes the ability to simulate all relevant physical phenomena. Demonstrate the ability to accurately represent the flow front, temperature change, & residual stress state.

PHASE II: Fully develop the manufacturing simulation tools developed in Phase I and validate the models and tools on typical CMC turbine engine components. Working closely with OE and CMC component manufacturers, demonstrate the cost and/or cycle time reduction claims.

PHASE III / DUAL USE: Military application: Melt-infiltrated CMCs are applicable to military engine hot-section components such as combustors, turbines, and exhaust components and offer weight savings, improved durability, and reduced cooling. Commercial application: Melt-infiltrated CMCs are in development for commercial and industrial applications such as power turbines and commercial aircraft engine components. Developments would be fully transferable.

REFERENCES:
1. Erdal, M., Guceri, S., and Danforth, S.C., ""Impregnation Molding of Particle-Filled Preceramic Polymer Infiltration Into Fiber Preforms: Process Modeling,"" J. Am. Cer. Soc., Vol. 82, No. 8, pp. 2017-2028 (1999).

2. Goela, J.S., and Pickering, M.A., ""CVD-SiC Manufacturing Process Reproducibility,"" Cer. Eng. Sci. Proc., Vol. 19, No. 4, pp. 579-588 (1998).

3. Materials & Manufacturing Directorate web site, www.ml.afrl.af.mil

KEYWORDS: ceramic matrix composites, CMC, cost, cycle time, manufacturing, melt infiltration, process characterization, process modeling

AF081-039 TITLE: Rapid Method for Aircraft Fastener Surface Preparation

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors

OBJECTIVE: Metallic fasteners are hand abraded to prepare the surface for primer application. An alternative process is desired to save labor hours and associated hazardous materials expense.

DESCRIPTION: The preparation of aerospace fasteners for installation and subsequent painting is currently a labor-intensive process to obtain proper adhesion, corrosion protection, and electrical properties. The fasteners are used to join aluminum and composite airframes. Titanium fasteners are used most often. The fastener heads are currently grit blasted to provide adequate adhesion prior to installation. After installation, a small amount of chromated primer is applied to each individual fastener to prevent corrosion of aluminum substrate. After curing for a specified amount of time, an electrically conductive sealant is applied to provide a smooth exterior surface. This operation is currently performed by hand for thousands of fasteners on each aircraft. Advancements in materials to reduce or eliminate the amount of materials or processing steps and/or advancements in application equipment and robotics would reduce the costs and increase the throughput of this manufacturing operation. Coordination with a prime contractor for integration of the technology to manufacturing environments is encouraged.

PHASE I: Investigate alternative materials and nonmanual processes for use in surface preparation of metallic fasteners. Demonstrate desired mechanical, electrical, and corrosion-protection properties.

PHASE II: Demonstration of the Phase I materials and/or processes to aircraft subassembly. Validate electrical intregrity and corrosion/exterior durability characteristics in a complete subassembly or structure.

PHASE III / DUAL USE: Military application: New technology will be used on new military aircraft production and/or sustainment of existing aircraft structures. Commercial application: Potential for private sector use in manufacturing of commercial aircraft and aluminum alloy structures.

REFERENCES:
1. US Military Specification: Polyurethane Coatings for Aircraft and Support Equipment, MIL-PRF-85285C (AS), 30 April 1997.

2. Thompson, S.D., White, B.L., and Snides, J.A., ""Accerlerated Corrosion Testing of Graphite/Epoxy Composites and Aluminum Alloy Mechanically Fastened Joints,"" Final Report, AFWAL-TR-84-3115 (AD Number: ADA164772), Wright-Patterson AFB OH, 1985.

3. Technical Standard Order: Aircraft Mechanical Fasteners, TSO-C148, 1997.

KEYWORDS: metallic fasteners, surface preparation, hazardous materials, installation, corrosion

AF081-040 TITLE: Wear-Resistant Coatings for Aircraft Structures

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop wear-resistant coatings for aircraft structures.

DESCRIPTION: Fighter aircraft must operate with precision and reliability in extreme environments to accomplish Air Force missions effectively and economically. These aircraft have many moving parts that are subjected to high wear conditions across large temperature, load, and humidity ranges. At present, advanced wear-resistant coatings are not prevalent in aeronautical components. Coating advancements over the last 20 years have resulted in significantly better coatings, i.e., toughness and adhesion. Recent advancements are being made through the use of nanostructured coating architectures as well as advancements in ""smart"" coatings where embedded sensors/devices can predict coating lifetimes and operating parameters. The next-generation wear-resistant coating technologies may have a significant impact on the cost and performance of advanced systems such as aeronautical components. This program seeks to create, demonstrate, and transition innovative physical vapor deposition smart coatings technologies with relevance to aircraft components that can significantly reduce wear and increase component lifetimes in the extreme environments in which Air Force systems operate.

PHASE I: Identify potential applications for advanced wear-resistant coatings on aircraft structures/components. Demonstrate the application and performance on representative substrate materials with bench-level wear tests at various conditions of temperature, load, and humidity relevant to the application.

PHASE II: Apply an optimized wear-resistant coating to selected aircraft subcomponents for wear evaluation in a flight-simulated condition. Evaluate the economic feasibility (initial costs and repair costs) for inclusion of the coating technology on flight hardware.

PHASE III / DUAL USE: Military application: Wear-resistant coatings have application across aircraft and ground-based Air Force systems and DoD weapon systems. Commercial application: A large commercial presence exists for wear-resistant coatings in the tooling industry. However, advanced technologies may pave the way for more widespread use in precision applications.

REFERENCES:
1. Voevodin, A.A., Capano, M.A., Laube, S.J.P., Donley, M.S., and Zabinski, J.S., ""Design of a Ti/TiC/DLC Functionally Gradient Coating Based on Studies of Structural Transitions in Ti-C Films,"" Thin Solid Films, Vol. 298, pp. 107-115, 1997.

2. Voevodin, A.A., O'Neill, J.P., and Zabinski, J.S., ""WC/DLC/WS2 Nanocomposite Coatings for Aerospace Tribology,"" Tribology Letters, Vol. 7, pp. 75-78, 1999.

KEYWORDS: adhesion, aircraft structures, coatings, erosion, jet engines, high temperature, physical vapor deposition, wear resistance.

AF081-041 TITLE: Innovative Coating Removal Techniques

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop removal techniques for coatings that are innovative. Need on-aircraft external coating selective removal process. Removal process cannot damage aircraft structure or underlying primers.

DESCRIPTION: Current coatings are removed via mechanical and hazardous chemical means. This is time consuming, waste producing, and not selective. The field and depot have a need to selectively remove coatings. Mechanical and chemical removal is not selective. It does not allow a top coat to be removed from a primer or coatings around doors to be removed without harming the surrounding coatings. It also does not provide for tapering of coating layers.

This program would require innovative techniques other than mechanical or chemical removal. It could include reformulation of coatings to facilitate removal or an easily removed primer or adhesive layer. It could also include selective removal processes via laser or other means. Solution is not limited to standard techniques and can be a system approach.

PHASE I: Contractor shall show proof of concept for a removal technique. Evidence shall be submitted to show that the removal concept has significant potential for fast and effective removal.

PHASE II: Contractor shall completely develop a removal technique, perform testing to demonstrate rapid removal rates without substrate damage.

PHASE III / DUAL USE: Military application: Applicable to military weapon systems. Commercial application: Could be applicable to standard aircraft coatings.

REFERENCES:
1. Reinhart, Ted, ""Rapid Removal of Radar Absorbing Coating,"" UDR-TR-2000-00031, February 2000.

2. Fletcher, Alan, ""SAE Aerospace Information Report on Aircraft Sealant Removal Techniques,"" 2007.

3. Fletcher, Alan, ""Evaluation of Electrically Conductive Materials,"" AFRL-ML-TR-2006-4203 (Ad Number B321259), 2006.

KEYWORDS: coating, removal

AF081-044 TITLE: High Speed Penetration Modeling

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: Develop improved assessment and simulation techniques for evaluating the dynamic response of crushable granular and/or viscoelastic materials packaged within cavitities of higher strength containers subjected to harsh environments such as high speed impact and impacts into high strength materials such as rock and high performance concrete.

DESCRIPTION: It is becoming critically important to be able to accurately predict the dynamic response of penetrating warheads. Weapon/target interaction scenarios that once assumed weapon survivability must now be assessed at higher levels of fidelity. Ultra-high performance concrete structures, bedrock tunnel facilities, basement bunkers, and high velocity impact conditions all subject penetrating warheads to extreme loading conditions. The filler material (explosive or simulant), depending on the composition, can be either elastically compressed or plastically compacted several inches during the impact/penetration event. The filler material may then rebound and produce extreme loading conditions for both mechanical and electronic components contained in the warhead and possibly result in a system failure.

There is a need to develop improved modeling capabilities and the diagnostic tools required to collect validation data for these models. Additionally, there is a need to demonstrate the ability to model the impact/shock response and to more accurately assess component-level concerns such as fuze electrical boards, fuze wells, threaded retaining rings, closure plates and other complex components that must survive the impact and penetration events. Modeling innovations to capture material/component response are important to understand the influences of load paths and how to mitigate or isolate component vulnerability from shock/impact loads.

PHASE I: Develop innovative conceptual diagnostics and modeling capabilities to better understand and quantify hard target penetrating warhead response under extreme dynamic loading conditions. Prepare models in sufficient detail and fidelity that they may be readily demonstrated in the next phase.

PHASE II: Refine and demonstrate new analytical techniques and diagnostic tools. Correlate these improved analytical techniques with the innovative predictive modeling capabilities developed in the previous phase. The models will be exercised sufficiently to demonstrate that dynamic response can be characterized under harsh impact/penetration conditions.

PHASE III / DUAL USE: Military application: The new analytical techniques and predictive capabilities could be used by all branches of the military for evaluating the dynamic response of hard target penetrators subjected to harsh environments such as high speed impacts into any target material as well as conventional speed impacts into rock and high performance concrete. Commercial application: Diagnostic techniques could be used for aircraft and automotive design for enhanced crash worthiness as well as for aircraft and automotive Black Boxes for crash analyses. These techniques and tools could also be used by NASA for the design of survivable asteroid impact probes and space vehicle/satellite shield design.

REFERENCES:

1. Accession Number: ADA410839
Full Text (pdf) Availability:
Url: http://handle.dtic.mil/100.2/ADA410839
Citation Status: ACTIVE
Title: Dynamic Deformation Properties of Energetic Composite Materials

2. Accession Number: ADA419438
Full Text (pdf) Availability:
Url: http://handle.dtic.mil/100.2/ADA419438
Citation Status: ACTIVE
Title: Evaluation of PBXN-109: The Explosive Fill for the PenguinAnti-Ship Missile Warhead

3. Accession Number: ADA263244
Citation Status: ACTIVE
Title: The Equivalent Flat Nose Diameter of Hemispherical Nose Cylindrical Projectiles for Impact Induced Detonation of Energetic Materials.
Fields and Groups : 190100 - AMMUNITION AND EXPLOSIVES
190900 - EXPLOSIONS
Corporate Author: ARMY MISSILE COMMAND REDSTONE ARSENAL AL SYSTEMS SIMULATION AND DEVELOPMENT DIRECTORATE

4. Accession Number: ADP000477
Citation Status: ACTIVE
Title: Advanced Development of Insensitive PBX's for Less Vulnerable Munitions,
Corporate Author: NAVAL SURFACE WEAPONS CENTER SILVER SPRING MD

5. Accession Number: AD0915795
Citation Status: ACTIVE
Title: The Sensitivity, Performance, and Material Properties of Some High Explosive Formulations
Fields and Groups : 190100 - AMMUNITION AND EXPLOSIVES
Corporate Author: PICATINNY ARSENAL DOVER NJ

KEYWORDS: Impact, Penetration, Hard Target Defeat, Dynamic Response, Low-Order Reaction, Deflagration, Detonation, Auto-Initiation.

AF081-045 TITLE: <u>Penetration Survivable Advanced Energetics</u>

TECHNOLOGY AREAS: Battlespace, Weapons

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

OBJECTIVE: Develop and validate a model/test for meso-scale interaction of explosive components during a penetration event. Typical environment: rubbery binder material with solid particle components.

DESCRIPTION: Typically explosives are high solids which means the amount of solid particles can range from 60% to 90% of the total volume. An innovative solution to this complex environment would be to model the interaction of the binder with the casewall, binder with the particle or the particle to particle interaction. There are a number of things occurring in the explosive during the penetration event, for example; particle fracture, debonding, friction, localized shear heating, and void collapse. The ability to model the response of the explosive fill to the penetration event will help the warhead designer to develop an explosive that has a better chance of surviving the penetration event.

PHASE I: Develop a model that can simulate the binder/particle interaction. Develop a planned set of experiments that can verify the results from the model.

PHASE II: Develop and demonstrate potential new test apparatus and conduct testing to evaluate model results.

PHASE III / DUAL USE: Military application: The computer models and new test techniques could be used by all branches of the military for looking at explosives subjected to a variety of conditions such as shipping and handling. Commercial application: Commercial Explosive Shipping Safety Information. The strength and behavior of the shredded tire particles in the binder would provide beneficial knowledge to pavement designers.

REFERENCES:

1. 11th International Detonation Symposium "Low Pressure Equation of State Measurements for Explosives Using Piston Test Techniques"

2. 12th International Detonation Symposium "A Test Method and Model to Determine the Thermal Initiation Properties of An Energetic Material in a Low Pressure Long Duration Event

KEYWORDS: Penetration, Hard Target, Survivable, Explosives, Advanced Energetics, Ordnance, Intense Pressure and Friction Test, Computer models, Simulations

AF081-047 TITLE: <u>Flight Control Technology for Tightly Controlled Hard Target Impact</u>

TECHNOLOGY AREAS: Air Platform, Weapons

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

OBJECTIVE: Develop innovative technologies and demonstrate the capability to tightly control high speed penetration weapons' attitude and angle-of-attack conditions at target impact.

DESCRIPTION: Hard and deeply buried target defeat is of high interest to the U. S. Air Force. To be able to accomplish this difficult mission, future penetration weapons must be capable of very high speed impact and be able to zero out any error in attitude and angle-of-attack. If these errors are not reduced to near zero, the high speed penetrators would not survive the violent impact conditions. Because targets themselves are becoming increasingly more difficult to penetrate, precise control of impact conditions, along with higher speeds, is imperative. Novel technologies and solutions are sought to accomplish the precise control of impact conditions. For example, precise control could be aided by airframe divert thrusters, innovative aerodynamic control methods, and advanced guidance algorithms, or a combination of the above. These are only suggested areas for determining the feasibility of solving this very complex problem. The field of potential solutions is wide open for researching the answers and presenting results in Phase I. Demonstrating the results is the primary goal in Phase II.

PHASE I: Conduct innovative research for technologies to precisely control penetration weapons' attitude and angle-of-attack at impact. Define and determine key technical challenges of the candidate solution approach. Develop model and simulate design. Present a plan to demonstrate the performance.

PHASE II: Develop, fabricate and test prototype hardware of the preferred design concept of Phase I.

PHASE III / DUAL USE: Military application: Transition the design concept technology to other Services. Commercial application: Precision autopilot application, mining and demolition work.

REFERENCES:

1. Air Force Research Laboratory/Munitions Directorate Public Website, http://www.eglin.af.mil/afrl_mn/

2. Fleeman, Eugene L., ""Technologies for Future Precision Strike Missile Systems - Missile Aeromechanics Technology "", Jul 2001, Accession #: ADP010952.

3. Berglund, Erik, ""Guidance and Control Technology"", 01 Jul 2001, Accession #: ADP010953.

4. Lu, Ping, Doman, David B., Schierman, John D., ""Adaptive Terminal Guidance for Hypervelocity Impact in Specified Direction"", 01 Jan 2006, Accession #: ADA445166.

5. Dupuis, A., Berner, C., Bernier, A., ""Aerodynamic Characteristic of the A3 DRDC-ISL Reference Projectile: Missile with Lattice Fins""; 12 Dec 2005
Accession #: ADA457243

KEYWORDS: Hard target defeat, penetration weapons, flight control, divert thrust control, aerodynamic control, reaction jet, advanced guidance

AF081-049 TITLE: Compact Multifunctional Ordnance for Urban Combat

TECHNOLOGY AREAS: Weapons

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

OBJECTIVE: Establish approaches to a compact multifunctional ordnance that can change its lethal mechanisms in real time to exploit the vulnerabilities of the target while minimizing collateral damage.

DESCRIPTION: The global war on terrorism (GWOT) has brought new military missions, concerns, and requirements—namely how to fight in urban settings and minimize collateral damage to noncombatants, friendly forces, and infrastructure. The Ordnance Division seeks cross-cutting technologies in damage mechanisms, energetic materials, and fuzing that promote (1) higher energy density and insensitivity during the munition storage/transport stage, (2) variable output during the energy release stage, and (3) variable coupling of this energy to the target during the target interaction stage.

The ideal ordnance has the following attributes: (1) variable yield or selectable lethal range for mission flexibility and low collateral damage; and (2) compactness for high weapon loadouts and compatibility with internal carriage aircraft, small unmanned air systems, or precision guided submunitions. AFRL/MN has high interest in new high-energy-density energetic materials and novel initiation methods (shock, electromagnetic, or a combination) that enable variable sensitivity (from an inert, non-detonable state to a fully sensitive, reactive state capable of full energy release), variable reaction rate (from slow burns to fast deflagration to detonation or detonation-like velocities), and variable volumetric effects (from low pressure, high impulse to high pressure, low impulse).

PHASE I: Develop novel approach(es) for varying explosive effect (yield or other metric) and use physics-based models to evaluate the concept(s). Develop success criteria and metrics. Conduct small-scale proof-of-concept test(s) to show concept feasibility and merits.

PHASE II: Develop, demonstrate, and validate an exploitable selectable effect in a prototype based on the modeling, concept development, and success criteria developed in Phase I. Deliverables are a medium-scale prototype demonstration, experimental data, a model baselined with experimental data, and substantiating analyses.

PHASE III / DUAL USE: Military applications: (1) selectable effects warheads suitable for military operations in urban terrain (MOUT); (2) controlled neutralization of improvised explosive devices (IEDs); (3) reactive armor; and (4) extremely insensitive detonating systems. Commercial applications: (1)safer automotive airbags with selective output adjusted for passenger size/weight; (2) low-collateral-damage ordnance for Homeland Security’s counter-terrorism units; (3) oil/gas well fire extinguishing; (4) mining/quarry operations; (5) explosive demolition; (6) pyrotechnics design, production, and disposal; (7) safe, green disposal of obsolete/expired explosives.

REFERENCES:

1. A.F. Belyaev, V.K. Bobolev, A.I. Korotkov, A.A. Sulimov, and S.V. Chuiko, "Transition from Deflagration to Detonation in Condensed Phases," Akademy Nauk SSSR – Ordena Lenina Institut Khimicheskoi Fiziki (Academy of Sciences of the USSR – Institute of Chemical Physics), Moscow, 1973. [Translation by R. Kondor, 1975, available from U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161, Report TT74-50028, ISBN-0-7065-1496-3, www.ntis.gov].

2. M.A. Cook and T.C. Gwyther, "Influence of Electric Fields on Shock of Detonation Transition," Utah University, Air Force Office of Scientific Research Report AFOSR-65-2653, 1965. [Approved for public release, DTIC Accession Number AD0629239, www.dtic.mil].

3. A.G. Merzhanov, Yu.A. Gordopolov, and V.S. Trofimov, "On the Possibility of Gasless Detonation in Condensed Systems," Shock Waves, Vol. 6, pp. 157-159, 1996.

4. A.Yu. Dolgoborodov M.N. Makhov, I.V. Kolbanev, A.N. Streletski, and V. E. Fortov, "Detonation in an Aluminum–Teflon Mixture," JETP Letters, 81 (7), pp. 311–314, 2005.

5. Various authors, "Multifunctional Energetic Materials," Materials Research Society Symposium Proceedings, Volume 896, 2006.

KEYWORDS: collateral damage, urban combat, dial-a-yield, selectable effects, volumetric effects, deflagration, insensitive munitions, dual-use materials, nanoenergetics

AF081-050 TITLE: Micro Munition Adaptive Structure Flight Control Technology

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Conduct innovative research to develop adaptive structure technologies which will enable in flight airframe reconfiguration of micro air vehicles.

DESCRIPTION: Due to packaging and collateral damage concerns one section of munition development is leading towards smaller more capable platforms. This miniaturization ultimately results in constraints of volume and energy for all systems onboard including flight control. This topic is to research innovative in flight airframe configuration changes utilizing adaptive structures or materials to achieve results that surpass servo driven methods.
Adaptive structures, which could incorporate a range of smart materials, could prove to be very useful to miniaturization efforts, especially in airframe configuration changes, i.e., morphing. For instance, utilizing adaptive structure technology the micro munition could convert from a loitering high aspect wing configuration into a sleek dash configuration for conducting strike missions or diverting quickly to another area of the battle space. Because of the small size of micro munitions the power budgets for actuation or morphing are small as compared to larger platforms. Elimination of larger, heavier and more expensive electromechanical servos would greatly enhance micro munition development. This technology should permit airframe configuration changes to optimize performance.

PHASE I: Identify research and develop innovative technologies to address the challenges of in flight airframe configuration changes. Design and fabricate a prototype adaptive structure actuator. Provide a demonstration plan for accomplishments to be made in Phase II.

PHASE II: Finalize development of the phase I technologies and produce functional hardware capable of being flight demonstrated as a representative micro air vehicle. The final deliverable will be a demonstration of the performance advantages of the developed adaptive structure technology.

PHASE III / DUAL USE: Military application: Micro Munitions and Micro Air vehicles Commercial application: Small Unmanned Air Vehicles for tracking suspects and vehicles; aid in search and rescue efforts

REFERENCES:
1. Goldfarb, Michael, ""An Elasto-Dynamic Omithoptic Flying Robot Insect,"" DTIC ADA398293

2. Lagoudas, Dimitris C. Sanders, Brian and Cross, Charles, ""AFOSR Workshop on Research and Applications of Active Materials and Smart Structures,"" DTIC ADA395003

3. Lynch, Christopher S., ""Development of Stress Gradient Enhanced Piezoelectric Actuator Composites,"" DTIC ADA435846

KEYWORDS: Micro Munition, Adaptive Structure, Flight Control

AF081-051 TITLE: Processing for Flexible Sensors

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop requirements and resolution-enhancing algorithms to provide a single sensor the capability of target track for guidance and fuzing.

DESCRIPTION: Situations occur in which two sensors, in disparate situations, must be used to provide adequate performance of a sensor system over the entire range. Significant cost and complexity savings could be realized at the system level if one of the sensors could be made sufficiently flexible to cover both operating conditions.

An example of this situation that is of interest to the military is Guidance Integrated Fuzing (GIF), in which the functionality of the weapon seeker (acquires and tracks the target at long ranges and relatively low update rates) and the weapon target detection device (TDD), the sensor used for detecting the target and providing the information for the fuzing function, which only needs to function at short ranges, but must operate at a very high rate to meet the stringent requirements of the developing endgame) be combined so that one sensor provides both functions adequately.

Insight into what the resulting performance would be for various sensors to be used in this dual-sensor mode is needed. For the GIF problem, as an example, the seeker sensor is usually active RF, and the TDD can be active RF or active or passive EO/IR.

The contractor is free to choose whatever approach may appear most likely to be fruitful. Attention is drawn to the fact that in biological systems, hyperacuity is a processing technique that appears to be used universally to extract information of adequate resolution from sensors that cannot provide it in some traditional sense.

PHASE I: Develop simulation to conduct trade studies of various sensor types and performances required for target track for guidance and fuzing. Prototype algorithms to both acquire and track a target as a seeker, and then perform TDD functions and target aimpoint selection. Recommend a preferred system.

PHASE II: Develop a prototype in hardware and software that will demonstrate the feasibility of the system recommended in phase I.

PHASE III / DUAL USE: Military application: Military application: Guidance Integrated Fuzing is of interest to all Services Commercial application: Generalizations of the developed technique would have commercial applications. For example, an inertial sensor capable of providing high resolution output at one bandwidth, and lower resolution output at a much higher bandwidth. Similarly, an acoustic sensor that could provide fine spectral resolution at one bandwidth, and less spectral resolution output at a much higher bandwidth.

REFERENCES:
1. J-Y Okamura and N. J. Strausfeld, “Visual System of Calliphorid Flies: Motion- and Orientation-Sensitive Visual Interneurons Supplying Dorsal Optic Glomeruli,” The Journal of Comparative Neurology, 500: 189 – 208 (2007)

KEYWORDS: sensor fusion; guidance integrated fuzing; guidance aided fuzing; hyperacuity; range fractionation

AF081-053 TITLE: Monitoring and Prognostics for Rolling Element Bearing Health in Gas Turbine Engines

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

OBJECTIVE: Reduce costs caused by failure of turbine engine bearings through monitoring bearing condition, predicting remaining life, and indicating preemptive action.

DESCRIPTION: Safety incidents due to failure of rolling element bearings in aircraft gas turbine engines are a significant cost to the Department of Defense. There are various diagnostic technologies currently fielded to detect impending bearing failure: magnetic chip detectors for collecting debris from engine lubrication system; off-line oil analysis for detecting metallic elements in engine lubricant which may indicate wear or damage to components; scanning electron microscope/energy dispersive X-ray (SEM/EDX) particle analysis for identifying particles in the lubrication system that originated from bearing damage; and vibration monitoring to detect damaged bearings. This Small Business Innovation Research (SBIR) topic is looking for improvements of current bearing health monitoring methods or new technological concepts that will reduce the costs due to bearing related safety incidents and/or have lower procurement and operational costs. Some technologies that have been looked at, but need further development, are detection and counting of particles in lubricant, X-ray fluorescence particle analysis, bearing load monitoring and active control of bearing thrust load, improved vibration sensing, intelligent lubricant filters, and bearing health prognostic algorithms. Other novel, effective technologies that are not listed above will also be considered.

PHASE I: Develop technological concept to predict impending bearing failure with sufficient warning to take mitigating actions. Warnings may be real time or maintenance action indications. Evidence that phase II goals can be met should be provided. Interaction with major engine companies is recommended.

PHASE II: Develop, test, and demonstrate an operable prototype device that fulfills the technological concept. Demonstration of prototype device should provide sufficient developmental maturity to allow design and production of deployable device and allow for an estimate to procure and operate the device.

PHASE III / DUAL USE: Military application: The technology to be developed will be used on military aircraft engines to predict impending bearing failure before damage occurs to the gas turbine engine and aircraft. Commercial application: Prognostics of bearings used in civilian aircraft, industrial gas turbines, power generation equipment, paper mills, metal rolling, etc., will decrease costs through better maintenance planning.

REFERENCES:
1. Hess, A., Calvello, G., and Dabney, T., ""PHM a key enabler for the JSF autonomic logistics support concept,"" Proceedings of the IEEE Aerospace Conference, IEEE, New York, Volume 6, 2004, pp. 3543-3550.

2. Hess, A., ""The Prognostic Requirement for Advanced Sensors and Non-Traditional Detection Technologies,"" DARPA/DSO Prognosis Bidder's Conference, September 26-27, 2002, Alexandria, VA, http://www.darpa.mil/dso/thrust/matdev/pdf/Hess.pdf.

KEYWORDS: rolling element bearing, gas turbine engine, engine health monitoring, prognostics, lubricant system, bearing failure

AF081-054 TITLE: Analyzing False Alarm Susceptibility and Assessing Mitigation and Prediction Strategies in Turbine Propulsion Health Management (PHM) Systems

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

OBJECTIVE: Develop a prototype decision and information fusion software tool which reduces vulnerabilities in PHM systems that lead to high false alarm rates.

DESCRIPTION: PHM systems are gaining wider acceptance and transitioning to advanced platforms for both ground and on-line applications. However, the potential for false alarms remains despite recent techniques employing high fidelity modeling and advanced techniques. Current experience shows false alarms, and can-not duplicate (CND) conditions occur at a higher rate than design predictions show. PHM system design vulnerabilities that lead to false alarms can arise from many sources, including signal conditioning noise, detection circuitry performance, engine electrical and transient events, sensor noise sensitivity, and interaction between these sources. New system designs are becoming more complex and interdependent, while the requirements for PHM to perform with greater resolution and predictive capability are increasing. As a result, mitigation of potentially high false alarm rates is a technical challenge in future advanced PHM systems. The consequences of false alarms vary from loss of efficiency to serious health monitoring performance degradation, below a baseline capability. Therefore, reducing vulnerabilities in PHM systems in an issue that must be addressed if expected cost, life, and safety benefits of these systems for turbine engines will be achieved. Current approaches to reduce false alarms employ design tradeoff analysis that evaluates relevant performance factors for a particular system application. These analyses are used to determine potential architectures, hardware technology, types of algorithms, detection thresholds and performance levels to achieve reasonable false alarm rates. However, reducing false alarms by trading resolution and detection thresholds (safety) for performance is not acceptable for future engine applications.

Reducing false alarms in complex PHM systems to very low rates, close to zero, beyond the state-of-the-art, will require decision fusion, information fusion, and low level anomaly detection technology used in new ways. Reducing false alarms may also require analysis of built-in test (BIT) capability, evaluation of system topology, failure analysis, and identifying system transient behavior as inputs for decision analysis. It is appropriate to develop a comprehensive strategy in designing a false alarm assessment and software mitigation capability that identifies system vulnerabilities by evaluating the system design static and dynamic factors. Static factors include noise levels, thresholds, and topology. Dynamic factors include sensitivity to multiple BITs, and model confidence.

Demonstrating relevant low-probability false alarm PHM system performance may be difficult to perform in the field due to the length of time required for appropriate conditions and transient events required to occur. However, appropriate demonstration can be accomplished on rig tests and in the laboratory using hardware in the loop simulation techniques with actual PHM hardware and software.

PHASE I: Develop a concept and prototype software tool design for a turbine engine application. Demonstrate the capability to reduce false alarm rates for PHM applications using simulation.

PHASE II: Implement the Phase I prototype software/hardware design into a viable and stand alone unit that can be applied to a relevant turbine engine PHM application. Demonstrate the reduced false alarm rate capability in a relevant simulation with actual PHM hardware and software, or on an engine test rig.

PHASE III / DUAL USE: Military application: Applicable to improved safety and performance for advanced fighter and transport engine PHM systems. Includes sensors and on-line diagnostic/prognostic systems. Commercial application: This research and development applies to on-line and ground-based commercial aircraft PHM systems and related diagnostic support equipment.

REFERENCES:
1. William R. Simpson and John W. Sheppard, “Analysis of False Alarms During System Design,” ARINC Research Corporation, Annapolis, MD, May 18, 1992.

2. Wil Harkins, “False Alarm Mitigation Techniques,” NASA report LLIS # 0837, April 2004.

3. kerry Westervelt, ""Root Cause Analysis of BIT False Alarms,"" Naval Air Warfare Center Aircraft Division, Patuxent River, MD, 2004.

4. Air Force Research Laboratory, Propulsion Directorate, Turbine Engine Division, www.pr.afrl.af.mil

5. Duane Allen, “Probabilities Associated with a Built-In-Test System, Focus on False Alarms,” Naval Surface Warfare Center, Corona, CA, 2003.

KEYWORDS: false alarms, diagnostics, system observability, faults, modeling, aerospace control, electronic systems, parameter identification, propulsion health management

AF081-055 TITLE: Expanding the Processing Capability of On-Line Propulsion Health Management (PHM)

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

OBJECTIVE: Increase FADEC capability to accommodate PHM algorithms that require intensive computations and sensors that produce high data rates.

DESCRIPTION: PHM systems have great potential for capability improvement, cost reduction, and high return on investment for turbine engines. However, future PHM systems incorporating damage prediction, combustion diagnostics, flow control, and control integration, will require the ability to process large amounts of data and make decisions in less than 20 milliseconds. Expected data rates from sensors can be in excess of 200 KHz, while bus communication rates are expected to be above 100 megabits per second. Approaches to implement advanced PHM signal processing on engine FADECs are currently being researched in the laboratory. Most approaches employ model-based or data-driven algorithmic methods and require collection and analysis of large amounts of streaming data. Implementation of optimization algorithms and complex models in real time with qualified commercial controller hardware for engine PHM systems is a significant challenge. Current controller chips for state-of-the-art (SOA) FADECs use the Motorola PPC 603e processor, qualified for the engine temperature environment. They operate at slower throughput compared with SOA commercial processor chips used for personal computers. They have limited capability to run complex PHM models, operate on large data constructs, and handle high-rate engine sensor data in real time. The use of optimization techniques, large database analysis, and physics-based models employ software techniques that require very high speed processors to achieve real-time capability. The need to transfer high speed data is also increasing. Future engine communication buses will be required to operate above 100 megabits per second to communicate with aircraft, power, and sensor systems.

Novel solutions to increase FADEC and PHM signal conditioning and computation capability by ten times is required. Solutions should not add significant hardware and software components to existing engine FADEC controls. Developing a systems approach using advanced hardware and software component integration is an appropriate methodology to solve FADEC and PHM future capability issues. Applicable technologies include, but are not limited to, use of field programmable gate array (FPGA) processor elements, analog signal processing, and advanced algorithms. Investigation of mixed signal analog/digital very large scale integrated (VLSI) circuits for signal processing applications may also be considered. Optimization of the processing core (for analog or digital) has been used to significantly increase the throughput of matrix multiplication used in fast Fourier transforms (FFTs), and correlation algorithms. Both analog and nonlinear topologies are being investigated to cope with providing a fast and continuous response from high rate data. Investigation of advanced algorithms include: transforms, model order reduction, compression, and distributed processing. It is appropriate to evaluate designs that employ one or more strategies to reduce FADEC processing overhead while increasing engine prognostic capability.

PHASE I: Develop a conceptual processing capability that significantly improves PHM computational performance compared with the current SOA military FADEC engine control hardware and software technology.

PHASE II: Develop, test, and demonstrate a prototype PHM processing unit consisting of hardware, software, or both that implements the Phase I capability improvements. The techniques must be applicable to the military engine FADEC environment.

PHASE III / DUAL USE: Military application: Includes maintenance prediction, combustion diagnostics, and structural life prediction capability. Commercial application: Commercial vibration prognostics applications that provide an integrated PHM and FADEC capability.

REFERENCES:

1. Volponi, Allen J., “Data Fusion for Enhanced Aircraft Engine Prognostics and Health Management,” NASA Final Report, NASA/CR-2005-214055.

2. Singer, Bryan and Veloso, Manuela, ""Learning to Construct Fast Signal Processing Implementations,"" <i>Journal of Machine Learning Research</i>, December 2002, pp. 887 - 919.

3. Duarte, Marco F., ""Optimal Decision Fusion with Applications to Target Detection in Wireless Ad Hoc Sensor Networks,"" <i>Proceedings of the 2004 IEEE International Conference on Multimedia and Expo</i>, June 27-30, 2004, Taipei, Taiwan, pp. 1803-1806.

4. Air Force Research Laboratory, Propulsion Directorate, Turbine Engine Division, www.pr.afrl.af.mil

KEYWORDS: propulsion health management, FADEC, signal processing algorithms, mixed signal processing, full authority digital engine controls, field programmable gate array

AF081-056 TITLE: Integrally Bladed Rotor (IBR) Maintenance and Life Management

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

OBJECTIVE: Develop innovative concepts for maintenance and life management of turbine engine IBRs.

DESCRIPTION: Modern military gas turbine engines use IBRs, also known as blisks, for advanced fan and compressor applications. The ability to sustain IBRs in a safe and affordable manner is critical to the DoD, specifically the USAF. Built as a single piece of hardware, IBR-based components present a new and unique sustainment challenge. Gas turbine engine fans and compressors have been designed with inserted blades, and sustainment methods have been based on the ability to repair or exchange individual blades and disks. As a single piece of hardware, with structural coupling among all airfoils and the adjoining disk, individual components can no longer be separated, and maintenance must be performed on the whole stage.

The technologies developed and demonstrated under this topic will provide improved understanding of IBR structural dynamics emphasizing inspection, repair, and/or life practices that enable increased IBR durability and aircraft safety. The approach may emphasize and improve mistuning, inspection, alternative repair, microcrack detection, and/or other techniques and methodologies.

PHASE I: Identify an innovative technique and demonstrate the approach through modeling and simulation and/or experimental testing. Quantify the improved capabilities of the concepts. Document results in a Phase I technical report and provide a proposed Phase II Technology Maturation Plan.

PHASE II: Implement the Phase II Technology Maturation Plan focused on verifying the techniques and tools experimentally on representative hardware. Document results in a Phase II technical report and provide a marketing plan for Phase III dual-use applications.

PHASE III / DUAL USE: Military application: Includes the inspection, maintenance, and repair of turbine engine IBRs. Commercial application: Utilize similar processes developed for the military.

REFERENCES:
1. Air Force Research Laboratory – Propulsion Directorate. 20 July 2006. http://www.pr.afrl.af.mil/

2. Christodoulou, L. and Larsen, J.M., “Materials Damage Prognosis: A Revolution in Asset Management, in Materials Damage Prognosis.” eds. J.M. Larsen, et al., TMS, 2005, PP. 3-10.

3. “Engine Rotor Life Extension.” Air Force Research Laboratory - Materials and Manufacturing Directorate. Http://www.ml.afrl.af.mil/mll/p_erle.html

4. Lewis, S.L. and Harris, W., “Sustainment Measures for Fighter Jet Engines.” https://dspace.mit.edu/bitstream/1721.1/723/1/07_12_2001_Sustainment.pdf, 2001.

KEYWORDS: integrally bladed rotor, blisk, sustainment, inspection, maintenance, repair

AF081-057 TITLE: Chemical Kinetics for Vitiated Flows

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop easily implemented, robust models that can accurately predict chemical reaction rates of JP-8 fuel in vitiated, low pressure, high temperature flows.

DESCRIPTION: Over the past 50 years, requirements for high performance gas turbine engines have continued to push the state-of-the-art in flame stabilization technology for afterburners. Ever increasing requirements have dramatically changed the conditions where the afterburner is required to hold a flame. In current afterburner systems, inlet conditions such as temperature, vitiation level, operating pressure, velocity/Mach number, and turbulence levels are more extreme than previously experienced. Trends for future augmentor systems would indicate that these conditions will become even more severe.

There are several physical processes that occur in the afterburner. Fluid dynamic processes, including two-phased flow, wave propagation, and heat transfer are among the macro level processes. On the micro level, different physical processes occur including scalar mixing and chemical reactions. Models for all of these processes are at varying levels of sophistication. On the micro level, the sophistication of the models used to predict combustion and chemical reactions varies greatly. For combustion, several models exist including: Laminar Flamelet, Probability Density Function (PDF) closure, Linear Eddy Method, Eddy Breakup, and Linear Eddy Dissipation (Peters (2000) and Fox, (2003)). All of these models are formulated based on varying assumptions about the phenomenology of the flame. Also on the micro level, models for the chemical reactions range in complexity from very simple to very complex. Simple models assume that if fuel is mixed with air then the fuel is assumed to be immediately burned. At the other extreme, complex models with hundreds of mechanisms with hundreds of species are used to predict the exact timing of the fuel combustion process.

The sophistication of the chemical reaction models for a given fuel is purely a function of the amount of research that has been done on that fuel. In the case of modeling chemical reactions of single molecule fuels, like methane, much work has been done in developing models and validating the chemical kinetics models for these types of fuels. JP-8 is a multi-component fuel, containing hundreds of chemical compounds. For JP-8, the state-of-the-art in chemical kinetic modeling has not advanced as readily as single component fuels. This is due in large part to the chemical complexity of JP-8 fuel. Currently, a Multi University Research Initiative (MURI) sponsored by Air Force Office of Scientific Research (AFOSR) will accomplish much of the required research determining the important species, reactions, and rates of reactions of the chemical kinetic processes of multi-component fuels, like JP-8. This work will provide a great wealth of information on the chemical kinetic processes associated with JP-8 combustion in air over a wide range of temperatures and pressures.

Combustion in afterburners is very unlike combustion in the main burner. Combustion in afterburners occurs at much lower pressures, from 4-60 psia, over a wide range of fuel air ratios below and above stoichiometric, and with vitiated flows not air. The effects of low pressure, dissociated molecules, third bodies and rich combustion on the chemical reaction process needs to be explored experimentally at conditions appropriate to the afterburner. New models will be required to incorporating these effects. New models must accurately predict the relevant micro level chemical reactions and be computationally tractable.

PHASE I: Develop an improved structure for a chemical kinetics model applicable to vitiated, high temperature, sub-atmospheric pressure combustion. Include details of the improved model structure and the experimental approach that reveal phenomenology and provide data for model validation. Demonstrate the feasibility of an improved model structure.

PHASE II: Fully develop the chemical kinetics model and execute the validation approach described in Phase I. Deliver the improved models as stand alone software for easy incorporation into reduced order models and CFD codes.

PHASE III / DUAL USE: Military application: Stand alone software allows for improved models to be transitioned to military gas turbine original equipment manufacturers for incorporation into existing augmentor design practice. Commercial application: Stand alone software can be utilized on a range of commercial combustors addressing the issues of improved efficiency and reduced emissions.

KEYWORDS: afterburner, chemical kinetics, vitiation, high temperature combustion, low pressure combustion, computational fluid dynamics

AF081-058 TITLE: High Temperature Permanent Magnet Actuator Motor

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Increase temperature capability of compact electrical actuators, and demonstrate prototype permanent magnet motor through full operational temperature range of actuator.

DESCRIPTION: With the move toward more-electric aircraft, several systems have had to undergo major changes. Actuators are one such system in which aircraft have gone from a centralized hydraulic system to several electrically operated independent units. One of the challenges with the independent units is that the actual actuators generally take up more volume than they did with the centralized approach. To combat this, only motors with the highest power density are considered for use in electric actuators. To this end, we find that motors with permanent magnets are very prevalent in electric actuator applications. Another challenge is that with these independent units there is no longer a readily available fluid for system wide heat transfer. This requires the individual systems to provide their own cooling methodologies and/or operate at higher temperatures.
This SBIR topic proposes to attack these two challenges by developing a motor that has high power density and a permanent magnet that withstands high temperature for use in electrical actuator systems. The prototype is expected to incorporate novel permanent magnet formulations suitable for high temperature, high energy density, advanced cooling schemes to deal with the harsh environments, and wire capable of withstanding high temperature in a compact motor design. It is expected that the proposer shall integrate these technologies into a prototype motor and demonstrate the machine through the actuator's entire temperature range. The initial temperature of operation for this effort shall be 350 °C.

PHASE I: Phase I is expected to yield an innovative prototype motor design meeting the above constraints as well as provide evidence to substantiate the key design aspects included in the proposed machine. Support for modeling and simulation is anticipated.

PHASE II: During Phase II, it is expected that the proposer shall build and test the prototype motor. At a minimum, fullrange temperature testing, nonoperational temperature excursions, and endurance testing should be performed. Experimental results will be compared and reconciled with the model.

PHASE III / DUAL USE: Military application: This high-temperature motor is expected to be of immediate use in electrohydraulic actuators (EHA) and have definite advantages in electromechanical actuator (EMA) applications. Commercial application: This effort will benefit commercial aviation by increasing the reliability of the actuator motors as well as reducing the cooling requirements for electrical actuation.

REFERENCES:
1. Flight Test Experience with an Electromechanical Actuator on the F-18 Systems Research Aircraft - Presented at the 19th Digital Avionics Systems Conference, October 7–13, 2000, Philadelphia, Pennsylvania. G. Jenney and B. Raymond, Dynamic Controls, Inc., Dayton, Ohio; D. Dawson, Wright Laboratory, WPAFB,Ohio. http://www.nasa.gov/centers/dryden/pdf/88699main_H-2425.pdf

2. Performance of an Electro-Hydrostatic Actuator on the F-18 Systems Research Aircraft - Presented at the 16th Digital Avionics Systems Conference, Irvine, California October 26-30, 1997. Robert Navarro, NASA Dryden Flight Research Center,Edwards, California. http://www.nasa.gov/centers/dryden/pdf/88524main_H-2210.pdf

KEYWORDS: actuators, motors, electromechanical actuators, electrohydraulic actuators, permanent magnet motors, electrical actuators, high temperature

AF081-059 TITLE: Starter/Generator Efficiency Enhancement for High Performance Tactical Aircraft

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: To develop technologies that reduce the thermal burden of electrical starter/generator systems in high-performance tactical aircraft by improving their efficiency.

DESCRIPTION: Electrical power generation systems have inherent inefficiencies due to electrical and mechanical loss mechanisms. On modern tactical aircraft, these losses are ultimately deposited into the fuel. Excessive fuel heating that results in elevation of fuel temperature above acceptable thresholds is a concern for these aircraft. Improving the efficiency of electrical starting and generating systems will directly reduce the amount of heat deposited into the fuel. Technologies to improve the efficiency as well as more efficiently manage the heat (i.e., improved thermal management) are of interest. Technologies suitable for application in a secondary or auxiliary power unit with a high speed, directly driven electrical machine and a main propulsion engine starter/generator are solicited. The rotating machine, as opposed to the associated drive electronics, is the focus of the topic. It is recognized that a tradeoff exists between machine size and efficiency; technologies that improve efficiency while maintaining power density are of most interest. Representative loss mechanisms that offer the potential for reduction include bearing or friction losses, conductor or resistive losses, steel or core losses, and windage losses. Windage and core loss reduction technologies are the primary focus of this topic. Phase I is expected to develop an innovative approach to reducing the losses generated by these mechanisms, assess the benefit and impacts of the approach, and generate a preliminary design of how the approach would be integrated into the machine. Due to the emphasis of this topic, involvement of larger aerospace suppliers with potential to assist in the transition of any developments is highly encouraged.

PHASE I: Perform an analysis to assess loss mechanism(s) and provide an estimate of potential loss reductions or assess benefits of thermal management improvements to be achieved through the technologies developed under this topic. Define architecture or preliminary design of the improved starter/generator.

PHASE II: Finalize the preliminary design from Phase I and fabricate and validate a prototype to demonstrate predicted improvements. A representative subscale demonstration is expected to include thorough supporting analysis and/or relevant simulations.

PHASE III / DUAL USE: Military application: Anticipated Phase III military application is the starter/generator system or secondary power system in modern high performance tactical aircraft or unmanned aircraft systems. Commercial application: Due to the observed trend toward higher installed electrical power, these technologies are also expected to find application in commercial aircraft.

REFERENCES:
1. Chapman, Stephen J., <i>Electric Machinery Fundamentals</i>, 3rd Edition, McGraw Hill, ISBN 0-07-011950-3.

2. Fitzgerald, A.E., Kingsley Jr., Charles, and Umans, Stephen D., <i>Electric Machinery</i>, 5th Edition, McGraw Hill, ISBN 0-07-021134-5.

3. Propulsion Directorate website: http://www.pr.afrl.af.mil/

KEYWORDS: starter/generator, starter, generator, thermal efficiency, electrical power, thermal management

AF081-061 TITLE: High Propellant Throughput Microthrusters for Next-Generation Nanosatellites

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop high throughput micropropulsion thrusters for next-generation nanosatellites to enable dramatic maneuverability increases.

DESCRIPTION: Future Department of Defense (DoD)space missions require precise, fine positioning capabilities combined with large maneuverability requirements. These capabilities are currently performed with a combination of very small chemical thrusters, reaction wheels, and magnetic torque rods. These technologies can be heavy, redundant, complex, or not work in all situations. These issues are greatly exacerbated on nanosatellites, where mass and volume are premium resources. Advanced micropropulsion devices are an excellent solution since they can perform most of these functions in a single system. However, currently available micropropulsion systems suffer from low propellant fuel fractions. This low fuel fraction (often less than 15%) is often the result of complex fuel feed systems, inefficient acceleration mechanisms, or a combination of the two. As a result, micropropulsion has not found acceptance in the DoD, although precision pointing thrusters have been fielded by NASA. The purpose of this topic is to greatly improve the propellant mass fraction on existing or new microthrusters for critical DoD missions. The system envisioned is for use as primary propulsion for a 20-50 kg satellite with a 12 month mission lifetime. The entire propulsion system mass is limited to 5 kg, but should be easily scalable to 10 kg with additional propellant. Propellant fractions of 50-70% are desired. The minimum thrust level is 5 mN, minimum specific impulse is 240 sec, maximum available power is 25 W. Additionally, it is desired that the propellants used be easily handled and storable within the propulsion unit for 6-12 months prior to launch. Technologies of interest include electric and chemical micropropulsion systems. Electric propulsion systems typically produce higher specific impulse operation, but are hampered by high dry mass fractions. Very small chemical systems have significantly lower specific impulses, but also have much reduced dry masses. The technical challenges of this program lie in the ability to both maximize propellant throughput and performance in a single architecture.

PHASE I: Perform proof-of-concept analysis, M&S, and experiments that demonstrate the feasibility of the proposed micropropulsion concept.

PHASE II: Fabricate and demonstrate breadboard-level system performance for the proposed micropropulsion concept.

PHASE III / DUAL USE: Military application: These high throughput microthrusters would allow the use of tactically useful spacecraft to perform critical missions such as Space Situational Awareness (SSA) or Operationally Responsive Space (ORS). Commercial application: These thrusters would enable the commercial use of microsatellite constellations for earth sensing, communications, and other uses.

REFERENCES:
1. M. Micci and A. Ketsdever, Eds., Micropropulsion for Small Spacecraft, Progress in Astronautics and Aeronautics Series, V-187, AIAA Press, 2000.

2. AFRL Propulsion Directorate Website: http://www.wpafb.af.mil/afrl/pr/

KEYWORDS: electric propulsion, micro-chemical propulsion, micro-propulsion, propellant throughput, ANGELS, nanosatellites

AF081-062 TITLE: Bismuth Hall Thruster Contamination Characterization and Mitigation

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop diagnostics to characterize the plume properties of Hall thrusters operating on condensable propellants and quantify any spacecraft contamination effects due to a bismuth Hall thruster.

DESCRIPTION: The application of electric propulsion (EP) systems for orbit transfer of satellites will deliver larger payloads and provide greater mission capability when compared to chemical propulsion systems due to the higher specific impulse. A key requirement for Department of Defense (DoD) missions, however, is to perform orbit transfers in an acceptable amount of time. This requirement drives a need for both high-power EP systems and for thrusters that provide a high thrust-to-power (T/P) ratio. One technology that is capable of achieving the necessary T/P ratio is a Hall thruster operated on condensable propellants, such as bismuth. Due to its combination of high atomic mass and low ionization energy, operation on bismuth allows a Hall thruster to achieve much higher T/P than can be accomplished using xenon propellant. The higher T/P, in turn, provides for faster orbit transfer times than can be achieved using xenon propellant and increased payload delivery capability compared to chemical propulsion.

Despite their superior performance characteristics, Hall thrusters operating on bismuth present one key concern to spacecraft designers and operators: contamination. Because bismuth tends to condense on any surface it comes in contact with, it has the potential to contaminate spacecraft solar arrays, optics, and other sensitive components. Before bismuth Hall thrusters can be considered for implementation, a detailed understanding of the plume and its effects on typical spacecraft materials is required. This topic therefore solicits technologies to characterize and/or mitigate the contamination environment created by Hall thrusters operating on condensable propellants, including bismuth. Efforts that characterize both the effluent environment in a thruster plume and the effects of those effluents on key spacecraft materials such as optical glass and kapton are preferred over efforts that characterize only the thruster plume itself. A key technical challenge associated with this topic lies in the need to accurately characterize plumes consisting of liquid metals which, by their condensable and conductive nature, are not compatible with many traditional Hall thruster diagnostics.

PHASE I: Perform proof-of-concept analysis and/or experiments demonstrating the ability of proposed diagnostic techniques to accurately assess thruster plumes containing condensable propellants.

PHASE II: Experimentally measure and report key plume properties of Hall thrusters operating on condensable propellants and measure or assess the effects of the plume on key spacecraft materials.

PHASE III / DUAL USE: Military application: Characterization of bismuth Hall thruster plumes will allow this technology to be aboard critical DoD spacecraft, which will enhance spacecraft mobility while minimizing contamination. Commercial application: Bismuth Hall thrusters will allow very large spacecraft payloads to be orbited and repositioned quickly with minimal propellant usage.

REFERENCES:
1. A.W. Kieckhafer and L.B. King, “Bismuth as an EP Propellant: Practical Issues and Physical Properties,” AIAA-2005-4228, 41st AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Tucson, AZ, 2005.

2. M. Crofton and K. Diamant, “A Preliminary Study of Contamination Effects in a Bismuth Hall Thruster Environment,” AIAA-2005-4231, 41st AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Tucson, AZ, 2005.

3. D. Scharfe, T. Ito, and M. Cappelli, “Measurements in Stationary Reference Bi Discharge Cell for Diagnostics of a Bismuth Hall Thruster,” AIAA-2006-4638, 42nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Sacramento, California, July 9-12, 2006.

KEYWORDS: electric propulsion, hall thruster, bismuth, spacecraft contamination

AF081-063 TITLE: Materials Development for High Performance Solid Rocket Motor Cases

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

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

OBJECTIVE: Through innovative research, develop, demonstrate and validate an approach that improves composite materials for Solid Rocket Motor (SRM) cases to enable gains in performance and/or reliability.

DESCRIPTION: Recent DoD/NASA/Industry programs demonstrated the need for innovative development efforts to produce superior composite materials for solid rocket motor (SRM) cases. These improved materials may result in SRMs with superior performance, cost, and/or reliability. Composite materials for SRM cases typically consist of a matrix and continuous fiber reinforcement. The enabling advanced composite materials may result from the improvements in the matrices and/or the continuous fibers. An additional benefit to developing fibers is the fact that there exists a national need for the domestic development of advanced fibers for aerospace applications. Most high performance aerospace fibers have either been discontinued or the manufacturing of the fibers has shifted overseas. In either circumstance, this is a serious concern for the aerospace community and national security. There exist many different solutions to achieving the goal of improving SRM cases to enhance the performance, cost, and/or reliability. One such solution involves reducing the inert weight of the rocket motor. The case of a boost and orbit transfer (B&OT) SRM comprises about one-half of the inert weight of the rocket. An increase in performance of these systems can be realized by reducing the weight of the SRM. Furthermore, next generation B&OT SRMs will operate at higher speeds, which may require additional external thermal protection systems, provided the existing state of the art composite matrices are utilized. A high temperature composite resin offers the design engineer an expanded list of options, including, but not limited to, the reduction or elimination of the external insulation and the reduction of the composite case thickness. The reduction or elimination of the exterior insulation will directly affect the overall inert weight of the motor as will the reduction of the case wall thickness. The ability to reduce the case wall thickness may be enabled by producing SRM cases with higher specific strength and stiffness. The development of new fibers for composites is a key technology to achieve this goal. Additionally, in volume limited systems, the reduction or elimination of the exterior insulation reduces not only the overall inert weight but also increases the propellant mass fraction of the motor and, therefore, the delivered energy per unit mass at the system level.

The development of advanced materials for propulsion applications, such as solid rocket motors, will support current and future DoD ballistic missile and space launch applications. The proposed material development efforts are anticipated to build upon, and provide significant enhancement over, existing domestic and foreign state-of-the-art materials. The Phase II deliverables include a detailed plan for scaling-up and additional testing of the materials for SRMs. A partnership with a current SRM prime contractor is highly desired. Such a relationship would aid in the refinement and implementation of the contractor’s plan to integrate developed materials technologies into domestic SRM development. Lastly, to increase the probability of successful transition to Phase III, the technology development efforts proposed should leverage existing capability and ongoing SRM and rocket technology development efforts to the maximum extent possible.

PHASE I: Demonstrate the feasibility and benefit of the materials in SRM cases over the state of the art, increased performance or reliability, while not adversely affecting the system cost. This work will include analysis and/or research designed to understand the challenges of using the material solution.

PHASE II: Fabricate and demonstrate a sub-scale SRM case using the proposed material solution in a relevant environment. Required Phase II deliverables include 1) Technical report of demonstration/validation; 2) Detailed plan for scaling-up, additional testing, and marketing for Phase II Dual Use Applications; 3) Sub-scale SRM case.

PHASE III / DUAL USE: Military application: This effort supports current and future DoD ballistic missile applications as well as spacelift operations.

Commercial application: This effort supports current and future NASA space launch applications as well as commercial private ventures.

REFERENCES:

1. English, L. K., “Fabricating the Future with Composite Materials” Journal of Composites Technology and Research, v. 104, no. 1, p. 37-41, Jan 87.

2. Fisher, M.J., and Moore T.L., “Composite Motors Transition to Tactical Applications” CPIA Bulletin, v. 30, no. 5, September 2004.

3. Allred, R.E., Wesson, S.P., Shin, E.E., Inghram, L., McCorkle, L., Papadopoulos, D., Wheeler, D. and Sutter, J.K. “ The Influence of Sizings on Durability of High-Temperature Polymer Composites” High Performance Polymers, v. 15, no. 4, 395-419 2003.

4. Navy HyFly Program: http://www.globalsecurity.org/military/systems/munitions/hyfly.htm

5. IHPRPT: http://www.afrlhorizons.com/Briefs/Jun05/ML0403.html

KEYWORDS: solid rocket motor, composite materials, case, motor performance, boost and orbit transfer, fibers

AF081-064 TITLE: Health Management Tools for Rocket Engine Turbomachinery

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

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

OBJECTIVE: Develop innovative modeling tools, sensors, and signal processing for the prediction of the health of rocket engine turbomachinery.

DESCRIPTION: Rocket engine turbopumps operate at very high speeds and under very harsh thermal conditions. Thus, they are a high risk item in many rocket engines. Thermally, these devices operate at extreme conditions with potentially very high temperatures in the turbine section, and potentially very low temperatures in the pump section. In addition, the high rotation rates and small size make this device highly vulnerable to vibration. The purpose of this topic is to develop tools to better understand the current health of liquid rocket engine turbomachinery. The ultimate goal is to develop real-time health management/monitoring of these devices; however, a spiral (or incremental) approach to gaining this capability is likely the most prudent approach. Proposals seeking to leverage the tools developed in this program to the development and acceptance portions of the overall health management effort will be carefully considered. These types of tools will be critical to both current and next generation rocket engines. As rocket engines advance to the next generation of re-usable, operable designs, health management tools will be critical to their success. These tools will allow for quick turn-around, higher reliability, and ultimately improve performance.

PHASE I: Identify and assess the feasibility of tools that allow monitoring of the health of a rocket engine turbopump. Develop innovative system architecture integrating modeling, novel sensors, and signal processing to predict rocket engine health. Identify data sets that can validate the tool.

PHASE II: Develop, demonstrate and validate the tools so that experiments in sub-scale or full-scale hardware can be performed. These experimental results will be compared to model predictions. Deliverables for this effort will be the tools and models created along with the validation data collected.

PHASE III / DUAL USE: Military application: Health management tools will allow for higher reliability and increased operability of military systems. This will provide the military with new capabilities to complete its missions. Commercial application: Health management technologies will increase the reliability of commercial access to space systems thereby reducing the cost and risk to provide access to space.

REFERENCES:
1. G.P. Sutton & O. Biblarz, Rocket Propulsion Elements, 7th Ed., John Wiley & Sons, Inc., New York, 2001, ISBN 0-471-32642-9.

2. D.K. Huzel & D.H. Huang, Modern Engineering for Design of Liquid-Propellant Rocket Engines, Vol 147, Progress in Astronautics and Aeronautics, Published by AIAA, Washington DC., 1992, ISBN 1-56347-013-6.

3. R.L. Christenson, M.A. Nelson, & J.P. Butas, "Rocket Engine Health Management – Early Definition of Critical Flight Measurements", presented at 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 20-23 July, 2003. AIAA 2003-5251.

4. M. Davidson and J. Stephens, "Advanced Health Management for the Space Shuttle Main Engine, 40th AIAA/ASEM/SAE/ASEE Joint Propulsion Conference and Exhibit, 11-14 July 2004, AIAA 2004-3912.

KEYWORDS: rocket engine turbomachinery, engine health management, engine health monitoring, fault detection, isolation and recovery, sensors, liquid rocket engines

AF081-065 TITLE: Multi-Mode Propulsion for Orbit Transfer, Maneuvering, Station Keeping and Attitude Control

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: To develop innovative, lightweight, high performance, multi-mode propulsion systems that integrate with current and future Department of Defense(DoD) Spacecraft.

DESCRIPTION: The current trend for government spacecraft is to increase functionality and complexity while maintaining launch volume and mass. These trends and requirements are driving higher precision requirements for positioning and timing of thruster components, while simultaneously shrinking the volume and mass budget available for propulsion. Future propulsion systems need to be smaller, lighter, cleaner, and lower risk, while providing a wide range of thrust that can meet requirements for small delta V maneuvers (attitude control/station keeping) to large delta V maneuvers (orbit insertion/rephasing). The Air Force (AF) is seeking the synergistic combination of advanced propulsion elements that would enable a spacecraft to perform high thrust missions or low thrust, propellant conserving missions on demand once on-orbit as the need arises. For example, such a system could include an advanced high thrust monopropellant thruster and a high Isp Electric Propulsion (EP) thruster in one system, while minimizing total system mass and complexity by designing the EP thruster and attitude control system to utilize the same monopropellant feed system. The EP system could share the spacecraft power system to further save weight, volume, and complexity. Therefore, the AF is soliciting the propulsion community's ideas on high performance advanced propulsion components and how to integrate these concepts to meet the real and varied needs of operational spacecraft.

PHASE I: Select propulsion concepts and identify how spacecraft propulsion performance would be improved while reducing overall spacecraft complexity. A proof of concept demonstration is desirable. Technical challenges or barriers should be identified. An approach to a phase II effort should be outlined.

PHASE II: Further develop the Phase I effort by building and testing a prototype thruster, thrusters, or thruster system with feed. Government furnished test facilities and hardware may be available and could be requested if desired. Further interaction with the spacecraft prime contractors would be desirable.

PHASE III / DUAL USE: Military application: Multi-mode propulsion is applicable to DoD and various spacecraft.The high thrust capability is applicable to repositioning spacecraft while the low thrust capability is applicable to station keeping. Commercial application: Commercial communication satellites have the same requirements for repositioning and station keeping as military satellites.

REFERENCES: 1. Micci, M.M., et al., Micropropulsion for Small Spacecraft, Progress in Astronautics and Aeronautics Series, Vol. 187, American Institute of Aeronautics and Astronautics, 2000.

2. Gulczinski, F.S., et. Al., "Micropropulsion Research at AFRL," AIAA-2000-3255, 36th Joint Propulsion Conference, Huntsville, Alabama, 2000.

3. Koelfgen, Syri, et. Al., "A Plasmoid Thruster for Space Propulsion", AIAA-2003-4992. Joint Propulsion Conference, 2003.

4. Choueiri, E.Y., and Ziemer, J.K., "Quasi-Steady Magnetoplasadynamic Thruster Performance Database", Journal of Propulsion and Power, 17:967-976, 2001. September-October.

KEYWORDS: electric propulsion, magneto-plasma-dynamics (MPD), spacecraft propulsion, advanced propulsion, magneto-hydro-dynamics (MHD), plasma

AF081-066 TITLE: Highly Reliable, Reusable, Non-Toxic Rocket Engine Ignition Systems

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop highly reliable, reusable, non-toxic ignition systems for booster and upper stage liquid rocket engines. This includes developing the modeling and simulation tools to validate the system.

DESCRIPTION: Many rocket engines have ignition systems which utilize toxic materials, hypergolic propellant combinations, or solid propellants. These systems will not be suitable for the proposed highly responsive, highly reusable engine systems that the Air Force is planning to meet future mission needs. These next generation systems will both reduce the cost of operations by providing reusable operation and will enable new missions by having enhanced operability, which will allow future space access vehicles to have attributes such as the ability for space access vehicles to be quickly made available for their next mission. However, the reliability of the ignition system cannot be compromised as these systems must be able to launch on demand. To meet these requirements, new approaches are required to ignite these engines and replace current concepts that utilize hazardous or otherwise dangerous materials. Selected concepts must be able to reliably start liquid booster and upper stage engines without the use of these hazardous materials and must allow for maximum system operability. It is envisioned that the igniters developed in this effort will transition to the next generation Air Force booster and upper stage engines. The booster engines will be liquid oxygen/kerosene oxygen-rich, staged combustion engines similar to the Air Force Research Laboratory Hydrocarbon Boost Engine Phase II program. Upper stage engines will use gas generator, staged combustion, or expander cycles and will use liquid oxygen as the oxidizer and will potentially use hydrogen, methane or kerosene as the fuel.

The result of this effort will be highly operable, highly reusable, highly reliable ignition system that can potentially transition into future systems. Since the cost of testing full-scale engine systems is prohibitive under a SBIR program, it is expected that demonstration of these activities will be performed on sub-scale or lab-scale hardware, which may not be fully representative of the actual application. In order insure that the applicability of the system, modeling and simulation will likely need to be used to simulate ignition in larger scale devices. These modeling and simulation activities will be a key part of this effort.

PHASE I: Identify the potential ignition systems which meet the requirements. Perform initial modeling and simulation analysis to demonstrate the applicability of the ignition system to future Air Force booster and upper stage engines.

PHASE II: Develop and integrate the ignition system into a test environment that is simulative of future Air Force booster and upper stage engines. Perform proof of concept testing. Utilize the modeling and simulation tools to show the applicability of the ignition system to full-scale applications.

PHASE III / DUAL USE: Military application: Future military spacelift missions will use reusable launch vehicles to reduce cost and increase utility. These systems will require quick turn capability and no extensive decontamination procedures. Commercial application: Future commercial spacelift missions will utilize reusable launch vehicles in order to reduce cost. These systems will require new ignition systems to enable this capability.

REFERENCES:
1. G.P. Sutton & O. Biblarz, Rocket Propulsion Elements, 7th Ed., John Wiley & Sons, Inc., New York, 2001, ISBN 0-471-32642-9.

2. D.K. Huzel & D.H. Huang, Modern Engineering for Design of Liquid-Propellant Rocket Engines, Vol 147, Progress in Astronautics and Aeronautics, Published by AIAA, Washington DC., 1992, ISBN 1-56347-013-6.

3. Yang, V et. al, Liquid Rocket Thrust Chambers: Aspects of Modeling, Analysis, and Design, Vol 200, Progress in Astronautics and Aeronautics, Published by AIAA, Washington DC, 2004, ISBN 1-56347-223-6, pp 403-436.

4. Oberkampf, W.L. & Trucano, T.G. “Verification and Validation in Computational Fluid Dynamics“, Vol. 38, Progress in Aerospace Sciences, 2002. Pp. 209-272.

KEYWORDS: ignition, non-toxic igniters, thrust chambers, reusable rocket engine, responsive space access, verification and validation

AF081-067 TITLE: Experimental Characterization of Particle Dynamics Within Solid Rocket Motors

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop experimental diagnostics and characterize particle dynamics for implementation in solid rocket motor modeling codes.

DESCRIPTION: The development of robust and accurate computational tools to predict the flow, heat transfer, and material response within a solid rocket motor (SRM) can enable significant improvements in launch vehicle performance, development, life cycle cost, and reliability. SRM computational simulation efforts currently incorporate state-of-the art algorithms that are largely based on empirical models based on heritage designs and materials. To accurately model the next generation of SRMs, incorporating new materials, propellants, designs, and experimental characterization of particle dynamics throughout the motor, from particle creation at the propellant burn surface to nozzle exit, is needed. Data collection may occur within a motor. The sensitivity of model accuracy to particle characteristic uncertainty will provide guidance as to the data that needs to be collected (ex. particle size/velocity/shape, and flow field parameters), experimental accuracy required, identification of critical flow areas, prioritization of experiments, and be critical to experiment design. These results will be used in ongoing modeling and simulation projects to support the evaluation and optimization of motor designs incorporating advanced materials and configurations. This capability will support current and future Department of Defense (DoD) ballistic missile and space launch applications. The proposed technology development efforts should detail the improvement that their effort will make over the state-of-the art. To increase confidence in the probability of successful transition to Phase III, the proposed technology development efforts should detail the impact of the technology on the advancement of SRM technology, and identify candidate transition opportunities.

PHASE I: The effort should include diagnostic design & measurement, uncertainty analysis, data reduction development, and demonstration of Phase II feasibility. Deliverables should include detailed results of the effort.

PHASE II: The effort should include the fabrication of diagnostic(s), validation of diagnostic(s) including error analysis and experimental characterization of particle dynamics in SRMs or analog environments. Deliverables should include final designs and fabrication details, validation data and analysis results; experimental results and analysis; final diagnostics.

PHASE III / DUAL USE: Military application: This effort supports current and future DoD ballistic missile and space launch applications. Commercial application: It will support the commercial space launch vehicle development. It will also support future development in the fields of commercial coal power plant combustion and high pressure liquid machining.

REFERENCES:
1. Sutton, G. P., Rocket Propulsion Elements, 6th Ed., Wiley-Interscience, New York, 1992.

2. Kovalev, O., "Motor and Plume Particle Size Prediction in Solid-Propellant Rocket Motors," AIAA Journal of Propulsion and Power, Vol. 18, No. 6, 2002.

3. Geisler, R.L., "A Global View of the Use of Aluminum Fuel in Solid Rocket Motors," 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002.

4. Laredo, D, "Motor and Plume Particle Size Measurements in Solid Propellant Micromotors " AIAA Journal of Propulsion and Power, Vol. 10, No. 3, May-June 1994

KEYWORDS: solid rocket motor, particle dynamics, experimental diagnostic, motor performance

AF081-068 TITLE: Combined GPS & Comm Antenna Technology

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop lightweight, wide bandwidth, affordable antenna technologies for combined GPS/Communication uses (specifically, VHF, UHF, and GPS signals).

DESCRIPTION: GPS and Communications capabilities could be greatly benefited by advances in aperture design and maturing fabrication techniques. Direct printing technologies whereby conductive patterns can be deposited on top of non-planar substrates allow realization of affordable antenna designs that can be fitted to small, irregularly shaped platforms. Integration of antenna elements into structural assemblies is another maturing technical area that can provide substantial benefit to the solution of, multifunction, conformal aperture design.

PHASE I: Survey antenna methodologies including direct-write, structurally embedded, and conformal technologies. At the end of Phase I candidate design approaches to realization of an antenna for small radius of curvature shall be presented with an analysis of performance and plans for design manufacture.

PHASE II: Antenna designs will be manufactured with performance tests to validate design models. The model will be refined by the actual measured performance to verify a complete design capability.

PHASE III / DUAL USE: Military application: Military applications for small GPS/Comm antennas abound; weapons to man portable systems to small UAV applications are relevant areas for insertion of this capability. Commercial application: Commercial uses of a small integrated antenna design could be equally prolific especially for the automotive industry.

REFERENCES:
1. Reference 1 Direct-Write Processes as Enabling Tools for Novel Antenna Development by BS. Irwin, RM Taylor, MJ Wilhelm Materials Research Society symposia proceedings ; v. 698. Materials Research Society, c2002 pg 281-286

2. Reference 2 Analysis of Finite Arrays of Axially Directed Printed Dipoles on Electrically Large Circular Cylinders
Vakur B. Ertürk, Roberto G. Rojas, and Kit Wing Lee IEEE TRANS on Antennas and Propagation, Vol 52, NO. 10, Oct. 2004

3. Reference 3 Micromachining technologies for miniaturized communication devices, Clark T.-C. Nguyen, Pg 24 SPIE Vol. 3511, September 1998

KEYWORDS: Antenna, GPS, direct-write, wide frequency bands

AF081-069 TITLE: <u>Improvements to Sense and Avoid (SAA) Systems for Unmanned Aircraft Systems (UAS)</u>

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Weapons

OBJECTIVE: Investigate Autonomous SAA technology that would enable SAA techniques and systems suitable for mini- UAS (<50 pounds, such as a Scan Eagle).

DESCRIPTION: Current sense and avoid systems (S&A) using visible/infrared/RF sensor technology require SWAP (space, weight, and power) that far exceeds that available in mini-UAS. Yet, an aircraft of this size still represents a significant mid-air collision hazzard to other aircraft operating in the same airspace. In addition, these types of UAS are frequently operated in close proximity to the ground and cultural features (buildings, towers, etc.). While the performance levels needed for these lower, slower UAS are relaxed relative to that needed for a large UAS such as a Global Hawk, the severe SWAP limitation presents a technical challange to creating an S&A capability for this class of aircraft. It is anticipated that the detection and avoidance maneuver would be function autonomously to minimize the performance requirements on the sensors and make maximum use of the maneuvering capability of these small UAS.

PHASE I: The first phase of research will focus on assessing the requirements of an S&A system for a mini-UAS taking into account the performance of a typical vehicle. A concept would then be synthisised that would assess feasibility, sensor performance, and enabling proccessor technologies.

PHASE II: Design and fabricate a prototype breadboard S&A system that meets the program objectives. Perform a demonstration of the breadboard system.

PHASE III / DUAL USE: This technology would greatly enhance the air safety of military tactical reconnaisance UAS. Many civilian (state-owned, such as police or forest service applications as well as private, such as electronic news gathering) applications will use this type of aircraft which will require an effective S&A funtion to be safe.

REFERENCES:
1. ASTM F 2411-04, Standard Specification for Design and Performance of Airborn Sense-and-Avoid System. RTCA DO-304, Guidance Material for Unmanned Aircraft Systems.

KEYWORDS: SAA, S&A, collision avoidance, UAS

AF081-070 TITLE: <u>Automated Pixel Geo-Registration for Precise Imaging</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To develop a front-end system that derives accurate sensor models for follow-on use by a geo-registration or other exploitation system.

DESCRIPTION: The ability to accurately determine geo-coordinates in imagery from airborne sensors is of importance to the Air Force because it allows capabilities like targeting, cross-sensor fusion, multi-look change detection, and moving-target detection. However, the ability to geo-register (3D geo-coordinates from pixel coordinates) such data may be limited by sensor-model parameters which are unknown or known only approximately. Laboratory measurements can be used to create a preliminary sensor model, but eventually actual flight data are required to refine such models to the point where the errors in the model do not limit the geo-registration accuracy. However, even the use of flight data requires human identifiable features in ground-truth imagery. These are not always available. Thus, it is of interest to generate usable sensor models from available imagery and meta-data with minimal or no operator intervention. A possible approach might be based on emerging fully automated georegistration systems. This approach would utilize imagery taken from multiple viewing geometries. Errors in the sensor model manifest themselves as spatial inconsistencies in the geo-registered images produced for the various geometries. If these inconsistencies can be automatically quantified, then it may be possible to use them to refine the sensor and viewing parameters. Innovative implementations might include agent or web-based exploitation systems that would have this capability as a front-end process. The system could ingest imagery (with little prior knowledge of a sensor/platform system); automatically generate a sensor model (with component errors); and subsequently utilize the sensor model immediately for exploitation. Alternative approaches and implementations are welcome. A challenge is to develop a prototype system that does not sacrifice accuracy while utilizing only limited prior knowledge about the sensor. Example unknowns may include delays in telemetry, lens distortion, sensor/airframe misalignment, sensor modalities, etc.

PHASE I: Consider various approaches and implementations for the system. Using sensor data, establish the limits on the ability to measure inconsistencies between geo-registered data sets, and show how well these can be used to improve the sensor models. Verify results.

PHASE II: Develop the baseline approach into a robust, automated subsystem. Evaluate the accuracy/consistency. Expand the subsystem into one or more systems which could be incorporated into the processing chain of an airborne sensor system.

PHASE III / DUAL USE: Military application: This effort has the potential to enable a more automated process that could “discover” the needed parameters and build a sensor model (suitable for targeting) based on properly collected imagery. Commercial application: This effort may enable precise image analysis, georegistration and visualization capabilities for geospatial image processing commercial applications with only limited knowledge of a sensor system.

REFERENCES:
1. F. Moffitt, and E. Mikhail, “Photogrammetry," 3rd Edition, New York, Harper and Row, 1980.

2. L.G. Brown, "A survey of image registration techniques," Association for Computing Machinery, 1992, Vol. 24, pp. 325-376.

KEYWORDS: Sensors, signal processing, geo-registration, geolocation, precise imaging, camera models, physical sensor models, rigorous sensor models

AF081-071 TITLE: Hyperspectral Persistent Surveillance Exploitation Algorithms

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

OBJECTIVE: Develop algorithms to exploit persistent hyperspectral information (HSI) imagery for target detection, tracking, and ID; develop processing methodologies to enable HSI-based target exploitation.

DESCRIPTION: Multiple DoD activities are investigating the use of wide-area framing cameras combined with image registration and multi-track processing to discriminate and monitor moving targets. Perhaps the most difficult practical challenge encountered by such systems in a complex urban environment is maintaining the correct association between successive observations of the same target over long periods. This task can be particularly daunting when the target-specific “features” derived from sensor measurements are limited to broadband intensity, shape and motion information, when target motion is variable and unpredictable, and when a large number of potentially confusing objects with similar features are present in the scene.

Hyperspectral data can potentially improve target tracking by providing additional features to identify targets. Recent developments in hyperspectral imaging technologies for persistent imaging require development of rapid, automated signal processing methods to efficiently detect, track and identify targets of interest in urban scenarios. While the use of hyperspectral imaging (HSI) information can significantly expand the dimensionality and information content of the feature space that can be exploited for continuous target recognition, it introduces additional complications due to environmental changes in spectral signature phenomena over extended time periods. The purpose of this proposed topic is to develop the signal processing methods required to efficiently detect, track and identify targets of interest using HSI alone, or HSI in combination with coincident high-resolution imagery. Evaluate the effectiveness of these algorithms and implement baseline processing capability that can be applied to existing or planned near-term sensor systems.

PHASE I: Develop methods for processing hyperspectral imagery from persistent imaging scenarios. This imagery will be provided and is 512x512 pixels spatially and 28 wavelength bands in the visible spectrum. The frame rate is around 12 hertz and the imagery is several minutes long. Demonstrate proof-of-concept for application of these algorithms and provide a development path that leads to real-time automated implementation.

PHASE II: Refine the Phase I algorithms and procedures and apply to data obtained from hyperspectral sensors.

PHASE III / DUAL USE: Military application: Additionally the methods developed will be useful for remote sensing applications at longer repeat coverage rates for both multi-spectral and hyperspectral systems. Commercial application: The technology developed here will have application to industrial monitoring or tracking applications.

REFERENCES:
1. Hyperspectral Collection and Analysis System (HyCAS)
Advanced Concept Technology Demonstration (ACTD)
Transition Plan, Version 2, February 2006

KEYWORDS: Hyperspectral

AF081-074 TITLE: Electronic Bumper for Rotorcraft Brownout Approach and Landing

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop a lightweight, low cost sensing and display system for maintaining safe clearance from obstacles during brownout approach and landing

DESCRIPTION: Brownout is the loss of visual cues during helicopter approach and landing in dry arid regions due to recirculation of dust by the rotorwash. Brownout is a serious problem for all services, leading to numerous aircraft and personnel losses in Afghanistan and Iraq. The most serious (Class A) mishaps involve collision with an obstacle or dynamic rollover due to the landing gear impacting sloped/uneven terrain or a ground hazard. Pilots rely upon calls from spotters positioned in doorways around the aircraft to maintain clearance from these obstacles. An “Electronic Bumper” system would detect and track major obstacles/hazards, including other aircraft in the flight, during brownout, and virtually all low/no visibility approach and landing. The system would help the pilot maintain safe clearance through the pilot-vehicle-interface, supplementing or replacing gunner/loadmaster calls. The sensor system would need to penetrate brownout dust clouds as well as all other degraded visual environments that limit visibility during rotorcraft approach and landing. Example obstacles include trees, poles, wires, vehicles, aircraft, walls, and buildings. Greater than hemispherical coverage will be required in order to detect/track other aircraft in the flight. The system should be able to sense to at least the main rotor diameter, 500 ft would be desired. The system should be extendable to provide longer range cable warning/obstacle avoidance during low level flight. An imaging sensor capability is not required. Detected/tracked obstacles/hazards could simply form the basis for display cues to the pilot. A lightweight, low cost solution is needed. Stretch goal is 10 lb total system weight, $10,000 unit cost. These weight/cost goals will require a highly innovative sensor solution in order to meet the desired operational performance. Innovative display solutions will be required in order to provide additional situation awareness and obstacle proximity alerts without adding to display clutter and pilot workload. This technology would have wide application across the USAF, Army, Navy, and USMC rotorcraft fleets as a stand-alone low cost modification, or as part of an integrated system.

PHASE I: Develop a system level concept and preliminary design. Perform analyses to demonstrate sensor spatial coverage, resolution, obstacle detection/tracking. Formulate candidate display concepts. Perform laboratory tests of critical components to demonstrate feasibility of the system concept.

PHASE II: Demonstrate the proposed Electronic Bumper system concept. Design/fabricate prototype hardware/software. Perform risk reduction field experiments. Conduct ground/flight demonstrations for obstacle detection/tracking and pilot cueing. Conduct analyses to demonstrate how operational performance and system weight and system cost goals could be met with a follow-on production system.

PHASE III / DUAL USE COMMERCIALIZATION: Technology developed under this program could be deployed across all US military helicopters, police and civil agency helicopters, with potential application to ground forces and homeland security.

KEYWORDS: Rotorcraft, Brownout, RADAR, Cockpit Displays, obstacles/hazards

AF081-077 TITLE: Innovative Micro Air Vehicles & Control Techniques for Urban Environments

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Develop innovative guidance & control algorithms that allow micro air vehicles (MAVs) to both operate (fly) in the urban canyon as well as loiter in areas of interest.

DESCRIPTION: Military operations must often be performed in the urban canyon. These environments are extremely cluttered, requiring precise guidance, navigation and control to successfully operate an air vehicle (specifically MAVs). Military operations in these environments are often characterized as Intelligence, Surveillance, Reconnaissance (ISR) missions. MAVs provide the possibility for low, slow flying ISR platforms. In addition, ISR mission commanders often find it desirable to be able to loiter over a specific target or area of interest in order to enhance data-gathering about that target or area. Loitering requires a significant change (relative to straight and level flight) in the guidance and control methods of air vehicles, especially in the urban canyon.
An important obstacle to MAV flight control in the urban canyon is the significant turbulence-like effect created by winds in the presence of buildings, walls, etc. Combining this challenge with the need to both travel through the urban environment (in order to reach the target or area of interest) and then loiter upon arrival at the target or area requires advanced control algorithms and techniques. A control system that includes a man in the loop (MITL) using a data link is both unreliable and of too limited overall control loop bandwidth to compensate for the high dynamics of urban canyon flight. A solution to this challenging problem involves developing autonomous algorithms capable of both navigating through the urban canyon and maintaining station upon arrival at the target or area of interest. Autonomous flight of loiter-capable air vehicles (i.e. helicopters or vertical lift vehicles) represents a challenging control problem, with complex, noisy, dynamics. These dynamics severely limit the ability of a helicopter-MAV to perform autonomous flight control functions, due to the lack of sufficiently-capable control algorithms. Current flight control algorithms for MAVs only permit way-point to way-point navigation. In the complex aerodynamic environment of an urban canyon, this is not sufficient to complete the mission. A more advanced control concept is needed to develop a “smart-MAV.”

PHASE I: Define algorithms that could, with further development, provide a MAV with capabilities to successfully conduct ISR missions in the urban canyon using autonomous reference to local structures (including loitering over areas of interest).

PHASE II: Develop a demonstration of the algorithm design. Produce a simulation of a suitable vehicle (such as those being developed by DARPA) which can be controlled by the new algorithm in a simulated urban canyon. The end result will be a prototype system ready for integration into a MAV.

PHASE III / DUAL USE: Military application: Innovative control algorithms/techniques can significantly enhance the performance of MAVs or reduce the processing resources required to host them. Commercial application: Commercial application: Law enforcement, search and rescue, and coastal and border surveillance.

REFERENCES:
1. Ng, Andrew Y., Kim, H. Jin, Jordan, Michael I. and Sastry, Shankar, "Autonomous Helicopter Flight via Reinforcement Learning," NIPS 7, 2003.

KEYWORDS: micro UAV, guidance and control, loiter, autonomous control POC: Dr. John McCalmont, AFRL/SNH

AF081-078 TITLE: Airborne Palliative for Helicopter Brownout Dust Abatement

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Develop an airborne dust abatement solution to restore visual approach during approach and landing by helicopters in desert environments.

DESCRIPTION: Brownout is the loss of visual cues during helicopter approach and landing in dry arid regions due to recirculation of dust by the rotorwash. Brownout is a serious problem for all services, leading to numerous aircraft and personnel losses in Afghanistan and Iraq. Mainstream solutions being pursued by the services include improve aircraft handling qualities, low speed symbology to help the pilot stabilize the aircraft, and imaging sensors to aid in landing zone situation awareness. An innovative and more direct solution to the problem would be to disrupt the recirculation of dust particles with an onboard system. Dust abatement solutions have been developed for helipads, utilizing palliatives that are applied in bulk (requiring up to 3 tons of water) and require up a full day to cure prior to operations. This approach is suitable for forward operating and refueling points, but is not applicable to tactical missions. However, the basic principles might be applied or creatively extended. The concept for an airborne palliative is to minimize the entrainment of dust particles and/or to conglomerate the dust particles that are entrained by the rotorwash so that, due to their increased mass, they drop out of the airstream, restoring the capability for a visual approach by the aircrew. This might be accomplished through use of a coacervate, electrostatics, acoustics, or other phenomenology. The intent would be for the particles to remain near the ground, and not recirculate, causing brownout. The development of this concept may require an unusual combination of disciplines which include but are not limited to: chemistry, soils, airflow/aerodynamics, electrostatics, acoustics, and atmospheric attenuation of visible light. But the payoff is high flexible helicopter operations in desert environments.

PHASE I: Perform "proof of concept" laboratory demonstrations of candidate solutions with controlled sand/dust particles and airflows. Develop a full scale system concept. Conduct analyses to estimate full scale system parameters and predicted performance.

PHASE II: Design/fabricate a prototype system for demonstration in a realistic or simulated dust environment. The government will provide assistance in obtaining access to a demonstration site and a light helicopter to demonstrate the system. If a government test site or helicopter is not available then the demonstration may be conducted by the contractor at a suitable laboratory or facility. Fully document demonstration results. Conduct the analysis to predict performance for medium and heavy lift helicopters.

PHASE III / DUAL USE: Military application: Technology developed under this program could be deployed across all US military helicopters, that require desert operations. Commercial application: Technology developed under this program could be deployed across police and civil agency helicopters that require desert operations.

REFERENCES:
1. Reference 1: “Evaluation of Expedient Methods for Mitigating Dust on Helipads,” ERDC/GSL TR-04-10 Sep 2004, by J.S. Tingle, A. Harrison, and J.F. Rushing.

2. Reference 2: “Sandblaster Phase I Fight Test Final Report,” Midwest Research Institute, Dr. Chat Cowherd.

3. Reference 3: “AFRL Brownout Integrated Solution Study Final Briefing,” AFRL, Mr. Walter Harringtron.

4. Reference 4: “Brownout Core Operational Tasks,” AFRL, May 2006.

KEYWORDS: Brownout, Dust Abatement, Soils, Desert Operations

AF081-079 TITLE: Algorithm to Emulate RF Signal of Multiple Targets for Countermeasures Technique Assessment

TECHNOLOGY AREAS: Information Systems, Battlespace, Weapons

OBJECTIVE: Develop an optimum algorithm to emulate radio frequency (RF) target signals for multi-platform to enhance electronic warfare countermeasure development and protect aircraft from RF missile threat systems.

DESCRIPTION: The objective of this program is to provide an efficient and accurate algorithm for a multiple target radio frequency (RF) signal emulator using triad antenna array network consists of dual-polarized, conical horn antennas, arrayed in equilateral triangular fashion to form triads, which are excited by RF signal sources. By properly exciting the appropriate triad, or triplet, of horn elements, a complex radiating source is emulated at a location within the triad. Continuous adjustment of attenuators by the controller affords implementation of complex flight paths of the platform whose target return is being simulated. When multiple triad antenna arrays are networked together to produce a triad antenna array network (TAAN), more sophisticated and complex scenario of RF signals can be emulated for multi-target platform countermeasures application.

PHASE I: Conduct proof of concept and present the alternate approaches to control (steer) the radio frequency (RF) signals within the triad antenna array network (TAAN). Demonstrate the control movement of a simple six-array antenna element with two RF target signals.

PHASE II: Validate the developed algorithm demonstrate in a complex scenario, the number of possible states in the emulator is exponentially increasing with the number of triad antenna array elements and the number of active separate targets. An efficient and accurate algorithm will be needed to generate all possible states and conditions. Military: Multi-target platform to enhance asymmetric warfare techniques, sensor data available to fighter aircraft, and will be useful for detection, recognition, and tracking of threat systems.

PHASE III / COMMERCIAL: Techniques applicable for commercial carriers to defeat radio frequency threat systems.

REFERENCE:
1. Multiple-target tracking with radar applications; Artech House, C1986

2. “Emulate Glint Signal with a Simple Triad Antenna Array”, S. M. Hong, R.R. Kissell, RF Design, September, 1998

3. “Multi-objective evaluation of target sets for logistics networks”, P. D. Emslie, MS Thesis, AFIT, 2000

4. “Temporal clustering in the multi-target tracking environment”, T. S. Kelso, Ph.D. dissertation, Univ. of Texas at Austin, 1988

5. “Multi-targets miss distance measurement based on a sequence of image processing techniques” , S. Hou and S. Wu, 8th Int’l Signal Processing Conf., Vol. 2, 2006

6. “A solution of multi-target tracking based on FCM algorithm in WSN”, L. Fan, H. Wang, and H. Wang, 4th IEEE Int’l PerCom Workshop Conf., March 2006

7. “Multi-target angle tracking via antenna array”, YH Chen, YT Lian, and CH Chen, AP-S Digest, June 1995, Vol. 1, Pgs 459-462

8. “Tracking Multi-target and Target Types Using Random Sets”, SR. Tian, Y He, and X. Yi, Int’l Radar Conf. , Oct 2006, Pgs 1-3

9. “Multi target tracking simulation in multi function radars”, M. Yaman, M. Efe, 12th IEEE SP-Comm Appl Conf., April 2004, Pgs 587-590

10. “A new multi-target angle tracking algorithm for antenna array”, YH Chen, PL Kuo, GJ Li, IEEE AP-S Int’l Symp. July 1997, Vol. 2, Pgs 1012-1015

KEYWORDS: Triad Antenna Array, signal emulator, algorithm, angular error, multi-target platform, radio frequency

AF081-082 TITLE: Fiber-optic RF Distribution (FORD)&digital control signals network across a PCB in GPS User Eqpt

TECHNOLOGY AREAS: Sensors, Electronics

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

OBJECTIVE: Investigate,design and develop a fiber optic network as a means for distributing RF and high speed digital control signals across a Printed Circuit Board (PCB).

DESCRIPTION: The use of fiber optics will be studied and demonstrated as a way of significantly reducing the potential for inter-board Electromagnetic Interference (EMI). High performance RF circuits found in highly robust GPS UE are especially sensitive to inter-board EMI, which results in spurious signals and poor circuit–to-circuit isolation. A fiber optic cable has the beneficial characteristics of extremely low cross-coupling and is not conductive along its length. Therefore, it shows great promise as a means of distributing RF and high-speed digital signals across a PCB with limited EMI. This innovative concept is directly applicable to PCBs which have high-level RF signals traversing near multiple, sensitive RF circuits found in robust GPS UE.

PHASE I: Perform cost/benefit trade-off study of fiber optic technologies taking into account SWAP and cost factors. Provide modeling, simulation and prototyping as required to validate the FORD concept. Prepare a technical report that describes Phase I efforts and the results of trade-off studies.

PHASE II: Design, develop and test a brassboard system that demonstrates your Phase I designed FORD concept. Prepare a Technical Report that will contain detailed test results highlighting performance benefits of your design, SWAP and cost estimates for a production system, and a Phase III implementation plan with a specific SWAP/cost constrained robust GPS system.

PHASE III / DUAL USE: Military application: Design, develop and test a production representative implementation of your design in a SWAP/cost constrained GPS system. Commercial application: Commercial Applications will be along the same lines as the Military

REFERENCES:
1. NORTHROP GRUMMAN SPACE TECHNOLOGY DAYTON OH
Assured Reference Technology Research (ARTHR) Project. Delivery Order 0004: Fiber-Optic RF
Conference paper preprint, 2 Jan 2006-2007
Author(s):
McLaughlin, Daniel
Wells, Jeffrey
Wurthh, Timothy
Dresher, Daniel

KEYWORDS: FORD, RF, Fiber Optics,

AF081-085 TITLE: Two-Beam Transmit Satellite Antenna for Limited Field-of-View (FOV)

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

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

OBJECTIVE: Develop/Demo low cost,low weight two independent simultaneous transmit beams antenna for TSAT downlink

DESCRIPTION: Current MILSATCOM system supports one downlink beam in frequency band 20.2-21.2 GHz. To increase the MILSATCOM capacity in the near future, a multi-band, multi-beam satellite antennas will be needed. The objective of this effort will be to develop and demonstrate simultaneous and completely independent two-beam transmit antenna for MILSATCOM down link. The antenna should be able to electronically scan each beam within conical volume with half-cone angle of 8 deg. The beamwidth is about 1 deg while the radiated power is about 120W per beam. The focus of this effort should be on limited field-of-view antennas to minimize number of active components, and therefore cost. The antenna architectures such as reflectors with array feeds as well as phased arrays may be considered. The contractor shall explore several creative approaches and perform the trade space analyses in terms of performance, cost, weight and power. In addition the contractor will analyze the interference issues between the two transmit beams due to mutual coupling effects as well as possible coupling of transmit signals into the receive channels. The company will have significant flexibility in formulating its approach to meeting the technical goals.

PHASE I: Investigate several limited-scan antenna architectures for MILSATCOM providing simultaneously two independent transmit down-link beams. Select one candidate architecture and perform the design trade-off study in terms of performance, weight, power and cost.

PHASE II: For the proposed antenna concept identified in Phase I, perform detail numerical simulation and refine the design trade-offs including fabrication and reliability. Fabricate and test most critical antenna subsystem, which could be reflector feed or
a 4 x 4 subarray.

PHASE III / DUAL USE:
Military application: Future MILSATCOM systems (AEHF,TSAT) will provide highly secured, high data rate communications which will require extremely wide-band or multiple-frequency bands, multiple-beam satellite antennas. Innovative solutions for light-weight, low-cost technology for such antennas is desperately needed. The antenna could be directly applicable to future MILSATCOM TSAT.

Commercial application: Commercial SATCOMs are also evolving toward improved coverage, bandwidth, data throughput, and connectivity which will also need wide-band, multiple-beam antennas. Thus there is a great need for generic multiple-band, multiple-beam light weigh satellite antennas. In addition multi-beam and multi-band antenna technology could be applied to ground /aircraft terminals (military as well as commercial) that communicate with multiple satellites.

REFERENCES:
1. Mailloux, R.J., Phased Array Antenna Handbook, Artech House, Norwood, MA, 1944., Chapter 8.

2. Sergei P. Skobelev, " Methods of Constructing Optimum Phased-Array Antennas for Limited Field of View," IEEE Antennas and Propagation Magazine, Vol. 40, No.2, April 1998.

KEYWORDS: Multi-beam satellite antennas, scanning reflector antennas, limited field-of-view phased array antennas, light weight and low power antennas for space applications.

AF081-086 TITLE: Distributed Control Actuator Aeroservoelasticity Methodology

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Establish analytical tools, free-play criteria for design, construction and controlled actuation of control surfaces with varying amounts of free-play. Validate with wind tunnel and flight certification test data.

DESCRIPTION: In-flight incidents supported by flight tests, wind tunnel tests, and analytical studies have shown that control surfaces with excessive free-play (or backlash) can induce limit cycle oscillation (LCO). LCO is a self-excited sustained vibration of limited amplitude which can impact pilot handling quality, ride quality, and weapon aiming capability. It also can induce structural fatigue or, under some circumstances, catastrophic flutter.

Modern aircraft with control surfaces are often not balanced with mass balance weights to preclude flutter, but instead prevent flutter by relying on retained stiffness in powered actuators. Controlling free-play on these control surfaces becomes very important because a much larger destructive potential exists if free-play-induced LCO with sufficiently large amplitude occurs.

Joint Service Guidance Military specification JSSG-2006 establishes free-play limits for all-movable control surfaces to provide assurance of freedom from LCO during normal and failure mode operation of aircraft. These free-play limits are carried over from the MIL-A-8870 specification and the Federal Aviation Administration (FAA) adopts the same free-play limits for commercial aircraft. The free-play limits are a very stringent requirement because the manufacturing tolerance of the moving parts associated with the control surface must be reduced to the extent that the resulting free-play satisfies the military specification, thus significantly increasing manufacturing costs. Furthermore, the free-play angle must be frequently monitored throughout the service of the aircraft because free-play may increase due to wear in the individual parts. This also significantly increases the inspection burden and maintenance costs of the aircraft. Current analytical techniques fall short in being the sole means for verification of design free-play limits beyond the specification limits. A combination of analysis, wind tunnel tests, wear tests, vibration tests and if necessary flight flutter testing is usually required. Therefore, it is highly desirable that an analytical technique by which the free-play specification limits can be safely relaxed be available.

The JSSG-2006 and MIL-A-8870 free-play limits specification was established based on a 1955 Wright Aeronautical Development center technical notes (WADC TN 55-624) which stated ""Free-play in all-movable controls should be limited to 1/64 degrees unless it can be shown by means of experimental flutter model data that reasonable deviations from this free-play limit can be tolerated for the particular all-movable control design being considered."" However, wind tunnel flutter testing is very costly for a new prototype aircraft, and data from such wind tunnels tests are not available to provide design free-play requirement in the early design stage of a new aircraft structure.

Fortunately today, because of advances in computational aeroservoelasticity, it should now be feasible to establish the free-play requirement for a new control surface design based on analytical techniques. The analytical techniques should be able to cope with the given nonlinear characteristics of the aircraft structure with an adaptable computational method. Flight conditions to be analyzed must include all flight regimes for the Air Force aircraft, and at trimmed or untrimmed conditions. External excitation (EE)should include gust, pilot-command input or random aeroacoustic excitations. The flight control law should be modeled by the software to simulate the statically unstable aircraft. Sources for validation include the NASA Langley wind tunnel and USAF flight certification tests.

PHASE I: Develop a nonlinear aeroservoelastic methodology for free-play/LCO analysis and prediction for a given aircraft structure under gust excitation. Validate predictions on legacy wind tunnel test article/data.

PHASE II: Generalize free-play method as mature software for closed-loop aeroelastic system in trim/untrim state. EE includes gust, stick or random aeroacoustic. Establish flight control law modeled by software to simulate statically unstable aircraft. Build prototypical test article with variable free-play settings. Correlate model predictions with wind tunnel data on prototype.

PHASE III / DUAL USE: Military application: Use free-play aeroservoelastic tool & limit methodology with conservative wind tunnel results to safely justify relaxing MIL-SPEC burden on key warfighter systems in detailed design/early production phase. Commercial application: Following military application, tool and methodology are adopted by the FAA. Adopted by all major civ/mil aerospace industries as a design/analysis tool for free-play-induced LCO/flutter prevention.

REFERENCES:
1. Hoffman, ""Subsonic Flutter Tests of an All-Movable Stabilizer with 35 deg Sweepback,"" WADC Technical Note 55-623, November 1955.

2. Tang, D., Kholodar,D.,and Dowell,E.H., ""Nonlinear Response of Airfoil Section with Control Surface Freeplay to Gust Loads,"" AIAA Journal, Vol. 38, No. 9, 2000, pp. 1543-1555.

3. Price, S.J., Alighanbari, H., and Lee, B.H.K., ""The Aeroelastic Response of a Two Dimensional Airfoil with Bilinear and Cubic Structural Nonlinearities,"" Journal of Fluids and Structures, Vol. 9, 1995, pp. 175-193.

4. Murphy, K.D. Bayly, P.V., Virgin, L.N., and Gottwald,J.A., ""Measuring the Stability of Periodic Attractors using Perturbation-Induced Transients: Applications to Two Nonlinear Oscillators,"" Journal of Sound and Vibration, Vol. 172,1994, pp. 85-102.

5. Gerry Larkin, ""Proposed FAA Policy on Control Surface Free-play"" Aerospace Flutter Dynamics Council, Seattle, October 2004.

KEYWORDS: free-play, control surface, limit cycle oscillation, military specification, variable setting, nonlinear structures, nonlinear aeroservoelasticity, external excitations, gust

AF081-087 TITLE: Due Regard Technology for Unmanned Aerial Systems

TECHNOLOGY AREAS: Air Platform, Information Systems, Ground/Sea Vehicles, Sensors, Electronics

OBJECTIVE: Develop technology capable of autonomously detecting cloud edges to enable autonomous avoidance of weather and maintain operation in visual meteorological conditions.

DESCRIPTION: Current UAS flights are severely restricted to avoid potential collision with other air platforms. Federal Aviation Administration (FAA) Regulation 7610.4 [1] states that remotely operated aircraft must have an equivalent level of safety, comparable to see-and-avoid requirements for manned aircraft, to satisfy FAA safety requirements.

When operating in international air space, all aircraft must either file a flight plan and follow directions received from an air traffic control authority, or operate autonomously, exercising due regard for the safety of other aircraft by detecting them and maneuvering to avoid them. The due regard requirement must be effective against all air traffic, with or without transponder-based collision avoidance systems such as TCAS [2] or ADS-B [3]. Mission requirements often dictate operations of U.S. reconnaissance aircraft in such international airspace without benefit of ground-based control (i.e., they must operate while exercising due regard for the safety of others). Manned aircraft accomplish and maintain due regard via the on-board pilot using visual scanning techniques. Since UAS such as Global Hawk, which perform such missions, has no human pilot on board, and is currently unable to find and avoid clouds and other visual obscurants, a radar is anticipated to serve as the primary sensor of intruding air traffic in many cases. However, there will be times when mission requirements will not allow the radar to be on (EMCON), and the UAS will be required to rely on a passive electro-optical (EO) or infer-red (IR) sensor system to sense and avoid traffic. This requires the UAS to maintain operations in visual meteorological conditions (VMC), that is, it will have to stay clear of clouds so that it can see the other air traffic. UAS are currently unable to ascertain VMC autonomously. Algorithm technology to provide detection of cloud edges so that a safe flight path may be calculated and recommended to the flight control system (remain well clear of the cloud and maintain sufficient clear lines of sight to permit timely detection of any intruding air traffic) is needed to be integrated into the now-developing SA suite. Key obstacles to providing this capability are UAS size, weight, and power (SWaP) constraints available for hosting data processing, and the need to use existing passive sensor performance. The UAS cannot host a separate EO/IR sensor for this function. Existing sensors are those used for the Sense and Avoid collision avoidance function and an IR nose camera used for runway clearance assurance during landing. These sensor locations are available for the desired new functionality provided the original functions are preserved. This is a point solution and can not require modifications to the external air traffic control system in the continental U.S (CONUS) or worldwide.

The solution to this UAS problem is anticipated to be integrated into the multi sensor suite and algorithms of an SA system consisting of a passive EO sensor with ability to passively track a variety of traffic types at distances sufficient to enable on-aircraft autonomous action to assure collision avoidance, a miniature radar with similar detection and tracking range, a TCAS II cooperative collision avoidance capability, and ADS-B in a future upgrade.

The government will provide technical information of the SA suite to include SWaP constraints as well as equipment limitations. No hardware or aircraft will be provided by the government.

PHASE I: Define algorithm requirements and architectural design, subject to SA system constraints. Develop a high-level algorithm design that satisfies the requirements. Develop a software simulation of the function to show compliance with the intent of due regard requirements and show design efficacy.

PHASE II: Design, build, and demonstrate an affordable due regard prototype system on a manned UAS surrogate. Demonstrate the ability to perform collision avoidance by detecting weather cells and cloud edges and recommending a maneuver to avoid them.

PHASE III / DUAL USE: Military application: Any UAS operating in international airspace in which the due regard requirement is required. Commercial application: Any UAS operating in international airspace in which the due regard requirement is required. Any UAS operation where autonomous cloud avoidance (stay well clear) is a requirement.

REFERENCES:
1. FAA Federal Aviation Regulations (FAR).

2. FAA Order 7610.4.

3. FAA, ""Introduction to TCAS Version 7,"" US Department of Transportation, Federal Aviation Administration, 2000.

4. RTCA, ""Minimum Aviation System Performance Standards For Automatic Dependent Surveillance Broadcast (ADS-B)"", RTCA/DO-242A, Washington DC, 2002.

5. DoD Directive 4540.1, Use of Airspace by US Military Aircraft and Firings Over the High Seas, January 13, 1981.

KEYWORDS: due regard, collision avoidance, sense and avoid, UAS

AF081-088 TITLE: Verification of Cold Working and Interference Levels at Fastener Holes

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: To develop a methodology for measuring stresses at and around cold-worked holes and determine the effectiveness of cold working in terms of expected fatigue life.

DESCRIPTION: The Air Force has determined that the benefits from cold working a hole, or using an interference-fit fastener, include significantly increased life of a structure subjected to fatigue loading. There is currently no technique for determining how well the material structure immediately surrounding the hole has responded to the cold working process. Hence, the beneficial effects of cold-worked holes and interference fit fasteners are not accounted for in the structural integrity analysis used to determine when to inspect aircraft structures for cracks. Moreover, some holes, after cold working, might still be a liability with respect to remaining fatigue life as opposed to an unaccounted benefit. Thus, there is a need for an inspection technique that ensures every fastener hole has been properly worked and a methodology for determining the effectiveness of cold working in terms of expected fatigue life. One potential technique is X-ray diffraction (XRD) which is a proven technique that produces a quantifiable measurement, and is a direct method for measuring stresses in a material since strain is measured without the need of calibration for secondary effects related to stress. Alternative techniques and methodologies that accomplish the same goal are also sought. Most cracks initiate at the surface; therefore, the soundness of a structure or system can be quantitatively determined by measuring residual stresses at the surfaces of the structures and systems in question.

PHASE I: Establish framework and models for using XRD (or other technique) information to quantify the residual stresses at a cold-worked hole and utilize the information to predict expected fatigue life. Framework and model should be verified using coupon level testing.

PHASE II: The Phase II effort will implement the Phase II Methodology Development Plan. Deliver a prototype model for Government evaluation that can be used with commonly available structural analysis and life prediction software such as FRANC3D and AFGROW.

PHASE III / DUAL USE: Military application: Aircraft platforms are used more than expected and knowing the condition of specific locations of concern as determined by some quantifiable and repeatable means will aid maintenance decisions. Commercial application: Opportunities exist in the automotive, railroad, heavy equipment, oil drilling and construction industries.

REFERENCES:
1. X-Ray Residual Stress Analysis - The Potential for Locating precursors to Component Failures,"" NTIAC Conference, San Antonio, Texas, April 1987.

2. ""Correlation of Residual Stress to Bearing Condition,"" Conference Proceedings, Residual Stress in Design, Process and Materials Selection , pp. 169-181, April 1987.

3. ""X-Ray Diffraction Stress Analysis as an NDE Technique,"" Review of Progress in QNDE, Williamsburg, Virginia, June 1987.

4. Assessment of Component Condition From X-Ray Diffraction Data Employing the Sin2ø Stress Measurement Technique,"" ASM Conference on Residual Stress, Indianapolis, Indiana, May 1991

KEYWORDS: residual, stress, measurement, nondestructive, coldwork, interference, X-ray, diffraction

AF081-089 TITLE: Design/Life Prediction Tools for Aircraft Structural Components with Engineered Residual Stresses

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop validated models and design tools for optimizing the benefits of introducing engineered residual stresses into aircraft structural components.

DESCRIPTION: The introduction of engineered residual stresses, through processes such as glass shot peening, laser shock processing, and low plasticity burnishing, has been found to dramatically increase fatigue life of several aircraft components, with attendant benefits of enhanced safety, operational cost reduction and improved performance. However, for full exploitation of these technologies, there is a need for validated models that can be used to determine optimal surface regions in a given component and for prescribing optimal processing parameters. Such models, when used in conjunction with structural design and life prediction software, would help maximize the benefit to total cost ratio on a component specific basis. A validated methodology would be extremely useful since it would reduce the costly experimental iteration currently required to field each new application. Further, it would allow for optimized designs rather than those that simply meet the requirement.

A successful methodology will allow for the prediction of fatigue behavior in components containing both applied stresses and residual stresses induced by various means including but not necessarily limited to laser shock processing and low plasticity burnishing. A successful prototype system will also be capable of accounting for stress concentrations. An incorporated methodology for predicting lower bound fatigue behavior due to the material damage and residual stress states surrounding cracks and foreign object damage (FOD) would also be desirable.

The Air Force welcomes creative and innovative approaches to obtaining the desired models for use as design tools.

PHASE I: Demonstrate feasibility of a proposed model to predict induced residual stresses and effects on fatigue behavior of structural components. Conduct experiments to validate the model. Deliver a proposed methodology development plan for Phase II implementation.

PHASE II: Implement the Phase II Methodology Development Plan. Deliver the prototype model in the form of a user friendly, executable code or as a package that can be used with commonly available structural analysis and life prediction software.

PHASE III / DUAL USE: Military application: Same applications for commercial industry original equipment manufacturers. Commercial application: The impact of induced residual stresses has been limited to certain high-value-added applications in which costly empirical optimization could be accommodated.

REFERENCES:
1. Clauer, A. H. and D. Lahrman, F.""Laser Shock Processing as a Surface Enhancement Process,"" International Mechanical Engineering Congress & Exposition, Orlando, FL, Trans-Tech Publications,2001, Switzerland.

2. Montross, C. S., Tao Wei, Lin Ye, Graham Clark, and Yiu-Wing Mai, ""Laser Shock Processing and its Effects on Microstructure and Properties of Metal Alloys: a Review,"" International Journal of Fatigue, Vol. 24, No. 10, 2002, pp. 1021-1036.

3. Beghini, M., Bertini, L., and Vitale, E., ""Fatigue Crack Growth in Residual Stress Fields: Experimental Results and Modeling,"" Fatigue Fract. Engng Mater. Struct. Vol. 17, No. 12, 1994, pp. 1433-1444.

KEYWORDS: LSP, life prediction, residual stress, fatigue, modeling, low plasticity burnishing

AF081-090 TITLE: Distributed Satellite Resource Management for Defensive Counterspace

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop and demonstrate automated resource management (RM) technologies that manage real-time defensive counterspace (DCS) and space situational awareness (SSA) activities.

DESCRIPTION: There has been a focus in recent years towards applying data fusion technologies for the detection and discrimination of spacecraft events. The complement of the Joint Directors of Laboratories (JDL) fusion model is the RM model that allows for formal management of each of the JDL fusion levels. Based upon a-priori information, the RM can provide automated tasking, prioritized response options or decision aids for user response tasking. These response options need to be more sophisticated than simple checklist-based courses of action in service today because multiple simultaneous events may necessitate non-linear combinations of time-phased responses. Automated response options provided to operators from RM can be demonstrated to be more suitable than would be expected from military or civilian personnel operating only from checklists. Resource management (RM) will advise satellite operators of possible response actions in a timely manner to the situation as provided by level 0-3 fusion developed for DCS and SSA. These include: abnormality detection/recognition, abnormal event tracking, event relationship and situation tracking and mission impact prediction. RM will be driven by the specific individual satellite mission objectives (i.e., Level 3 Management outputs). These will be used to drive Level 2 resource relationship (e.g., resource conflicts and synergisms) management, Level 1 independent resource scheduling, and Level 0 signal management. This proposal seeks to develop prototype levels 0, 1 and 2 RM algorithms for satellite defense, then demonstrate that the RM approach is general enough to be successfully applied to other missions. The resources considered in this effort are satellite commanding (e.g., notifying the appropriate command, closing shutters, changing subsystem operating modes, maneuvering the satellite, modifying the communications, processing management, and sensor and data collection management.) As an example, distributed level 1 RM can generate relevant cross-unit recommendations. Furthermore, a Space Operations Squadron (SOPS) is not currently authorized to directly task (i.e., manage the resources of) a space surveillance network (SSN) unit to increase surveillance of a resident space object of interest within a specified distance of a protected satellite. Distributed level 1 RM at a SOPS could generate RM recommendations that include increased data fusion vigilance for similar problems on other satellites or increased alerting for changes in space environment conditions once environmental impacts materialize. To improve the operator situation awareness and response decision making, the proposer should provide for sensor, communications, and/or data collection management, visualization, and reporting.

PHASE I: Demonstrate RM prototypes specifically tailored to an operational unit, such as a satellite operations squadron, that has direct control over organic resources. Performance of the automated RM capability versus unaided operator responses will also be compared for accuracy and timeliness.

PHASE II: The algorithms developed in Phase I will be refined for more sophisticated event conditions that could occur in cross-constellation RM situations. The RM capability will be integrated with abnormality event fusion using spacecraft telemetry, space environment data, orbital proximity, and INTEL data sources. In addition, level 2 RM capability of cooperative resource tasking may be developed.

PHASE III / DUAL USE: Military application: Data Fusion and Resource Management (DF&RM) tools, in conjunction with automated data fusion techniques, are critical at both the individual space ops level and at the Joint Space Ops Center level. Commercial application: The same technology is applicable to commercial satellites which have a need to perform automated event detection and response in order to safeguard resources and maximize operations time.

REFERENCES:
1. Steinberg, A. and C. Bowman, “Rethinking the JDL Data Fusion Levels”, NSSDF JHAPL, June, 04.

2. Bowman, C. L., “The Dual Node Network (DNN) Data Fusion & Resource Management (DF&RM) Architecture” AIAA Intelligent Systems Conference, Chicago, September 20-22, 2004.

KEYWORDS: Resource Management, Defensive Counterspace, Space Situational Awareness, Response Options, Decision Aids, Automated Tasking

AF081-091 TITLE: Optical Transmitter for Inter-satellite Communications

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop compact, efficient and lightweight optical transmitter suitable for use in inter-satellite communication links.

DESCRIPTION: The Transformational Satellite (TSAT) program is under development as part of the Air Force's commitment to bringing secure, robust, high capacity satellite communications to the battlefield. Because laser inter-satellite links (ISL) enable significantly greater data throughput when compared to conventional RF communication systems, the TSAT program is interested in supporting the development of optical transmitters that are lightweight, compact and can perform multiple functions. Typical optical transmitters currently employed in terrestrial and submarine optical networks consist of a DFB (Distributed Feedback) laser (as a CW (Continuous Wave) source) and a LiNbO3 modulator, but this configuration is bulky and the LiNbO3 modulator suffers from the well-known bias drift problem. Thus, this topic seeks to develop innovative optical transmitters in the form of compact monolithically integrated chips that perform one or more of the following functions: light generation, wavelength or frequency tuning, amplification, modulation (either electro-absorption (EA) or Mach-Zehnder), and/or multiplexing. Optical transmitters must be capable of supporting data rates >40 Gbps over missions life of up to 15 years. Other goals include operating wavelength of 1550 nm, tuning range >3nm, side mode suppression ratio (SMSR) >35dB, optical output power >13dBm, dynamic extinction ratio >10dB, modulator drive voltage <3V, operating temperature range between -40 deg. C to +85 deg. C, and total ionizing dose tolerance of >1 Mrad (Si),.

PHASE I: Develop innovative conceptual design for robust, lightweight and high data rate optical transmitter. Validate performance through modeling and simulation and create a detailed design meeting goals identified above.

PHASE II: Create prototype of optical transmitter from Phase I design. Characterize for relevant performance capability including operating wavelength, data rates, total dose tolerance, operating temperature range, reliability, and bit error rate.

PHASE III / DUAL USE: Military application: High data rate optical crosslinks could find use in DoD communications satellites and Unmanned Aerial Vehicles. Commercial application: Commercial applications include future upgrades to telecommunications satellites, rugged transmitters for terrestrial applications, and transmitters for power-limited systems.

REFERENCES:
1. http://www.kirtland.af.mil/afrl_vs/

2. http://www.afrlhorizons.com/Briefs/Jun05/VS0409.html

3. http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=5332

KEYWORDS: bragg filter, photodiode, fiber laser, tunable laser, laser communications, satellite communications, space environment, radiation hard communications, laser modulator, TSAT, optical transmitter

AF081-092 TITLE: Lightweight Solar Array Structure for Thin Multijunction Solar Cells

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop a lightweight thin multijunction solar cell array structure that enables a revolutionary increase in specific power.

DESCRIPTION: The recent developmental pursuit of high-efficiency thin multijunction solar cells has created the possibility of space-based specific power exceeding 1000 W/kg. This revolutionary development would dramatically decrease the mass and stowage volume for a space-based solar array, relative to State-of-the-Art (SOA) configurations. Reduced solar array mass and stowage requirements translate to reduced launch costs, mitigated satellite dynamics/controls issues, enhanced orbital maneuvering capabilities, and more. To make this challenging goal a reality, the Air Force is interested in the development of innovative thin multijunction solar cell substrate concepts that take advantage of and are compatible with next-generation solar cell electrical interconnects systems for III-IV materials. Previous developmental efforts in lightweight solar array designs have ultimately failed when mass is added to the array structure to increase stiffness. Conventional solar array structures, consisting of honeycomb substrates with aluminum and composite face-sheets, have been optimized for non-thin multijunction solar cells with approximately 140 – 170 micrometer thick crystalline solar cells and 75 – 300 micrometer thick coverglass. Current SOA solar arrays are limited to 30 kW due to launch vehicle fairing volume. Novel designs and innovative utilization of new materials would not only increase the array-level specific power, but could also be optimized to maintain the structural integrity of ultra-thin crystalline solar cells, and retain the stiffness requirements for launch and on-orbit attitude control. Innovative structural development designs may require novel deployment techniques to fully optimize array stowability. Proposals should focus on concepts that significantly improve SOA array level performance parameters (100 W/kg specific power, and 13 W/m3 stowability). These improvements will ultimately lead to reduced overall operating costs and improved mission capabilities for high power platforms supporting higher bandwidth communications for space based applications. Offerors are encouraged to work collaboratively with Air Force contractors developing other thin multijunction cell subsystems such as electrical interconnects, to ensure the government progresses toward a developmental path that is cost and technically effective.

PHASE I: Analytically demonstrate the feasibility of the development approach to produce an advanced solar array structure and module technologies optimized for 20 micron thick multijunction solar cells. Proof-of-concept demonstrations are encouraged but not required.

PHASE II: Apply results from Phase I to design, fabricate and test a prototype solar array structure that validates the design approach for significantly increasing an array's specific power and stowability capabilities, relative to SOA configurations.

PHASE III / DUAL USE: Military application: All DOD spacecraft use multijunction space solar cells for electrical power generation. The availability of solar arrays with improved specific power will increase the capability of military spacecraft. Commercial application: Commercial spacecraft will also benefit from improved specific power and the other benefits associated with thin multijunction solar cells.

REFERENCES:
1. Geens, W., K. Dessein, W. Köstler, M. Meusel, S. Taylor, P. Mijlemans, and G. Strobl, "Assessment of the Use of 100mm Thin Germanium Wafers for High Efficiency Space Solar Cells," 7th European Space Power Conference, May 9-13, 2005, Stresa, Italy.

2. Küchler, G., J. Müller and I. Köker, "COMED – Flexible Solar Generator," 7th European Space Power Conference, May 9-13, 2005, Stresa, Italy.

3. D'Abrigeon, L., A. Carpine and G. Laduree, ""Solarbus Solar Array: Innovative Light Weight Mechanical Architecture with Thin Lateral Panels Deployed with Shape Memory Alloy Regulator," 7th European Space Power Conference, May 9-13, 2005, Stresa, Italy.

4. Takamoto, T., T. Agui, H. Washio, N. Takahashi, K. Nakamura, O. Anzawa, M. Kaneiwa, K. Kamimura and K. Okamoto, "Future Development of InGaP/(In)GaAs Based Multijunction Solar Cells," 31st IEEE Photovoltaics Specialists Conference, Lake Buena Vista, FL, 2005.

KEYWORDS: Lightweight Structures , Thin Multijunction Solar Cells, Space Power, Solar Arrays

AF081-093 TITLE: Agile IR Filters

TECHNOLOGY AREAS: Sensors, Electronics

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

OBJECTIVE: Exploit emerging agile filter technology to enhance operational capabilities of advanced IR systems for intelligence,surveillance and reconnaissance (ISR) including space situational awareness

DESCRIPTION: The thrust of the current effort is to develop sensor concept(s) for a given military application(s) using an adaptive infrared focal plane array with tunable filters that allow rapid spectral band changes assuming technology will eventually lead to independent control at the pixel level (references 1 and 2). Sensor concepts will be developed for selected applications in which the agile filters demonstrate a unique capability or a significantly enhanced capability over fixed filter systems. Applications include sensors for future space-based systems for space situational awareness and missile defense, such as, the Space Based Infrared System (SBIRS), the Space Tracking Surveillance System (STSS), the Space Based Space Surveillance (SBSS) System , and UAV based sensors for tactical applications. Systems for missile defense and space situational awareness require increasing sophistication and must be able to function in any background. Requirements include the ability to detect, track, identify and characterize space objects at long range. Smaller dimmer evolving threats present inherently weaker infrared signatures that must be detected in scenes containing background clutter from terrestrial, earth limb atmospheric and celestial sources. The capability need extends to small, distant and dim objects that may be obscured by natural and man made infrared clutter that arise from atmospheric and man made structures. Background or foreground clutter that may obscure threat objects include terrain, tree canopy, clouds, stratospheric warmings, aurora, temperature inversions, polar mesospheric clouds and nuclear induced effects.

PHASE I: Identify and describe an ISR system application to exploit the capabilities of agile infrared filters operating at the system and or focal plane or pixel level that significantly enhances the capability to identify, find, fix, track, type, identify and characterize a threat object.

PHASE II: Develop and complete a preliminary system design study for the identified ISR system concept, demonstrate the advantages offered by the agile tunable infrared filters in terms of earlier detection, longer acquisition range or improved signal to noise level and or the ability to type, identify or characterize the target. Create simulations for effective visualization of the system concept.

PHASE III / DUAL USE: Military application: Military applications include missile defense and space situational awareness. Commercial application: Agile tunable optical filter devices may be applied to remotely detect gaseous leaks, pollutants, combustion products and combustion efficiencies in facilities and vehicles.

REFERENCES:
1. Defense Advanced Research Projects Agency (DARPA) Broad Agency Announcement 02-20 "Adaptive Focal Plane Array".

2. AFRL-SN-WP-TR-2005-1098, XC-AFRL-SN-WP, ""System Development Study for DARPA Phase I Adaptive Focal Plane Array,"" Final Report, 17 Jun 2003-31 Dec 2004, Kenneth J Barnard, ADB308690.

3. ""Analysis of Below-the-Horizon Spectral Data from MSX,"" Alexander S. Zachor, Air Force Research Laboratory PL-TR-97-2110, 10 August 1997.

KEYWORDS: agile filters, tunable infrared filters, adaptive focal plane array

AF081-094 TITLE: Novel Mitigation Techniques for Reconfigurable Computers for Space Based Applications

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop and implement novel radiation mitigation techniques for Reconfigurable Computers for Space Applications

DESCRIPTION: Demand for high performance on-board processing (OBP) for space-based applications are being driven by new and challenging DoD, commercial and civil applications such as software-defined radios, high speed Internet Protocol routing, digital channelizers, hyper-spectral image processors and space situational awareness. Reconfigurable Computers (RCC) are an ideal candidate for space-based OBP applications. They can be reconfigured to support a varying array of processing applications. Their Gigaflop/Watt ratio is orders of magnitudes higher than scalar processors. Algorithms developed can be ported to future generations of hardware with minimal modification. The challenge with Field Programmable Gate Array (FPGA)-based RCCs is mitigating the single event upsets (SEUs) caused by radiated charged particles (1,2,3).

Traditional mitigation techniques, such as triplication of code coupled with majority voting (designated as Triple Modular Redundancy (TMR)), have proven effective in mitigating SEUs (4). However, these methods incur a large penalty in power, mass, speed and processing resources. In the best case, the TMR approach would only increase FPGA usage by 3x as compared to a non-TMR’d design, but the penalty could be as high as 10x for certain applications (5). Additionally, some resources available in FPGAs cannot be utilized in a design because they do not lend themselves to being TMR'd, further reducing their processing output. New SEU mitigation approaches are needed to maximize the processing potential of FPGA based RCCs (6).

PHASE I: Develop novel SEU mitigation techniques for RCC systems and establish performance metrics for comparison to traditional approaches. Develop the ability to include other application algorithms and compare various mitigation methods in a computer-simulated radiated environment.

PHASE II: Develop a fully capable RCC hardware test system to measure actual performance of different mitigation techniques. Evaluate different application algorithms using different mitigation methods in a simulated radiated environment. Develop a flight experiment system for a RCC based OBP for a specific application.

PHASE III / DUAL USE: Military application: Nearly all satellites launched in the government and commercial space sectors contain control electronics that are vulnerable to SEUs in the space environment. Accordingly, nearly all players, both government and commercial, will benefit greatly from the increased reliability of space electronics resulting from this effort. On the military side, on board processing on reconfigurable computers is critical for a number of different DOD programs that require high performance processing (e.g., Alternative Infrared Satellite System (AIRSS), Space Based Radar). Commercial application: Enhancement of mitigation techniques are also of very high value for commercial and civil applications, for example, processing for autonomous docking and high speed image data compression, software defined radios, IP routing and digital channelizers. Such an improvement will also be valuable to commercial space communication firms. The operational lifetime of television, radio, and cell phone satellites will be extended with the development of more robust electronics.

REFERENCES:

1. Graham, Paul, Michael Caffrey, Jason Zimmerman and D. Eric Johnson, “Consequences and Categories of SRAM FPGA configuration SEUS, Military and Aerospace Programmable Logic Devices,” (MAPLD) 2003 conference paper.

2. Caffrey, Michael, Paul Grahm, Eric Johnson and Michael Wirthlin, “Single-Event Upsets in SRAM FPGAs,” MAPLD 2002 conference paper.

3. Fabula, Joe, Austin Lesa, Carl Carmichael and Saar Drimer, “NSEU Sensitivity of SRAM-based FPGAs,” MAPLD 2003 conference paper.

4. Rollins, N., M. Wirthlin, M. Caffrey and P. Graham, “Evaluating TMR Techniques in the Presence of Single Event Upsets,” MAPLD 2003 conference paper.

5. Rezgui, Sana, Kevin Somervill, Gary Swift, Jeffrey George and Carl Carmichael, “Complex Upset Mitigation Applied to a Reconfigurable Embedded Processor.”

6. Murray, Paul and Damon VanBuren, “Single Event Effect Mitigation in ReConfigurable Computers for Space Applications,” IEEE Aerospace Conference Paper, 2005.

KEYWORDS: Satellite operations, on-orbit processing, high performance processing, SEU mitigation algorithms, SEU algorithms, SEU mitigation techniques

AF081-095 TITLE: Advanced Cryogenic Refrigeration Technologies

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

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

OBJECTIVE: Develop innovative cryogenic refrigeration technology concepts.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require new breakthroughs and revolutionary improvements in cryocooling technology. Many different techniques have been reported that have potential for marked improvement in cryogenic cooling technology. Examples include use of systems Microelectromechanical Systems (MEMS) technology, hybrid thermodynamic cooling cycles, highly effective and miniaturized counterflow heat exchangers, low temperature - high capacity regenerators, across-gimbal cryogenic heat transfer system and long life, high pressure ratio DC flow compressors. MEMS technology and advanced manufacturing techniques have potential for use in miniaturized coolers and as advanced heat exchangers that have applications in many cooling concepts, including advanced reverse Brayton coolers, Joule-Thomson coolers, and hybrid expansion cycle coolers. The enabling characteristics of the heat exchangers are high effectiveness (>0.99) combined with low pressure drop and minimal mass and volume. High capacity regenerators for applications such as high capacity cooling at or below 35 Kelvin (3-10W) require innovative designs to enable efficient regeneration for the larger capacity heat loads. Long life (> 10 years, 100% duty cycle), high pressure ratio (4-6:1), DC flow (unidirectional flow) compressors are needed to enable the use of hybrid cooling systems that utilize a higher temperature cryocooler for pre-cooling and cool to low temperatures via a Joule-Thomson, reverse Brayton or other expansion cooling cycles. In order to address the context of USAF missions across a wide range of potential orbits, system mass minimization should be a key consideration in novel designs. These key technology developments will enable future cryogenic cooling technologies and offer significant leaps in efficiency, performance, low temperature capability and lifetime. Payload jitter (>10 hertz) minimization through control of exported vibration below the 10 mN total exported rms level is a significant objective.

Proposals should clearly indicate what cryogenic cooling temperature regime(s) their efforts will support out of the following objective regimes:

1. Launch and boost phase (not gimbaled): two stage cooling at 70-110 K for 10 W, at 160-180K for 20 W.
2. Midcourse detection phase (gimbaled): two stage cooling at 35 K for 2 W, at 85-95K for 20 W.
3. Midcourse discrimination phase (gimbaled): two stage cooling at 10 K for 0.2 W, at 45-50K for 5 W.

Showing how the component improvement would benefit currently available designs for space Electro Optical (EO) payload either as efficiency improvements or as reductions in payload budgets must be discussed in the proposal. Mass improvements for gimbaled payloads are currently assessed relative to the following payload trade budgets:

0.3 kg/W of heat rejection for rejection radiator
0.2 kg/W of power input
30% of refrigerator mass and radiator for on gimbal cooling

Consequently, moving a 100 W refrigerator of 10 kg mass off gimbal would save 0.3 x[10+ (0.3 x 100)] = 12 kg of payload mass. An alternative to save this same 12 kg mass penalty would be to increase cooling efficiency on gimbal so that the power input would be only 79.65 W. It should be obvious from this analysis approach that controlling size (up to an upper linear dimension limit of 2 meters) or component intrinsic mass is not a primary objective of this topic; instead, payload mass savings in excess of 10 kg are the prime mass objective.

Offerers are encouraged to work with system, payload and/or refrigeration contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE I: Efforts should concentrate on the development of the fundamental concepts for increased efficiency or reduced mass, jitter or power input of space EO payloads or their supported spacecraft and plan to further develop this technology in Phase II.

PHASE II: Phase II SBIR effort should utilize the innovation developed in Phase I and develop a breadboard device to demonstrate the innovation. This device should demonstrate the potential of the working prototype device to meet emerging operational specifications. Demonstration of the improvements in mass, input power, efficiency, reliability and/or cryogenic system integration should be made.

PHASE III / DUAL USE: Military application: Typical USAF military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Commercial application: Applications of this technology include NASA or commercial sector space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather or earth resource monitoring.

REFERENCES:
1. Davis, T. M., B. J. Tomlinson and J. Ledbetter, “Military Space Cryogenic Cooling Requirements for the 21st Century,” Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 1-10.

2. Roberts, T. and F Roush, ""Cryogenic Refrigeration Systems as an Enabling Technology in Space Sensing Missions,"" Proceedings of the International Cryocooler Conference 14, to be published in Cryocoolers 14, 2007.

3. Donabedian, M. and D. Gilmore, ""Spacecraft Thermal Control Handbook,"" Plenum Press.

4. Rich, Michael, Marko Stoyanof and Dave Glaister, ""Trade Studies on IR Gimbaled Optics Cooling Technologies,"" IEEE Aerospace Applications Conference Proceedings, v. 5, pp. 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.

5. Razani, A., et al, “A Power Efficiency Diagram for Performance Evaluation of Cryocoolers,” Adv. in Cryo. Eng., v. 49B, Amer. Inst. of Physics, Melville, NY; pp. 1527-1535, 2004.

KEYWORDS: cryogenic, cryocooler, cooling requirements, cooling loads

AF081-096 TITLE: Modeling, Simulation and Analysis Tools for Collaborative Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Decision aids and tools for modeling, simulation and analysis that enable the collaborative use of distributed assets to produce a common understanding of readiness of resources and real-time status.

DESCRIPTION: A variety of threats may impact the U.S. space domain and its operations. With regard to achieving capabilities of having common operating pictures and predictive battlefield awareness, the Air Force is interested in developing an optimized, layered and networked set of space-based sensors capable of real-time processing together with data mining and fusion. The effort will consist of concept exploration/development/employment as well as enabling technologies for cueing various additional automated observations by ground-/air-/space-based sensors for autonomous analysis and identification, tactical trend and knowledge depository. In order to meet the ultimate demand of timely delivering critical military information in an actionable format to war fighters, both future civilian and military systems that have different operating characteristics and are geographically separated are expected to have distributed functionality while working cooperatively to execute some meta-tasks. A meta-task may be defined broadly in terms of a small vocabulary of the English language; for example, “Take pictures at X degrees latitude and Y degrees longitude.” This request relies on the ability to efficiently task and schedule systems and sub-systems--in this case, satellite systems that are capable of accomplishing the tasks to maximize the payload information. Therefore, one of the critical components in autonomous decision making is the capability of converting meta-tasks into collections of executable tasks that need to be efficiently allocated to collaborative systems. Proposed advances should address multiple technical areas: (1) Innovative system-level architectures that will integrate collaborative systems. These collaborative systems may have distributed functionality, limited resources per system, varying levels of agility, etc.; (2) Investigations of characterizing meta-tasks from operational aspects and for integration of operations; (3) Development of optimal tasking and scheduling algorithms to maximize certain global payoff functions; and (4) Anticipation of multiple levels of both cooperative and non-cooperative strategies employed by collaborative systems. In addition, proposed solutions should take into account potential conflicts within collaborative systems that may arise due to pre-existing loads on constituent systems within an aggregate system. Offerors are encouraged to provide other related compositions of meta-tasks which may reasonably be defined by aggregating a series of meta-tasks into a meta-function and a series of meta-functions into a meta-capability as long as they are deemed to be essential to clearly characterize and design necessary solutions.

PHASE I: Develop a space-to-ground situational awareness scenario of integrating payload information from 4 Low Earth Orbit (LEO) satellites to produce a common operational picture; model typical meta-tasks; formulate payoff functions, optimal tasking and conflict resolutions; and select a comprehensive and scalable simulation platform.

PHASE II: Optimize the simulation platform with human-/hardware-in-the-loop and realistic CONOPs; identify human-in-the-loop metrics; investigate verification tools for rapid assessment of heterogeneous collaborative systems; assess changes in global performance of the total system; and finally, demonstrate the potential and feasibility of the technology.

PHASE III / DUAL USE: Military application: The technology will facilitate persistent target surveillance and tracking, integrated war-gaming and military campaign capabilities. It also provides global conditions and events awareness. Commercial application: Results from this work are highly applicable to inter-satellite communications, multi-layered sensing, network interconnection and design of internet protocols.

REFERENCES:
1. Cassandras, C. and S. Lafortune, ""Discrete Event Systems,"" Kluwer Academic Publishers, Boston, 1999.

2. Kang, W. and A. Sparks, ""Task Assignment in the Cooperative Control of Multiple UAV,"" Proceedings of AIAA Guidance, Navigation, and Control Conference, August, 2003.

3. Kang, W. and A. Sparks, ""Modeling and Computation of Optimal Task Assignment for Cooperative Control,"" Proceedings of IEEE Conference on Decision and Control, December, 2003.

KEYWORDS: collaborative systems, dynamic resource allocation, team tasking, conflict resolution, multi-agent architecture, comprehensive simulation platform

AF081-097 TITLE: Secure Active Global Radio Frequency Identification (RFID) System.

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Explore existing RFID tracking, Unique Identifier (UID), and secure encryption technologies, develop and provide a viable integrated and secure active RFID tracking solution resulting in real time item/asset tracking capability.

DESCRIPTION: Current asset tracking involves passive, electronically readable devices that wait to be read by geographically located, short range scanning devices. A real time long range secure and active RFID System is needed to verify the actual location, and precisely track in transit items via an encrypted military or commercial satellite network. This must be accomplished without providing targeting information and exposing tactical locations or logistics information to unfriendly forces.

PHASE I: Develop a model to demonstrate the feasibility of a secure, active, global, RFID tracking. This model will, by satellite communication, be able to activate a tracking device from a dormant state to rapidly transmit encrypted location and item identification data to the satellite that will send the data to the data requester. The RFUID System will return to its dormant state until reactivated. The conclusion of this phase will result in a detailed proof of concept model combining mature technologies in various fields that are not currently synchronized.

PHASE II: Design, prototype, produce and deliver the components necessary to field test a first article secure high gain, low power RFID system, with satellite interrogation capability.

MILITARY POTENTIAL: Knowing where the assets are at all times will improve logistical support and supply chain efficiencies. Additional benefits may include wearable IFF capabilities for individual military members deployed in a hostile environment.

COMMERCIALIZATION POTENTIAL: Secure active RFID tracking will make everyday objects interactive allowing for increased business efficiencies through the logistics supply chain. Companies will collect data and deliver services without human interaction.

REFERENCES:
1. National Institute for Standards and Technology

2. 15 U.S.C. 278g-3(6). Security of Federal Computers and Networks

3. ISO 15693. Vicinity Cards

4. ISO/IEC 18092. Near Field Communication

5. ISO 18000-6/6c. RFID Air Interface for Item Management

KEYWORDS: Active, RFID, UID, Asset, Tracking, Secure, Encryption, Crypto

AF081-100 TITLE: Real-Time, Remote Electronics Test Capability

TECHNOLOGY AREAS: Air Platform, Electronics

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

OBJECTIVE: Establish novel approach to create a real time interactive remote diagnostic maintenance environment for military avionics aircraft systems.

DESCRIPTION: Current Capability: System Program Office (SPO)/OEM engineers and intermediate/regional level maintenance technicians currently do not have the capability to provide real-time engineering services or troubleshooting assistance to Forward Operating Locations (FOL). Field level maintenance personnel use T.O. guidance, common support equipment, and system specific Automatic Test Systems (ATS) to fault isolate and troubleshoot aircraft wiring, software, and avionics problems to the LRU level. When faced with technical problems outside the scope of the T.O. guidance, field level personnel ship all affected LRUs to the depot for repair. Many of these LRUS are returned to the field with retest OK (RTOK) at the cost of thousands of dollars and scores of maintenance man-hours. Access to SPO/OEM engineers or intermediate/regional level maintenance technicians would reduce aircraft downtime at FOLs, reduce RTOK rates, save I/D-level repair costs, and increase aircraft availability.

This topic solicits a Real-Time, Remote Electronics Test Capability. This topic requests the development of a network centric system that allows SPO/OEM engineers and intermediate/regional level maintenance technicians direct access to the aircraft and avionics under test/repair at FOLs. The network centric system must be based on an open-system architecture using non-proprietary, industry standards that can interface with the aircraft's MIL-STD-1553 and/or ARINC data busses. The majority of Air Force aircraft avionics systems are fully integrated through MIL-STD-1553 and/or ARINC data busses. A new, network centric system that can interface the SPO/OEM engineers and intermediate/regional maintenance technicians to the FOL deployed aircraft will provide the following: 1) transmission of real-time avionics performance, test/repair, equipment configuration, and bus traffic data and information to the SPO/OEM engineers; 2) transmission of SPO/OEM engineer directed bus control, bus test instructions/messages, and TPS/OFP software to the avionics system; and 3) enable the real-time monitoring of avionics bus activity by the SPO/OEM engineers.

PHASE I: Develop a system architecture and define the equipment and user interfaces for a network centric system that provides a real-time, remote electronics test capability for SPO/OEM engineers supporting a FOL deployed aircraft.

PHASE II: Develop the real-time, remote electronics test capability and demonstrate the capability of remote testing the avionics on a deployed aircraft from a representative SPO or OEM facility.

PHASE III / DUAL USE: Military application: Potential DoD areas are real-time evaluation of onboard aircraft systems . Commercial application: Potential commercial areas are real-time evaluation of onboard aircraft systems as the architectures are extremely similar.

REFERENCES:
1. 28 Jul 2004, DoD Policy for Automatic Test Systems.

2. 2004, DoD Automatic Test Systems Hand Book http://www.acq.osd.mil/ats/default.html
National Security Systems (NSS), 05 May 2004.

3. A Modular Open Systems Approach (MOSA) to Acquisition, Version 2.0, September 2004.
KEYWORDS: Interactive, automated, systems, architecture, software, net centric, remote testing

AF081-101 TITLE: Development of Cad Plating Replacement with Alkaline Zinc-Nickel Electroplating for Threaded Fasteners/Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Demonstrate environmentally friendly alkaline zinc nickel plating for replacing cad plating on threaded fasteners/components for low and high strength steel alloy aircraft and propeller system compone

DESCRIPTION: All United States Air Force (USAF) aircraft utilize low and high strength steel threaded joints and fasteners throughout the planes . Specifically Warner Robins Air Logistics Center (WR-ALC) repairs the F-15, C-5, C-130, and C-17 aircraft and brushes cadmium plating on all low and high strength steel threaded joints and fasteners for these airframes. Threaded joints and fasteners manufactured from these alloys require sacrificial protective coatings to perform successfully in flight. Cadmium (Cd) has been the baseline coating for such threaded joints and fasteners for many years due to its many desirable functional qualities. In addition to providing sacrificial corrosion protection for steels, it has excellent lubricity characteristics on threaded applications and is easily electroplated onto a number of different metallic substrates and geometries, including threads. Nonetheless, cadmium is a toxic metal and known carcinogen that poses environmental and occupational safety and health risks throughout the life cycle of the plated parts.
For these reasons, the use of cadmium is regulated by strict worker exposure limitations propagated by the Occupational Safety and Health Administration (OSHA). Additionally, wastewater discharge from cadmium electroplating baths must meet effluent limitations dictated by the Clean Water Act, and any sludge from wastewater treatment must be managed as hazardous waste under the Resource Conservation and Recovery Act (RCRA). As a result of these regulations, the use of cadmium significantly raises the maintenance costs throughout the life of the plated parts.
The reduction and eventual elimination of cadmium from military systems will greatly reduce the environmental, safety, and health risks associated with thread and fastener coating; and some cost avoidance would be realized immediately as a result of decreased monitoring, personal protective equipment (PPE), and other cadmium-related requirements in the electroplating area. Several studies have shown real potential for Zinc-Nickel (Zn-Ni) as a cadmium replacement on threaded joints and fasteners, but more research is required to fully evaluate and characterize any benefits.
WR-ALC utilizes brushed cad on all threaded fasteners and components. A new Zinc-Nickel plating is environmentally friendly process that has excellent corrosion resistance that may meet and /or exceed that of cadmium plating. Once developed and qualified, it will be a drop in replacement at WR-ALC in its current plating facility and will be incorporated into the new Metal finishing facility which is opening within the next four years.

PHASE I: Demonstrate the feasibility of replacing cadmium plating with a new zinc nickel plating on low and high strength steel threaded fasteners/components on aircraft and propeller system components.

PHASE II: Further develop, optimize and implement the approach from Phase I and demonstrate the process improvements with zinc nickel threaded application development & test articles designed in Phase I. Mechanical & environmental properties as well as process techniques will be optimized and validated.

PHASE III / DUAL USE: Military application: There are many opportnities to eliminate cadmium from military aviation and ground vehicles with the zinc nickel plating process. Commercial application: There are many opportunities to eliminate cadmium from commercial aviation and ground vehicles with the zinc nickel plating process.

REFERENCES:

1. MIL-STD-870 Cadmium Plating, Type II, Class 2

2. MIL-STD-1500 Cadmium Plating, Type II, Class 1

3. AMS-QQ-P-416 Cadmium Plating, Type II, Class 2

4. http://www.electrochem.org/dl/ma/206/pdfs/0702.pdf

KEYWORDS: electroplating, Fasteners, High Strength Steel, Low Strength Steel, Threads, Zinc-Nickel, Cadmium

AF081C-016 TITLE: Affordable High-Performance Hearing Protection/Communication System

TECHNOLOGY AREAS: Materials/Processes, Human Systems

OBJECTIVE: Develop an affordable high performance hearing protection with communication system for use in the up to 150 dB noise environments found near high performance fighter aircraft such as the F-35 Lightning II, F-22, and F/A-18 E/F.

DESCRIPTION: Effective hearing protection-communication technology/systems for use in very high level (150 dB) military fighter aircraft noise environments need to have superior performance (high attenuation 45-50 dB), excellent usability (comfort and fit), and affordability, so that units will purchase systems for their personnel exposed to high level noise. The system must operate in the rugged military environment of flight lines and flight decks. The majority (~97%) of the users should be provided attenuation of at least 45 dB (NRR mean - 2 standard deviations). Previous work has shown that a combined earmuff/active earplug system comes close to meeting this performance. Personnel should be able wear the system for 4-12 hours per day with no significant discomfort. Batteries should be able to power the unit for a minimum of 18 hours before needing to be recharged. The system should deliver no less than 70% Modified Rhyme Test intelligibility in 140 dB listening environment (talker in quiet) and no less than 70% in a 130 dB talking environment(listener in quiet). The system should generate no more than 70 dBA noise when operated in a 200 V/m EMI field with frequencies from 100 kHz to 2.5 GHz. The target price for the system is $1200 per user in large quantities, i.e. 10,000 to 30,000 units.
Current active earplug technologies are limited in performance by driver characteristics such as overall output and phase delay. Innovative techniques/technologies will be needed to achieve 45-50 dB attenuation in a 150 dB noise field. Materials work will be required to improve the comfort of the hearing protection system while delivering very high noise attenuation performance. Affordability is a significant challenge requiring innovative and/or creative solutions to transducers, ANR controller design (analog, digital, hybrid), batteries, and communication system integration.

PHASE I: Define and develop approaches for the design and production of an affordable high-performance hearing protection and communication system for use in military noise environments up to 150 dB and EMI fields up to 200 V/m. Conduct technology experiments/demonstrations to demonstrate risk reduction for system performance and cost. Deliverables: A detailed analysis of design and production alternatives, identification of cost and performance driving parameters, a development and production strategy to ensure performance requirements are met while meeting the cost/affordability targets, a complete development plan of proposed solutions with progress, completion performance goals, and a plan for deployment of proposed solutions.

PHASE II: Design, develop, fabricate, and deliver a minimum of 10 affordable high performance hearing protection/communication systems which meet or exceed the system performance characteristics detailed in the description. The 10 systems shall be fabricated demonstrating and using techniques and processes developed for affordable production. Phase II should (1) implement development approaches based on Phase I plans; (2) demonstrate new processes showing controllability and repeatability, sustained ANR performance levels, and cost savings over prototype development processes; and (3) mature new processes for future transition to a production environment.

PHASE III / DUAL USE: Military application: Aircraft maintainers are the first-generation users, followed by pilots and crew of very high-noise platforms. Commercial application: There is expected demand for thousands of ANR ear plug units per year over five years, with demand focused in the heavy industry (mining, power generation, mechanical paint stripping, etc.) and Aerospace SDD hearing protection.

REFERENCES:
1. Casali, J.G., and Berger, E.H., ""Technology Advancements in Hearing Protection Circa 1995: Active Noise Reduction, Frequency/Amplitude-Sensitivity, and Uniform Attenuation,"" Am. Ind. Hyg. Assoc. J., Vol. 57, No. 2, pp. 175-185, 1996.

2. Gauger, D., “Active Noise Reduction (ANR) and Hearing Protection: Where It’s Appropriate and Why,” Spectrum Suppl. 1, p. 19, 2002.

3. Gauger, D., and Sapiejewski, R.S., ""ANR Headphones: Past and Present,"" Spectrum Suppl. 1, Vol. 16, p. 23, 1999.

KEYWORDS: active noise reduction, ANR, hearing protection, noise, hearing conservation

AF081C-042 TITLE: Mold-in-Place Coatings

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Define and demonstrate an improved manufacturing method for precision application of coatings directly onto aircraft.

DESCRIPTION: The Air Force requires an improved method for applying specialized coatings to fighter aircraft. Modern aircraft are composed of highly complex components with complex contours and restricted access for applying coatings. The current manufacturing application of these coatings involves a time-consuming robotic spray application and post-processing. Many coats are required to build the thickness of the applied material. Each coating requires an extended cure time for the volatile organic compounds (VOCs) to release from the base coating. Extensive quantities of VOCs are required to reduce the viscosity of the material in order to apply the material using legacy spray equipment. Additional capital equipment and processes are required with this approach to ensure environmental standards and personnel health protection. In addition to the lengthy spray/cure application process, both pre- and post-processing are required, adding additional time and cost to the process. Finally, the complex shapes and confined spaces involved add significant difficulty, time, and cost to application and pre- and post-processing.
A new method of application is needed to drastically reduce the cost and fabrication time of the current production methods. Process and prototype equipment are required to demonstrate application of the coatings to complex parts and shapes while minimizing the need for VOCs. The new application process and equipment must eliminate the need for environmental control process and equipment required for robotic spraying. The new application process and equipment must reduce the production cycle by 4 times and eliminate the need for pre- and post-processing such as masking and sanding.
Innovative solutions and associated prototype equipment must be reasonably applicable to a production environment. The probability of transition is a key risk factor to determining viability of any solution proposed. To improve the transition potential, any solution considered should include an analysis of steps, costs, and time needed to transition into a manufacturing environment. Teaming with a major air framer improves validity of transition study activities.

PHASE I: Conceptualize an improved manufacturing process for applying coatings to complex parts with complex shapes. Deliverables: A manufacturing process development plan with progress and completion performance goals and transition plan to a production partner.

PHASE II: Develop and construct a prototype coating system based on Phase I. Demonstrate a prototype system on a full-scale, complex, contoured component with various thicknesses and tapers. Demonstration coupons should be selected in conjunction with an aircraft production partner's inputs. The prototype system and associated process must be shown to be controllable and repeatable. Mature for production transition.

PHASE III / DUAL USE: Military application: Work with a major airframer to integrate an on-aircraft performance coating injection molding system capable of meeting emerging fighter aircraft requirements while reducing cost and cycle time. Commercial application: Coatings are extensively applied to commercial airplanes and helicopters. This technology development would be applicable to erosion coatings for helicopter blades and aircraft leading edge surfaces.

REFERENCES:
1. Bryce, Douglas M., ""Plastic Injection Molding: Mold Design and Construction Fundamentals (Fundamentals of Injection Molding),"" Fundamentals of Injection Molding Series, Society of Manufacturing Engineers, Dearborn MI, May 1998.

2. Potsch, Gerd, and Michael, Walter, ""Injection Molding: An Introduction,"" Hanser Gardner Publications, Cincinnati OH, September 1995.

3. Stoeckhert, Klaus, and Mennig, Gunter, ""Mold-Making Handbook,"" Hanser Gardner Publications, Cincinnati OH, November 1998.

KEYWORDS: coating, injection molding, manufacturing, on-aircraft processing

AF081C-043 TITLE: Direct Part Manufacturing (DPM) for Nonstructural Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate and validate direct part manufacturing technology for nonstructural components in aerospace applications.

DESCRIPTION: Nonstructural components such as clips, brackets, and ducting do not receive the attention of structural components in weapon system design. However, the large number of these parts provides a challenge in cost and lead time to manufacture. Laser additive manufacturing (LAM) has shown promise to accelerate manufacturing processing times, produce complex structures and improve the buy-to-fly ratio for metallic components. For polymer applications, Selective Laser Sintering (SLS) is an analogous technique to LAM. SLS is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data. While it began as a way to build prototype parts early in the design cycle, it is increasingly being used in limited run manufacturing to produce end-use parts. Typically for polymer applications, SLS is limited to nylons only capable of operating temperatures of 180F. The focus of this effort will be to develop advanced direct part manufacturing (DPM) techniques or materials for nonstructural aerospace parts that require up to a 270F service temperature, while maintaining the same part weight and dimensions. This higher temperature would allow several hundred potential parts in addition to the existing list of parts that could be manufactured via direct part manufacturing. In addition, use of DPM would allow for the integration of several parts manufactured using conventional techniques into a single part. Emphasis with be on low cost, light weight materials capable of being easily inserted into current and future aircraft applications. It is anticipated that direct part manufacturing would decrease recurring manufacturing costs for parts such as clips, brackets, and ducting up to 50-60%. The small business is highly encouraged to work with an aerospace part supplier or an airframe design company to increase the likelihood of a commercially viable process being developed.

PHASE I: Develop an experimental design to demonstrate the feasibility of obtaining the benefits described above through DPM. Identify techniques for applications requiring up to 270 F service temperature. Deliverable: Prototype application system development plan with progress and performance goals.

PHASE II: Scale up phase I results to demonstrate the ability of the advanced technique to fabricate a nonstructural component for an Air Force aircraft with the required weight, dimensions, material properties and temperature needed. A process assessment shall be made to document reduced cost and manufacturing cycle time. Implementation plans and qualification requirements shall be established.

PHASE III / DUAL USE: Military application: Clips, brackets, ducts, and similar nonstructural components. Commercial application: Clips, brackets, ducts, and similar nonstructural components for automotive or commercial aircraft applications. Small nonstructural medical devices and implants.

REFERENCES:
1. http://www.3dsystems.com.

2. http://www.eos-gmbh.de.

3. Dr. Livia Cevolini, ""How to Reach Rapid Manufacturing? Carbon Fiber and SLS"", Second RM Techical Forum, Girona, Spain, 14 December 2006.

4. Neal P. Juster, “Rapid prototyping using the selective sintering process”, Assembly Automation: Vol 14, Issue 2, 1994

5. J.P. Kruth, X. Wang, T. Laoui, L. Froyen, “Lasers and materials in selective laser sintering”, Assembly Automation: Vol 23, Issue 4, 2003

KEYWORDS: selective laser sintering, SLS, rapid manufacturing, 3-D models, polymers, powders