AIR FORCE
12.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

The Air Force (AF) proposal submission instructions are intended to clarify the Department of Defense (DoD) instructions as they apply to AF requirements.

The Air Force Research Laboratory (AFRL), Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the AF Small Business Innovation Research (SBIR) Program.

The AF Program Manager is Mr. Augustine Vu, 1-800-222-0336. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8:00 a.m. to 5:00 p.m. ET). For technical questions about the topics during the pre-solicitation period (09 November 2011 through 11 December 2011), contact the Topic Authors listed for each topic on the Web site. For information on obtaining answers to your technical questions during the formal solicitation period (12 December 11 through 11 January 2012), go to http://www.dodsbir.net/sitis/.

For additional information regarding the SBIR/STTR Programs, a Defense Acquisition University (DAU) Continuous Learning Module, FA010, entitled "Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)", may be accessed (subject to availability) at https://learn.dau.mil/html/clc/Clc1.jsp?cl. It is recommended that those taking the course register as "General Public" and select "only browse the module not getting credit". Site performance is enhanced by utilizing Internet Explorer. General information related to the AF Small Business Program can be found at the AF Small Business website, http://www.airforcesmallbiz.org. The site contains information related to contracting opportunities within the AF, as well as business information, and upcoming outreach/conference events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers, www.aptacus.org/new/Govt_Contracting/index.php. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

The AF SBIR Program is a mission-oriented program that integrates the needs and requirements of the AF 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 AF, the contract period of performance for Phase I shall be nine (9) months, and the award shall not exceed $150,000. 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 AF 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 AF 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–j), and Company Commercialization Report).

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-j), and Company Commercialization Report are excluded from the 20 page limit. Only the Proposal Cover Sheet (pages 1 and 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-j), and Company Commercialization Report, will not be considered for review or award.

Phase I Proposal Format

Proposal Cover Sheets: The first two (2) pages of the proposal will count as the Cover Sheets no matter how they print out. This will count toward the 20 page total limit. 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). 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 a .pdf document within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm ET).

Key Personnel: Identify in the Technical Proposal all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship. A technical resume of the principle investigator, including a list of publications, if any, must be part of that information. Concise technical resumes for subcontractors and consultants, if any, are also useful. You must identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants. You must also identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For these individuals, in addition to technical resumes, please provide countries of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this solicitation.

Voluntary Protection Program (VPP): VPP promotes effective worksite-based safety and health. In the VPP, management, labor, and the Occupational Safety and Health Agency (OSHA) establish cooperative relationships at workplaces that have implemented a comprehensive safety and health management system. Approval into the VPP is OSHA's official recognition of the outstanding efforts of employers and employees who have achieved exemplary occupational safety and health. An "Applicable Contractor" under the VPP is defined as a construction or services contractor with employees working at least 1,000 hours at the site in any calendar quarter within the last 12 months that is NOT directly supervised by the applicant (installation). The definition flows down to affected subcontractors.

Applicable contractors will be required to submit Days Away, Restricted, and Transfer (DART) and Total Case Incident (TCIR) rates for the past three years as part of the proposal. Pages associated with this information will NOT contribute to the overall technical proposal page count. NOTE: If award of your firm's proposal does NOT create a situation wherein performance on one Government installation will exceed 1,000 hours in one calendar quarter, **SUBMISSION OF TCIR/DART DATA IS NOT REQUIRED**.

Phase I Work Plan Outline

NOTE: THE AF USES THE WORK PLAN OUTLINE AS THE INITIAL DRAFT OF THE PHASE I STATEMENT OF WORK (SOW). THEREFORE, DO NOT INCLUDE PROPRIETARY INFORMATION IN THE WORK PLAN OUTLINE. TO DO SO WILL NECESSITATE A REQUEST FOR REVISION AND MAY DELAY CONTRACT AWARD.

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

Cost proposal information should be provided by completing the on-line Cost Proposal form and including the Cost Proposal Itemized Listing (a-j) specified below. The Cost Proposal information 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-j below) on how funds will be used if the contract is awarded. The on-line Cost Proposal, and Itemized Cost Proposal Information (a-j) will not count against the 20-page limit. The itemized listing may be placed in the "Explanatory Material" section of the on-line Cost Proposal form (if enough room), or 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 file includes your complete Technical Proposal and the Cost Proposal Itemized Listing (a-j) information.

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 should be reflected. 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. NOTE: Subcontract arrangements involving provision of Independent Research and Development (IRAD) support are prohibited in accordance with Under Secretary of Defense (USD) memorandum "Contractor Cost Share", dated 16 May 2001, as implemented by SAF/AQ memorandum, same title, dated 11 Jul 2001.

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, describe 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 2.11 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 a minimum, an offeror must include a Statement of Work (SOW) 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.

i. Any exceptions to the model Phase I purchase order (P.O.) found at https://www.afsbirsttr.com/Proposals/Default.aspx (see "NOTE" within "Phase I Proposal Submission Checklist" section, p. AF-5).

j. DD Form 2345: For proposals submitted under ITAR-restricted Topics, a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, http://www.dlis.dla.mil/jcp/.

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 $150,000.

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

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

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, Technical Proposal with any appendices, Cost Proposal, Itemized Cost Proposal Information, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR Web site at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the Web site. Your complete proposal **must** be submitted via the submissions site on or before the **6:00 am ET, 11 January 2012 deadline.** A hardcopy **will not** be accepted.

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without discussions (except clarifications as described in FAR 15.306(a)). Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. In addition, please review the model Phase I P.O. found at https://www.afsbirsttr.com/Proposals/Default.aspx and provide any exception to the clauses found therein with your cost proposal Full text for the clauses included in the P.O. may be found at http://farsite.hill.af.mil. **If selected for award, the award contract or P.O. document received by your firm may vary in format/content from the model P.O. reviewed. If there are questions regarding the award document, contact the Phase I Contracting Officer listed on the selection notification.** (See item g under the "Cost Proposal" section, p. AF-4.) The Government reserves the right to conduct discussions if the Contracting Officer later determines them to be necessary.

The AF 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 AF 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 early July, you will receive an e-mail serving as our acknowledgement that we have received your proposal. The AF is not responsible for notifying companies that change their mailing address, their e-mail address, or company official after proposal submission without proper notification to the AF.

AIR FORCE SBIR/STTR SITE

As a means of drawing greater attention to SBIR accomplishments, the AF has developed a SBIR/STTR site at http://www.afsbirsttr.com. Along with being an information resource concerning SBIR policies and procedures, the SBIR/STTR site is designed to help facilitate the Phase III transition process. To this end, the SBIR/STTR site contains SBIR/STTR Success Stories written by the Air Force and Phase II summary reports 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.

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 AF 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 AF 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 AF will utilize Phase II evaluation criteria in section 4.3 of the DoD solicitation, however the order of importance will differ. The AF will evaluate proposals in descending order of importance 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, AF support contractors may be used to administratively process or monitor contract performance and testing. Contractors receiving awards where support contractors will be utilized for performance monitoring may be required to execute separate non-disclosure agreements with the support contractors.

On-Line Proposal Status and Debriefings

The AF has implemented on-line proposal status updates for small businesses submitting proposals against AF 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 AF SBIR/STTR site (http://www.afsbirstr.com). The Small Business Area (http://www.afsbirsttr.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" link at the top of the page in the Small Business Area (after logging in). A listing of proposal submissions to the AF 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 provides 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 AF with a notification of selection or non-selection.** The AF 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 Cover Sheet will be notified by e-mail regarding proposal selection or non-selection. The e-mail will include a link to a secure Internet page containing specific selection/non-selection information. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced.

In accordance with FAR 15.505, a debriefing may be received by written request. As is consistent with the DoD SBIR/STTR solicitation, the request must be received within 30 days after receipt of notification of non-selection. Written requests for debrief should be uploaded to the Small Business Area of the AF SBIR/STTR site (http://www.afsbirsttr.com) Requests for debrief should include the company name and the telephone number/e-mail address for a specific point of contract, as well as an alternate. Also include the topic number under which the proposal(s) was submitted, and the proposal number(s). Further instructions regarding debrief request preparation/submission will be provided within the Small Business Area of the AF SBIR/STTR site. Debrief requests received more than 30 days after receipt of notification of non-selection will be fulfilled at the Contracting Officers' discretion. Unsuccessful offerors are entitled to no more than one debriefing for each proposal.

NOTE: FAR 15.505 (a)(2) states the debrief, at the offeror's request, may be delayed until after award. However, under the AF SBIR Program, debriefs are automated and standardized. Therefore, pre-award and post-award debriefs are identical.

IMPORTANT: Proposals submitted to the AF 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 AF to inquire about additional submissions.** Check the Small Business Area of the AF SBIR/STTR site 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 within approximately four months of proposal receipt. **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. Phase I awardees can verify selection for receipt of a Phase II invitation letter by logging into the "Small Business Area" at http://afsbirsttr.com. If "Phase II Invitation Letter Sent" and associated date are visible, a Phase II invitation letter has been sent. If the letter is not received within 10 days of the date and/or the contact information for technical/contracting points of contact has changed since submission of the Phase I proposal, contact the appropriate AF SBIR Program Manager, as found in the Phase I selection notification letter, for resolution. Please note that it is solely the responsibility of the Phase I awardee to contact this individual. There will be no further attempts on the part of the AF to solicit a Phase II proposal. The awarding AF organization will send a Phase II invitation

including a link to detailed Phase II proposal preparation instructions to the appropriate small businesses. Phase II efforts are typically two (2) years in duration with an initial value not to exceed $750,000.

NOTE: All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged that an approved accounting system be 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-j) 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 AF 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 AF 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 AF 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 AF 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 AF will select Phase II winners based solely upon the merits of the proposal submitted, including FAST TRACK applicants.

AIR FORCE PHASE II ENHANCEMENT PROGRAM

On active Phase II awards, the Air Force may request a Phase II enhancement application package from a limited number of Phase II awardees. In the Air Force program, the outside investment funding must be from a government source, usually the Air Force or other military service. The selected enhancements will extend the existing Phase II contract awards for up to one year and the Air Force will match dollar-for-dollar up to $500,000 of non-SBIR government

matching funds. If requested to submit a Phase II enhancement application package, it must be submitted through the DoD Submission Web site at www.dodsbir.net/submission. Contact the local awarding organization SBIR Manager (see Air Force SBIR Organization Listing) for more information.

AIR FORCE SBIR PROGRAM MANAGEMENT IMPROVEMENTS

The AF 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 AF also reserves the right to change any administrative procedures at any time that will improve management of the AF SBIR Program.

AIR FORCE SUBMISSION OF FINAL REPORTS

All Final Reports will be submitted to the awarding AF organization in accordance with the Contract. Companies **will not** submit Final Reports directly to the Defense Technical Information Center (DTIC).

SPECIAL INSTRUCTIONS for Topic AF121C-123
These special instructions apply only to topic AF121C-123, "Transparency Sensor System," and are in addition to the regular instructions listed at the beginning of the AF section of the solicitation.

This is a manufacturing-related R&D Critical SBIR topic. The primary focus of the Phase I effort is to demonstrate the feasibility of developing, integrating and transitioning innovative process technologies in a manufacturing environment to support the production of inline materials for advanced weapon system(s). For this effort, Phase I objectives are to define the requirements to establish an initial measurement capability to nondestructively measure and characterize inline thin film mat material in a production environment to ensure specification compliant materials are being produced. In addition to demonstrating the proposed technology solution, successful offerors should also consider the technical, business and transition activities necessary to lower the risk of technology insertion into the integration processes of a joint service weapon system.

The Air Force plans to award two Phase I contracts on this topic, each limited to $150,000. Phase I contracts will be executed at an accelerated pace, a seven-month effort, including four months for technical effort and an additional three months for reporting. The Phase I effort will identify and provide a proof of feasibility concept and a plan for the overall system concept and architecture. Phase I results must demonstrate a technical solution meeting all program end requirements.

As this effort is focused on AF and joint service weapon system specialty material production, successful offerors may find it useful to dialog and/or partner with an AF/DoD prime in order to understand specific system requirements, implementation risks and transition windows. Successful offerors may also benefit from consideration of technical readiness levels (TRL) as well as manufacturing readiness levels (MRL) when preparing responses to the Critical SBIR.
The primary focus of Phase II is to develop and implement to TRL/MRL 7 maturity the nondestructive evaluation measurement system defined under the Phase I effort. The AF plans

to award one Phase II effort of no more than $4M. Examples of the additional information needed in the Phase II proposal package include the following: innovative technical approaches to address the critical processes, associated return on investment (ROI), and potential related uses. Also, the Phase II proposal must include both business and transition plans. Submission of a Phase II proposal will be by invitation only. At that time, special instructions will be provided for proposal preparation.

SPECIAL INSTRUCTIONS for Topic AF121C-125
These special instructions apply only to Air Force Topic AF121C-125, "Inlet/Exhaust Damage Registration Sensor," and are in addition to the regular instructions listed at the beginning of the AF section of the solicitation.

This is a R&D Critical SBIR topic. The primary focus of this effort is to demonstrate the feasibility of developing, integrating and transitioning innovative process technologies in the field environment to support the identification, characterization and registration of defects/damage in the inlet/exhaust specialty coating of advanced weapon systems. For this effort, Phase I objectives are to define the requirements to establish an initial measurement capability to accurately and rapidly identify, characterize and register the defects to the aircraft coordinates. In addition to demonstrating the proposed technology solution, successful offerors should also consider the technical, business and transition activities necessary to lower the risk of technology insertion into the integration processes of a joint service weapon system.

The Air Force plans to award two Phase I contracts on this topic, each limited to $150,000. . Phase I contracts will be executed at an accelerated pace, a seven-month effort, including four months for technical effort and an additional three months for reporting. The Phase I effort will identify and provide a proof of feasibility concept and a plan for the overall system concept and architecture. Phase I results must demonstrate a technical solution meeting all program end requirements.

As this effort is focused on AF and joint service weapon system inlet/exhaust specialty coating inspection and characterization, successful offerors may find it useful to dialog and/or partner with an AF/DoD prime in order to understand specific system requirements, implementation risks and transition windows. Successful offerors may also benefit from consideration of technical readiness levels (TRL) as well as manufacturing readiness levels (MRL) when preparing responses to the Critical SBIR.

The primary focus of Phase II is to develop and implement to TRL/MRL 7 maturity the nondestructive evaluation measurement system defined under the Phase I effort. The AF plans to award one Phase II effort of no more than $4M. Examples of the additional information needed in the Phase II proposal package include the following: innovative technical approaches to address all program end requirements and potential related uses. Also, the Phase II proposal must include both business and transition plans. Submission of a Phase II proposal will be by invitation only. At that time, special instructions will be provided for proposal preparation.

Air Force Program Manager Listing

Topic Number	Activity	Program Manager
AF121-001 thru AF121-004	Air Vehicles Directorate AFRL / RB 2130 Eighth Street Wright-Patterson AFB OH 45433	Larry Byram (937) 904-8169
AF121-008 thru AF121-012	Directed Energy Directorate AFRL/RD 3550 Aberdeen Ave SE Kirtland AFB NM 87117-5776	Danielle Lythgoe (505) 853-7947
AF112-016 thru AF121-033	Human Performance Wing AFRL/RH 2610 Seventh, St, Bldg 441 Wright-Patterson AFB OH 45433	Sabrina Davis (937) 255-3737
AF121-036 thru AF121-051	Information Directorate AFRL/RI 26 Electronic Parkway Rome NY 13441-4514	Janis Norelli (315) 330-3311
AF121-055 thru AF121-075 AF121-0084-087	Space Vehicles Directorate AFRL/RV 3550 Aberdeen Ave SE Kirtland AFB, NM 87117-5776	Danielle Lythgoe (505) 853-7947
AF121-090 thru AF121-108	Munitions Directorate AFRL/RW 101 West Eglin Blvd. Suite 143 Eglin AFB, FL 32542-6810	Shirley Schmieder (850) 882-3362
AF121-111 thru AF121-133 AF121C-123, AF121C-125	Materials & Mfg. Directorate AFRL / RX 2977 Hobson Way, Rm 406 Wright-Patterson AFB OH 45433 Edwards AFB, CA 93524-7033	Debbie Shaw (937) 255-4839
AF121-135 thru AF121-169	Sensors Directorate AFRL/RY 2241 Avionics Circle, Rm N2S24 Wright-Patterson AFB, OH 45433	Claudia Duncan (937) 528-8510 Julie Harris (937) 528-8515

AF121-160 thru AF121-185 AF121-191, AF121-192, AF121-194 thru AF121-195	Propulsion Directorate AFRL/RZ 1950 Fifth Street Wright-Patterson AFB OH 45433	Mary Kruskamp (937) 904-8608 Barb Scenters (937) 255-9255
AF121-187 thru AF121-189 AF121-193	Propulsion Directorate West AFRL/RZO 5 Pollux Drive Edwards AFB, CA 93524-7033	Angela Harris (661) 275-5930
AF121-197 thruAF121-201	46 TW/XPXR 101 West D Avenue Bldg 1 Eglin AFB, FL 93524-6843	Ramsey Sallman (850) 883-0537
AF121-202 thru AF121-204	Arnold Engineering Development Center AEDC/TTSY 1099 Schriever Ave Arnold AFB, TN 37389-9011	Dhruti Upender (931) 454-7801
AF121-207 thru AF121-209	Air Force Flight Test Center AFFTC/XPR 1 S. Rosamond Blvd, Bldg 1, Rm 103A Edwards AFB, CA 93524-6843	Abe Attachbarian (661) 277-5946
AF121-212 thru AF121-215	Oklahoma City Air Logistics Center OC-ALC / ENET 3001 Staff Drive, Suite 2AG70A Tinker AFB, OK 73145-3040	Becky Medina (405) 736-2158
AF121-218 thru AF121-222	Ogden Air Logistics Center OO-ALC / LHH 6021 Gum Lane Hill AFB, UT 84056-2721	John Jusko (801) 586-2090
AF121-224 thru AF121-227	Warner Robins Air Logistics Center WR-ALC / ENSN 450 Third Street, Bldg. 323 Robins AFB, GA 31098-1654	Frank Zahiri (478) 327-4127

Air Force SBIR 12.1 Topic Index

AF121-001	Micro Scale Testing of High Speed Aircraft
AF121-002	Intelligent Controller Development for Cooperative UAV Missions
AF121-003	Structural Radio Frequency Electronics
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AF121-012	Characterization of GEO Insertion Maneuvers Utilizing Spectral, Photometric, and Image Analysis Techniques coupled with High Precision Orbit Determination Algorithms
AF121-016	Curved Flat Panel Microdisplay (CFPM)
AF121-017	Adaptive Gaming and Training Environment for Maintenance Operations
AF121-018	Color symbology in helmet mounted visors and heads up displays
AF121-019	Wide Spectral Response Focal Plane Array (FPA)
AF121-020	Performance-Based Simulation Certification (SIMCERT) System
AF121-021	Correlated Weather Visual and Sensor Effects for Distributed Mission Operations
AF121-022	Debrief and After-Action Review Technologies for Electronic Warfare Simulation and Training
AF121-023	Cognitive Measures and Models for Persistent Surveillance
AF121-025	Flexible Semi-Conformal Displays for Data Access in Military Field Operations
AF121-026	Flightline Boundary Sensor
AF121-027	3D Stereo Binocular Head Mounted Display (HMD) Technology for Joint Strike Fighter (JSF) Aircraft and Simulation
AF121-028	Measurement of Interpupillary Distance for Binocular Head-Mounted Displays (HMDs)
AF121-029	Network Threat Monitoring, Intrusion Detection, and Alert System for Live, Virtual, and Constructive (LVC) Operations for Space Training
AF121-030	Agent-Based Objective Performance Measurement Brief/Debrief and After Action Review Suite for Cyber Warfare Training
AF121-031	Enhancing Decision Making through Adaptive Trustworthiness Cues
AF121-032	Efficient Computational Tool for RF-Induced Thermal Response
AF121-033	Discourse Analysis for Insights into Group Identity and Intent
AF121-036	Ultra-Fast Transfer Techniques to Download Data
AF121-037	Next Generation Mobile Ad-hoc Networking (MANET) for Aircraft
AF121-038	Joint Aerial Layer Network High Capacity Backbone Antennas
AF121-040	Cloud/Grid/Virtualization Architecture for Air Force Weather
AF121-041	Directional Partial Mesh Airborne Networking
AF121-042	V/W Band Airborne Radomes
AF121-043	Software Isolation from Evolution of Hardware and Operation Systems
AF121-046	W-band Transmitter
AF121-048	Dynamic Reallocation and Tasking
AF121-049	Emerging Software Algorithms for Autonomous Sense Making Operations
AF121-050	Link Analysis of Knowledge Derived from Social Media Sources
AF121-051	Remote Attestation and Distributed Trust in Networks (RADTiN)
AF121-055	Graphene Memory Device
AF121-056	Integrated Li-Ion Battery Interface Electronics for Spacecraft
AF121-057	Novel Environmental Protection for Multi-Junction Solar Cells
AF121-058	High-Strain Conductive Composites for Satellite Communications (SATCOM) Deployable Antennas
AF121-059	Wide Temperature Optical Transceivers
AF121-060	High Conductance Thermal Interface Material for Use in Space Applications
AF121-061	Spacecraft Autonomy
AF121-062	Light Weight Shielding for Satellite Protection from Severe Space Weather
AF121-063	Joint Processing of Multi-band Signals with Information Assurance

AF121-064	A Small Satellite-based System for Active and Passive Sounding of the Ionosphere, Direct Current (DC) through High Frequency (HF)
AF121-065	Space Particle Radiation Sensor
AF121-066	Miniaturized Neutral Wind Sensor
AF121-067	Broadband High Temperature Focal Plane Array (FPA)
AF121-068	Innovative Technologies for Operationally Responsive Space (ORS)
AF121-069	Advanced Space Energy Storage that Incorporates Long Cycle Life at High Depths of Discharge
AF121-070	Compact Type I Space Encryption Hardware
AF121-071	Multi-function Laser Module (MFL) for Enhanced Space Surveillance
AF121-072	Dual-mode Wavefront Sensor for Space Surveillance
AF121-073	Anti-reflective Coating for High-Efficiency Solar Cells
AF121-074	Wide Field of View (FOV) High Gain Pulse Optical Amplifier
AF121-075	Rigid-Panel-Solar-Array Deployment Synchronization Mechanisms for Rapid Assembly and Reduced Cost
AF121-084	Automated Distributed Data Fusion of Correlated Space Superiority Events
AF121-085	Advanced Algorithms for Space-Based Next-Generation Infrared Sensor Exploitation
AF121-086	Omni-directional Adaptive Imaging Sensor
AF121-087	Automation of Satellite On-orbit Checkout and Calibration Process
AF121-090	Modeling of Synergistic Effects for Cooperative Strike
AF121-091	Miniature High-Altitude Precision Navigation Alternative
AF121-092	High-Speed Weapon Radomes
AF121-095	Mobile Target Secondary Debris (MTSD)
AF121-096	Next Generation Static Warhead Testing (NG-SWaT)
AF121-097	Weapon Burial Secondary Debris (WBSD)
AF121-098	Guided Munition Delivery Accuracy Methodology for Weaponeering Against Moving Targets (GuMDAM-AMT)
AF121-102	Detection of Hostile Fire from the Remotely Piloted Aircraft (RPA)
AF121-103	Remotely Operated Sensor, Beacon, and Navigation Aid for Deep Battlespace (Remote Sensing)
AF121-104	Feature Representations for Enhanced Multi-Agent Navigation Strategies
AF121-105	Infrared Panoramic Projection for Wide Field of Sensor Testing
AF121-106	Autonomous Situational Awareness for Munitions
AF121-107	Kinetic Energy Control Technologies for Explosively-dispersed Fragments
AF121-108	Direct Detection Ladar Pulse Processing
AF121-111	Lightweight Electromagnetic (EM) Shielding Structural Materials
AF121-112	Near-Surface Residual Stress Measurements for Aerospace Structures
AF121-113	Residual Stress Engineering for Aerospace Structural Forgings
AF121-114	Lightweight Active Anti-Icing/De-Icing for Remotely Piloted Aircraft (RPA)
AF121-115	Fabrication and Process Optimization of Thick Laminates (= 40 ply) From High-Temperature Polyimide/Carbon Fiber Composites
AF121-120	Surface Preparation of Organic Matrix Composites (OMCs) for Structural Adhesive Bonding
AF121-121	Porosity-Free Molded Surfaces for Out-of-Autoclave (OoA) Composites
AF121-122	Advanced Process Control for Laser Sintered Thermoplastics
AF121-124	Inline Material Sensor (IMS)
AF121-126	Optical Filters on Thin Cover Glass
AF121-127	Spatially Controlled Optical Attenuator
AF121-128	Simulation of Small-Scale Damage Evolution During Processing of Polymer Matrix Materials Systems
AF121-129	Innovative Nondestructive Damage Characterization Methods for Complex Aircraft Structures
AF121-130	Computational Process Model Development for Direct Digital Manufacturing (DDM)
AF121-131	Passive Microfluidic Devices as Biological Fuel Cell Platforms
AF121-135	Passive multi-spectral sensor for defense against hypersonic missiles (SAMs and A-A)

AF121-136	Low Frequency Direction Finding Antennas for Small Unmanned Aircraft Systems (SUAS)
AF121-137	High Gain Ka-Band Data Link Antennas with Wide-Field-of-Regard (WFOR)
AF121-138	Airborne Passive Radar
AF121-139	Improved Real Time Geo-Registration Techniques For Airborne Imagery
AF121-140	Multi-Sensor Data Compression
AF121-142	Unified Move Stop Move Combat Identification
AF121-143	Inverse Synthetic Aperture Radar (ISAR) For Terrestrial Targets
AF121-144	Wind Turbine Clutter Mitigation for Terminal Air Traffic Control (ATC) Radars
AF121-145	HF Digital Receiver
AF121-146	Passive Optical Taggants for Laser Designated Friend or Foe Identification
AF121-147	Low Size, Weight and Power Direction Antenna for Common Data Link
AF121-148	Virtual Receiver/Exciter (VREX) Generalized Simulator with Selectable Waveforms to Support Radar and Software Analysis
AF121-152	W-band Airborne SATCOM Power Amplifier
AF121-153	V-band Microwave Power Module
AF121-154	Low Noise Amplifier with Noise-cancelling for Satellite Communications
AF121-155	Next Generation vacuum Nanoelectric Device
AF121-156	Power Efficient Software Defined Radio (SDR) Mobile Architecture Technology for Handheld Devices
AF121-157	Quantitative assessments leveraging effects based analysis for degraded PNT
AF121-158	GPS Enhanced Dynamic Spectrum Access
AF121-159	Monolithic S-band Multichannel Transmit/Receive Module for Communication Phased Array Antennas
AF121-160	Laser Instrumentation for Development of Sensors Aboard Hypersonic Air Vehicles
AF121-163	Performance Prediction for Airborne Multistatic Radar
AF121-164	Conformal Coherent Optical Sensor
AF121-165	Uncertainty-Preserving 3D Reconstruction from Passive Motion Imagery
AF121-166	Low Cost Universal Reliability System On-A-Chip for Multi-Channel Characterization
AF121-169	Bearings for High-Speed Cruise Missile Engine
AF121-170	Prognostics Approaches for Remote Piloted Aircraft (RPA) Propulsion and Vehicle Systems in Harsh Environments
AF121-171	Optimizing Coating Processes and Chemistries for Enhanced Hot Section, Low Cycle Fatigue (LCF) Life
AF121-172	In Situ, Real-time Monitoring of the Properties of Engine Part Coatings
AF121-173	Engine Health Management of Mechanical Systems for High Performance Turbine Engines
AF121-174	Adaptive Heat Rejection for Two-Phase-Enabled Aircraft Thermal Management Systems (TMS)
AF121-175	Hydration Tolerant, low Thermal Conductivity (K) Thermal Barrier Coatings
AF121-181	Low-Temperature Sintering Processes for Ceramic-Coated Heat Exchangers
AF121-182	Miniature Infrared Camera for High Temperature and High Pressure Applications
AF121-183	Novel Silicon Carbide Epitaxy Process for Dramatic Improvements to Material Characteristics, Cost, and Throughput
AF121-184	Thermal Management for Military Aircraft High Performance Electrical Actuation System
AF121-185	Prognostic Health Management (PHM) of Electromechanical Actuation (EMA) Systems for Next-Generation Military Aircraft
AF121-187	Reconstruction Algorithms for High-Energy Computed Tomography Images of Rocket Motors
AF121-188	Techniques to Suppress Cavitation in Liquid Rocket Engines
AF121-189	Novel Engine Cycles for Upper Stage Liquid Rocket Engines
AF121-191	High-Frequency Sensors and Actuators for Scamjet Engine Controls
AF121-192	Wireless Power for Battlefield Airmen Operation
AF121-193	Mapping Liquid Mass Fractions in Optically Dense Rocket Combustion Chambers
AF121-194	Spatiotemporal Dynamical System Analysis Tools for Very Large Data Sets

AF121-197	Fire Suppressant Transport Model
AF121-199	Aircraft Tire Thermal Measurment Device
AF121-201	Massive Parallel SAR Scene Simulator
AF121-202	High-Speed, Multispecies Sensing in Gas Turbine Engines and Augmentors
AF121-203	Modeling and Simulation for Combined Space Environment Chambers
AF121-204	Fabrication Process for Small, High-precision Aerodynamic Balances
AF121-207	Floral Disruptor - Directed Energy Weed Abatement and Prevention Tool
AF121-208	System Identification and Modal Extraction from Response Data
AF121-209	Low Background Blackbody
AF121-212	Re-evaluation of Oil Analysis Program
AF121-213	Condition Based Maintenance: Planning and Implementation
AF121-214	Wireless Technology for Probes and Accessories for Nondestructive Inspection Testing Instruments
AF121-215	Alternatives to Gold-Plate Engines for Test Cell Correlation
AF121-218	Designer Soap for Washdown of Work Areas Where Hexavalent Chrome Paints/Primers are Applied
AF121-219	Chemical Treatment of Metal Finishing Industrial Wastes and Wastewaters in the Presence of Chelating Substances
AF121-220	Physiological testing for Hexavalent Chrome exposure in the human body
AF121-222	Hand Held Real Time Particulate Loading Sensor
AF121-224	Common Global Information Grid Interface for Electronic Warfare systems
AF121-225	Just In Time (JIT) Aircraft Maintenance System
AF121-226	Next Generation Aircraft Simulation Technology
AF121-227	Common Operational Specific Emitter Identification (SEI) functionality for sustained Electronic Warfare (EW) systems
AF121C-123	Transparency Sensor System (TSS)
AF121C-125	Inlet and Exhaust Damage Registration Sensor

Air Force SBIR 12.1 Topic Descriptions

AF121-001 TITLE: Micro Scale Testing of High Speed Aircraft

TECHNOLOGY AREAS: Air Platform, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Formulate innovative approaches for design, manufacture, and test of "micro-scale" ramjet/supersonic combustion ramjet (RAM/SCRAM) experimental flight research. Demonstrate affordable fabrication and test of the vehicles and/or enabling technologies.

DESCRIPTION: Many established aerospace and emerging entrepreneurial companies are developing and flight testing small rocket technologies. The Air Force Research Laboratory, through its Pathfinder program, is leveraging these emerging concepts to demonstrate enabling technologies for a next generation Reusable Boost System (RBS), including hypersonic flight with vehicle dry weights of only a few thousand pounds. The goal of this SBIR project is to leverage these investments and techniques to design small, high performance experimental airbreathing vehicles that can be affordably fabricated and tested. Technological trends facilitating small stages include an ongoing computer/software revolution enabling affordable design, integration and test; micro-miniaturization of electronics and mechanical actuators; integrated high and low temperature structural concepts employing high strength to weight composites structures; light weight structures and thermal protection supporting hypersonic flight; high thrust/weight small rocket engines, thermally choked ramjets, scramjets, and turbo-machinery.

Numerous hypersonic flight programs, to include AFRL's X-51 and HIFiRE, ESA's EXPERT, and Germany's SHEFEX-2, exemplify the current state of the art in hypersonic flight experimentation. There is a desire to drive the trend downward in both size and cost where practical. Programs like X-51, with costs upwards of $100 million, have led to smaller, science-based experimentation efforts like the HIFiRE flights that can be done for less than $10 million. Other changes that delivered savings include opting to use weapons ranges (such as Woomera in Australia and PMRF in Hawaii) for launches as opposed to man-rated launch ranges (such as Cape Canaveral in Florida). Additionally, the use of sounding rockets to boost the flight research vehicles (FLiRVs), instead of ICBM class rockets, is contributing to cost savings. The development time needed to get to the first launch is also trending downward. As the overall scale of the effort comes down from the demonstration level (X-51) to the flight experiment level (HIFiRE), the time to get to the first launch has been reduced from 7-8 years to 4-5 years. A goal of this SBIR effort is to continue the trend and reduce the cost, development time to first launch, and vehicle weight by as much as 50%.

Approaches to flight testing the vehicle(s) developed in the present effort shall address the viability of technology transition. Air-launched or ground-launched approaches must include realistic estimates for costs, including range costs, costs of flight-readiness and safety reviews, and costs associated with hardware modifications to ensure a successful flight testing program after Phase II. It is the responsibility of the offeror to build a strong case for follow-on flight testing.

The offeror must demonstrate a clear understanding of applications for the RAM/SCRAM vehicles. In the current SBIR solicitation, RAM/SCRAM implies an integral aeropropulsion concept including a low-speed propulsion system combined with a ramjet/scramjet propulsion system. It is not required for the flowpaths to be shared between the two propulsion systems, although it may be beneficial. Potential system applications include tactical hypersonic Intelligence, Surveillance & Reconnaissance (ISR) aircraft, upper stages for Responsive Space Access launch vehicles, and small tactical hypersonic missiles.

Similarly, a clear understanding of the technology is essential. For example, RAM/SCRAM systems require high engine efficiency across a broad Mach range as well as very light weight airframe and propulsion technologies. Demonstrating these technologies at small scale is very challenging and in some cases not practical. Offeror's are expected to demonstrate a clear understanding of the technologies including scale-up effects. Offerors may seek to design and fabricate an entire stage or only critical components.

PHASE I: Define the technical challenge and quantify the attributes of the emerging technologies required to enable small, affordable RAM/SCRAM experimental vehicles. Examine innovative approaches for design of the experimental vehicle that validates the enabling technologies, assesses feasibility/risk, and identifies the most technically effective and cost efficient approach. Construct an operationally representative mission and develop trajectories for an operational RAM/SCRAM system with technologies enabled by the experimental vehicle. Identify system level and technology applications of the proposed innovation. As a threshold, the vehicle can include multiple stages, but the goal is to have the entire propulsion cycle and flight vehicle in single stage. Although multiple system applications are encouraged at least one of the following missions should be evaluated for military utility: 1) a high speed tactical ISR reusable vehicle, 2) a reusable upper stage for a RBS capability, 3) a tactical hypersonic missile. An overall goal of this SBIR effort is to reduce the cost, development time to first launch, and vehicle weight by as much as 50% from the demonstrated HIFiRE program.

PHASE II: Develop the detail level design of the vehicle defined in Phase I of this project. Develop, demonstrate and validate the system design, critical hardware components and/or enabling technologies. Demonstrate the experimental hardware or component prototypes developed in Phase I. Required phase II deliverables will include any experimental hardware and a final report including design data, manufacturing and test plan, test data, updated future applications, etc.

PHASE III DUAL USE APPLICATION:
Military Application: Key military applications may include, but are not limited to: 1) a tactical hypersonic ISR aircraft 2) an upper stage for a RBS capability, or 3) tactical hypersonic missile
Commercial Application: Potential commercial applications include, but are not limited to: 1) high speed reconnaissance aircraft, and 2) commercial access to space systems.

REFERENCES:
1. AFRL Reusable Boost System Pathfinder Pre-solicitation Notice on Fed Biz Opportunities, https://www.fbo.gov.

2. European Space Agency (ESA) Hypersonic Flight Experiment, EXPERT - http://www.esa.int/esaMI/EXPERT/SEMYRKQORVF_0.html

3. German Hypersonic Flight Experiment, SHEFEX-2 - http://www.spaceflight.esa.int/pac-symposium2009/proceedings/papers/s3_22turn.pdf

4. US Air Force Hypersonic Flight Experiment, HIFiRE – Dolvin, Doug J., "Hypersonic International Flight Research Experimentation", AIAA/DLR/DGLR 16th International Space Planes and Hypersonic Systems and Technologies Conference, Bremen, Germany, October, 2009.

KEYWORDS: Hypersonic, combined cycle, ISR, space access, hypersonic cruise, hypersonic UAV, RPV

AF121-002 TITLE: Intelligent Controller Development for Cooperative UAV Missions

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop learning algorithms for cooperative control and mission planning for unmanned aircraft.

DESCRIPTION: As unmanned and autonomous systems become more prevalent in DoD, they will face increasingly complex and uncertain missions. The ability to learn and adapt will be essential to maintain effectiveness in the face of uncertainty and adversary countermeasures. During the last decade, extensive research

efforts have been directed at cooperative control for teams of unmanned vehicles. These problems typically involve elements of resource allocation, path planning, task assignment and scheduling, and Markov decision processes, complicated by uncertainty, task coupling, timing constraints, limited computation time, communication constraints, and dynamic mission elements (e.g., tasks). Although great progress has been made in cooperative autonomous control for task execution, cooperative decision-making and mission management algorithms, once programmed, are typically static, and cannot adapt or learn in the presence of uncertainty, unforeseen changes to the mission topology, or adversarial manipulation.

It is clear that both intelligent control, which allows a system to react to previously unencountered situations in ways that maximize objective functions, and cooperative control, which merges local objectives and team objectives in an efficient manner, are important to future battlefield operations. Even task assignment algorithms for relatively small collections of unmanned vehicles become computationally difficult to solve. One definition of an intelligent control system is one which perceives its environment and modifies control actions to maximize its system performance. Key characteristics include learning, memory, and the ability to modify decisions based on learned information. Learning algorithms, once trained, may enable satisfactory solutions with faster computation times. Additionally, the system should be able to adapt and expand the space of actions available to the team beyond a limited set of pre-defined plays . The characteristics of the plant to be learned could include a UAV, a team of UAVs, including their communication and sensor capabilities and operator, and the entire battlespace with which the UAVs must interact. Communication and sharing of information are critical factors. Communication can be imperfect and limited, with varying information across a fractionated system. Since learning convergence rates are typically slow, and data requirements substantial, offline learning likely will be necessary. Combinations of approaches from control theory, operations research, and computer sciences may all be appropriate. Although some degree of adversarial threats to the UAVs should be considered, differential games approaches are not required.

A simulation environment is needed for the development of intelligent cooperative control algorithms in the UAV mission context, including both ISR and more challenging combat missions involving threats. This environment will allow a variety of mission planning and control techniques to be studied, including those developed as part of this effort. A modular architecture is necessary, enabling other algorithms to be easily incorporated and tested. The simulation environment could be used as a truth model to enable offline learning, and then modified for use in supervised learning, or to test existing controllers. Development of effective cooperative intelligent control algorithms is necessary, both to fully exercise the simulation, and to demonstrate the potential value of learning in a cooperative system of autonomous assets.

PHASE I: Define intelligent cooperative control architecture that could, with additional development, provide a learning capability for UAV mission planning and execution. It is expected that the proposer will already have a baseline simulation available, focused on either UAVs or ground robots. All work should be at an unclassified level.

PHASE II: Produce a medium-fidelity simulation for testing learning cooperative control algorithms for UAV operations, including some degree of adversarial threats to the UAVs. Develop algorithms that enable the UAVs to cooperate in mission planning and execution, learn from experience, and improve performance over time through changes to the decision and control system. All work should be at an unclassified level.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Intelligent cooperative controllers will have many military uses. As unmanned and autonomous systems become more prevalent in DoD, they will face increasingly complex and uncertain missions. The ability to learn and adapt will be essential.
Commercial Application: Learning algorithms that can solve complex decision problems will have extensive commercial application. The problems to be solved here are highly similar to vehicle routing and job shop scheduling problems.

REFERENCES:
1. Joshua Redding, Alborz Geramifard, Aditya Undurti, Han-Lim Choi, and Jonathan P. How, “An Intelligent Cooperative Control Architecture”, Proceedings of the 2010 American Control Conference.

2. Ketan Savla and Emilio Frazzoli, “Game-theoretic learning algorithm for a spatial coverage problem”, Forty-Seventh Annual Allerton Conference on Communication, Control, and Computing, 2009, pp. 984-990.

3. Shie Mannor and Jeff S. Shamma, “Multi-agent learning for engineers”, Artificial Intelligence 171 (2007) 417-422.

4. G.C. Chasparis, J.S. Shamma, and A. Arapostathis, "Aspiration learning in coordination games", 49th IEEE Conference on Decision and Control, December 2010.

KEYWORDS: Cooperative control, learning, UAV

AF121-003 TITLE: Structural Radio Frequency Electronics

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop and demonstrate concepts to support structural integration of RF electronic devices and systems in conformal load bearing antenna structures (CLAS).

DESCRIPTION: The Air Force is developing RF CLAS to improve the performance of a wide variety of intelligence, surveillance, and reconnaissance (ISR), communication navigation identification (CNI), and electronic warfare (EW) functions, as well as air vehicle flight performance. CLAS is a synergistic marriage of structure and antenna. Antenna components are an integral feature of the structure in the CLAS concept. CLAS concepts developed to date primarily feature only passive antenna radiating elements and simple feed circuitry integrated in the structure. To expand the performance potential of CLAS, there is a need to integrate active components and multi-level circuitry typically associated with conventional printed circuit boards. This will enable capabilities such as reconfigurability, mode forming, and increased bandwidth. One of the key technical challenges associated with this level of integration is the creation of electrical features on or within a structural component typically fabricated from structural materials such as carbon fiber reinforced plastic (CFRP). There is also a need for conformal integration of antenna components on metallic components. Specific technical challenges needing investigation and development include via fabrication between composite plies containing conductive traces, incorporation of low-noise amplifiers (LNA) into the radiating structure, attachment of dielectric material to metallic surfaces to act as a substrate for radiating elements, wire bond methods for active components such as RF MEMS switches, and connector attachment methods at ingress/egress points. CLAS concepts require that the antenna components function and survive the air vehicle structural environment. Typical environmental conditions include a maximum strain level of +/-6000 microstrain, cyclic fatigue to within 1000 to 2000 microstrain for greater than 100,000 cycles, temperature ranging from -60 to 180 °F, and 90% humidity. The frequency range of interest is 30 MHz to 8 GHz. The intent of this effort is to address the technical challenges and demonstrate the feasibility to integrate active components and multi-level circuitry in a representative CLAS concept.

PHASE I: Develop one or more concepts, conduct exploratory fabrication techniques, down select concept (if needed), and fabricate specimen to demonstrate process feasibility and verify that performance goals are met. Analyze both mechanical and electrical performance.

PHASE II: Refine concept from Phase I and optimize for Phase II requirements. Fabricate functional device using the refined concept and conduct comprehensive testing. Deliver functional prototype to AFRL.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Any platform that would benefit from the drag reduction and weight savings offered by CLAS technology.
Commercial Application: Similar to military -- any vehicle where weight and drag are important design considerations.

REFERENCES:
1. Calus, P., Conformal Load-Bearing Antenna Structure for Australian Defence Force Aircraft, 2007.

2. Calus, P., Novel Concepts for Conformal Load-bearing Antenna Structure, 2008.

3. You, C., Tentzeris, M., Hwang, W., Multilayer Effects on Microstrip Antennas for their Integration With Mechanical Structures, 2007.

KEYWORDS: CLAS, antennas, conformal, low-profile, load-bearing

AF121-004 TITLE: Intelligent Course of Action (ICOA)Generation for Air Vehicle Self-Defense

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop innovative concepts for an Intelligent Course of Action (ICOA) generator that is capable of autonomous air vehicle self-defense.

DESCRIPTION: The Air Force projects that future Integrated Air Defense Systems (IADS) will pose significant threats to U.S. air supremacy by denying access to previously accessible air space. A key requirement for preventing future air space denial and allowing advanced IADS penetration is the development of onboard autonomous vehicle self-defense for both manned and unmanned aircraft. An onboard autonomous self-defense system will allow for automatic and semi-automatic response to incoming threats in real time. The self-defense system must be able to detect, identify, monitor and track threats; determine the appropriate defensive measures; and employ those measures to defeat the threats.

A key component of the overall self defense system will be an Intelligent Course of Action (ICOA) generator. The ICOA generator will be responsible for ranking perceived threats, determining which threats to engage, with what weapons, countermeasures, maneuvers or combinations thereof, and at what time. Optimized use of limited resources will be a key to autonomously defending an aircraft in a complex hostile air space/anti-access environment. The ICOA is not required to detect, identify, and maintain threat tracks. An ICOA generator will need to make real time course of action (CoA) decisions and provide a pilot, onboard or remote, the option to intervene in defensive adjudication. This ability to intervene is a key to pilot acceptance of the self defense system.

The proposed SBIR effort will conceptualize, design, and develop innovative approaches to ICOA generation as a part of an autonomous/semi-autonomous self defense system onboard a bomber class vehicle. Successful ICOA concepts will utilize a combination of available weapon systems, counter measures, and aircraft maneuvers in order to survive a dense future IADs penetration mission. The air vehicle will follow a pre-planned route during the mission using maneuvers as a means for improving engagement geometry. Inputs to the ICOA generator will include, but are not limited to, the available weapon systems, threat tracks, and the aircraft's pre-planned route. Using these inputs the ICOA concept will output "intelligent" courses of action ensuring aircraft survival (e.g. use self defense missile against threat X). Available weapon systems include, but are not limited to, an undetermined number of self defense missiles and directed energy weapons. A successful ICOA concept will be adaptable to the quantity of available weapon systems on a per mission basis. Threat systems encountered will include ground based and airborne systems, ranging from surface-to-air missiles, air interceptors w/advanced air-to-air missiles, electronic warfare systems, directed energy systems, and combinations of these. The ICOA generator will be required to handle multiple simultaneous shots at multiple angles from the aforementioned threat systems. Successful concepts will encompass, but are not limited to, real time operation, minimization of input data requirements, adaptation to evolving threat capabilities, and adjustment to ownship self defense capabilities, with a potential for multi-ship operations consisting of up to four aircraft. The proposed approach will be implemented in accordance with an interface control document (ICD) provided by the Air Force, allowing the ICOA generator to be integrated into an existing constructive simulation environment.

PHASE I: This effort will develop an initial concept for an ICOA generator. As part of concept development, the technical feasibility will be assessed and performance goals for the concept will be identified. Required deliverables for the Phase I effort will include a technical report and prototype ICOA generator.

PHASE II: This effort will mature the concept and Phase I prototype for integration in a constructive simulation environment. The prototype implementation will be based on the provided ICD, but integration into the simulation

environment will not be required. Required deliverables for the Phase II effort will include a technical report and the final ICOA generator prepared for implementation in the constructive simulation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Autonomous self defense systems will be indispensable to all manned/unmanned aircraft. This technology may be expanded to manage offensive tasks. This technology may also be applied to enhance constructive analysis and training simulation systems.
Commercial Application: Autonomous self defense could be applied to commercial aircraft in order to counter potential terrorist threats. These types of algorithms play a critical role in improving efficiency in processes such as manufacturing, shipping, etc.

REFERENCES:
1. United States Air Force Chief Scientist. (2010). Technology horizons: A vision for air force science and technology during 2010-2030.Washington, DC: Department of the Air Force. Retrieved from http://www.af.mil/shared/media/document/AFD-100727-053.pdf.

2. Chief of Naval Research. (2009). Naval S&T strategic plan. Washington, DC: Department of the Navy. Retrieved from http://www.onr.navy.mil/About-ONR/~/media/Navy%20and%20Marine%20Strategy%20Plans/Naval-Strategic-Plan-2009.ashx.

3. Norvig, P., Russell, S., (2009). Artificial Intelligence: A Modern Approach (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

KEYWORDS: Autonomy, self-defense, unmanned aerial vehicles, manned aircraft, simulation, course of action, integrated air defense systems, resource manager, artificial intelligence

AF121-008 TITLE: Free-Space Quantum Key Distribution

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a feasible operational concept for quantum key distribution between an Earth station and low-earth orbit (LEO), and advance the driving technology needs.

DESCRIPTION: Information management and information assurance (IA) are critical elements for all DOD operations and their importance is only expected to increase in the future. Quantum Key Distribution (QKD) promises, in theory, perfectly secure key generation and distribution based on quantum physics rather than the computational complexity of certain mathematical problems. Given the progress in the development of QKD protocols, implementations and related technology over the past two and a half decades, QKD may be a feasible technology to support the information assurance needs that face both national security space (NSS) missions and commercial information security.

Quantum cryptography technologies have become sufficiently mature to experience commercialization in recent years, and fiber-based QKD systems for terrestrial applications have been reported with bit rates in excess of 1 Mbit/s. Owing to the signal losses and increased background noise associated with long-distance free-space propagation, proof-of-principle experiments involving free-space optical channels have resulted in many orders of magnitude lower bit rates. Technical factors limiting the system bit rates can be attributed to the efficiency, speed,

and noise characteristics associated with components and data management. These include photon sources, single-photon detectors, and algorithms required to manage data, correct errors, and enhance security. For optical links between space and earth, the limited aperture sizes in conjunction with absorption, diffraction and atmospheric turbulence can lead to significant optical losses. Furthermore, scattering in the free-space channel can degrade signal-to-noise making daytime operation particularly challenging.

The goal of this SBIR solicitation is to identify an operational system concept for free-space QKD between low-earth orbit (LEO) and an Earth station capable of secret key bit generation in excess of 1,000 quantum bits per second, and develop a key component of that system that is identified as essential to its operation. Optical wavelengths of interest are those in the range of 750 to 1600 nm and within atmospheric transmission windows. A successful proposal will define the operational concept for a QKD system and describe the corresponding measures of effectiveness for the system's performance. The proposal should also identify the main technological problems that must be overcome or developed to realize the proposed system. The proposal will then identify limiting critical path technology(s) for development to support this system, and describe plans for the advancement of at least one of the limiting technologies to support the operational concept. This solicitation seeks to promote the development of sub-system technologies that provide the efficiency, speed, and noise characteristics that are necessary to achieve rapid key generation, and system designs that are robust to daytime operation and LEO satellite dynamics. The proposed key technology development(s) must be justified through analysis that includes the impact of the proposed technology development on performance of a space-ground QKD system with consideration given to security, size, mass, and power requirements.

Responses should identify driving technologies that will advance state-of-the-art free-space QKD. The proposal should demonstrate how the proposed innovation would impact secure key rates in QKD when considered together with a QKD protocol, atmospheric effects, electro-optical components, and beam control parameters. Metrics for evaluating the approach will include the rate of quantum key generation in secret key bits per second, distance of optical link, the duration of the engagements and number of engagements per day allowed by the beam control approach including any limitations associated with daytime operation. Practical consideration should be given to aperture and payload sizes associated with space-based systems.

PHASE I: Define a baseline QKD operational concept and associated measures of effectiveness. This concept should identify the driving technologies and the associated measures of performance that are required to support this concept. For at least one of these key-defined technologies, a plan should be proposed to advance the technology to support the proposer's defined system. The proposed plan shall be supported by analyses that integrate the proposed innovation with QKD security analysis for a given protocol with electro-optical and algorithmic phenomenology.

PHASE II: Execute the technology advancement plan developed in Phase I. Demonstrate and validate through appropriate characterization the prototype or critical aspects of the innovation. The innovation should be both achievable within a phase II SBIR and result in a significant impact on achieving or exceeding the performance goals identified in the solicitation. The phase II effort should include experimental demonstrations of any new techniques or components required to implement the system concept.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Encryption keys are needed for all DoD spacecraft, and many other operational systems. Ability to refresh keys on an as-needed basis to support future net-centric operations.
Commercial Application: Commercial secure communications will benefit in the same manner as military applications from this technology.

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1. Mink et al., "High speed quantum key distribution system supports one-time pad encryption of real time video," Proc. of SPIE 6244, 62440M (2006).

2. C. Bonato, A. Tomaello, V Da Deppo, G. Naletto, and P. Villoresi, "Feasibility of satellite quantum key distribution," New J. Phys. 11, 045017 (2009).

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KEYWORDS: Quantum key distribution, free space propagation, atmospheric propagation, information assurance

AF121-009 TITLE: Uncued Faint Object Detection in LEO and GEO

TECHNOLOGY AREAS: Sensors, Space Platforms

OBJECTIVE: Develop a method to detect and track faint objects (greater than or equal to 14th visual magnitude) in any orbit around the Earth using ground-based electro-optics sensors, without prior knowledge of the object's orbit.

DESCRIPTION: A key element of space situational awareness is the detection of new objects in space. New objects can be either newly launched in space or existing objects that are newly detected on orbit. As space becomes more crowded, the growing, large body of hard-to-detect objects (much of it debris) will impact the safety of our on-orbit assets. Detecting and tracking dim objects is important in all orbital regimes.

Typically, only a small subset of objects is routinely monitored, with the vast majority either too dim (small) or their position too variable to maintain contact. With the increasing number of objects in space, we should expect to have new objects appear that were previously unknown. The purpose of this effort is to develop a capability to detect hard-to-detect (dim) objects in space and determine their orbital parameters.

For objects in low earth orbit (LEO), one can track a known object, keeping the object in the field-of-view. This enables the sensor to integrate over a long time, which increases the sensitivity and enables tracking dim objects. In a surveillance mode, where the orbit of the object is not known, the object cannot be tracked. The sensor either stares at or scans the sky, looking for objects. In either case, the amount of time the object is in the field-of-view and therefore restricts the dimness of unknown objects that can be detected and tracked. Innovative methods are needed to reduce the brightness of an object that can be detected in surveillance mode in a LEO orbit.

In a geosynchronous orbit (GEO), objects are moving much more slowly through the field-of-view. Longer integration times are easier to achieve, making it easier to detect dim objects. The difficulty in GEO is in detecting dim objects in proximity to bright objects. Similar to detecting dim planets close by a bright star, a dim object close to a bright object in GEO is hidden in the glare of the nearby brighter object and is therefore difficult to detect. Innovative methods are needed to detect dim objects in GEO, particularly nearby other brighter objects.

To be effective, in LEO, these new methods should be capable of detecting objects significantly smaller than a 10 cm object. In GEO, it is desired to detect objects as dim as 19th visual magnitude.

PHASE I: Develop innovative electro-optical sensor design concepts, scanning methods or processing algorithms to detect dim objects in either LEO or GEO orbital regimes.

PHASE II: Demonstrate capability to detect dim objects in either LEO or GEO regimes. Demonstration (simulation, laboratory and/or field testing) will show the improvement in detection of dim space objects over existing techniques. Demonstrations will show traceability to improved performance in an existing ground-based optical system. A single system is not assumed to work in both regimes. Document the new technology to enable transfer to military use.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: The U.S. military will be able to utilize the new capability in the space surveillance network. This technology will enable fainter objects to be detected and tracked, providing a broader knowledge of all objects in orbit around the Earth.
Commercial Application: Commercial satellite operations will benefit from the new capabilities.

REFERENCES:
1. R. Sridharan, A. F. Pensa, "U.S. Space Surveillance Network Capabilities," SPIE vol 3434, pp 88-100, 1998.

2. Donath, T., et al, "Proposal for a European Space Surveillance System," Proc 4th European Conference on Space Debris (ESA SP-587), p.31, 18-20 April 2005.

KEYWORDS: Surveillance, detection, tracking

AF121-010 TITLE: Feature Identification from Unresolved Electro-optical Data

TECHNOLOGY AREAS: Sensors, Space Platforms

OBJECTIVE: Develop algorithms, techniques, or systems for estimating features of unresolved space objects from electro-optical data.

DESCRIPTION: For some electro-optical surveillance systems, distant objects of interest may be beyond the resolving capability of the sensor. In these cases, feature identification must rely on radiometric, spectral, and polarimetric measurements over time. Features can be used to quantify characteristics, such as albedo-area map and/or shape, configuration, rotational dynamics, and surface properties such as specular and diffuse albedo and/or emissivity. In addition, measured features can be used to match or discriminate with known objects or classes of objects and to identify their behavior. For example, photometric measurements from solar-illuminated asteroids have been used to estimate their spin state and shape. This approach relies on the inversion of time-resolved photometric data to produce a spin axis and rate estimate along with a shape assuming a fixed surface albedo.

The objective is to develop innovative feature estimation or matching approaches produced by new and/or existing electro-optical systems. Identified features should include error estimates and confidence levels in identifying and separating features. Feature extraction methods may be done with or without any prior knowledge of the object. With a prior knowledge, electro-optical measurements can be matched with a forward model.

There are obvious relationships between possible features and the underlying state of space objects, e.g., determining object spin from periodicities in temporal photometric measurements. We are looking for innovative approaches that go beyond the obvious relationships and create more powerful techniques that build broader relationships between space objects measurable signatures and important features of the space objects. The following examples suggest such possible broader approaches, but they are by no means exclusive or exhaustive:

• Combining unsupervised learning state variable methods (e.g., Kalman filter evolution of temporal behavior) with supervised pattern recognition methods
• Application of the evolving methods of data mining, such as unsupervised learning methods from statistical or information-theory based data clustering, to identify significant sources of features in large volumes of data
• Application of the recent merger of integral equation inversion methods with sparse mathematics optimization for direct approximation of the equations that govern the propagation of object features into the measured data

The breadth of approaches sought in this SBIR encompasses algorithms (computational methods), techniques (procedures of computation, analysis and archival compilation of relevant data) and systems (integrated devices, algorithms and techniques) that meet the goal of furthering broader knowledge and utility of unresolved electro-optical data.

Develop algorithms, techniques, or systems that provide the ability to identify features from a realistic non-resolved data set. The use of realistic radiometric forward modeling to correlate features with shape, size, material composition, attitude, or configuration is highly desirable. Provide a feasibility assessment of these algorithms.

PHASE I: Develop new concepts to identify features from unresolved optical data. Use of radiometric forward modeling is highly desired. Provide feasibility assessments of these algorithms and specify how they would characterize the physical structure of the object, such as size, shape, color, or how the object is oriented in space (spinning, in a stable attitude such as nadir pointing).

PHASE II: Evaluate concepts identified in Phase I for performance in correlating algorithm outputs with shape, size, material composition, attitude, and configuration. This may be demonstrated against typical space situational awareness (SSA) scenarios. Demonstrations used to test the developed techniques should use data on satellites for which there is an independent means of assessing truth. Typical scenarios and data on satellites for testing will be provided by the technical POC, upon request.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This technology will help national surveillance systems to maintain the space catalog by adding additional information in identifying objects in orbit.
Commercial Application: This technology is applicable in medical imaging, meteorology, and homeland security applications.

REFERENCES:
1. Wild, W.J., Astrophysical Journal, Part 1, vol. 368, Feb. 20, 1991, p. 622-625.

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3. Brandoch Calef, John Africano, Brian Birge, Doyle Hall and Paul Kervin, "Photometric signature inversion," Proc. SPIE 6307, 63070E (2006).

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5. Hall, D., Surface Material Characterization from Multi-band Optical Observations, The 2010 AMOS Technical Conference Proceedings, Kihei, HI, 2010.

KEYWORDS: Optical, infrared, identification, feature extraction, photometry, inversion, BRDF, unresolved

AF121-011 TITLE: Daytime Detection and Tracking of Objects in a Geosynchronous or Geo-transfer Orbit

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Provide persistent space situational awareness by detecting space objects in geosynchronous and geosynchronous transfer orbits using existing government infrastructure while minimizing long term operations and maintenance costs.

DESCRIPTION: As the number of space objects in geostationary earth orbit (GEO) increases, timely knowledge of newly inserted satellite orbital elements becomes more important to effectively track the object. Both foreign and domestic GEO satellite placement involves a geo-transfer orbit (GTO) that transitions the payload from an initial low earth orbit (LEO) to its final GEO location. The most direct approach has been a Hohmann transfer involving an initial LEO burn that injects the spacecraft into a GTO orbit, followed by an apogee circularization burn at GEO.

Advancements in propulsion technology have resulted in significant deviations from traditional Hohmann GTO type trajectories. As a result, the early determination of the targeted final orbit becomes significantly more challenging. Maintaining line-of-sight custody of the newly launched object in GTO and into GEO is critical. Current radar methods are limited beyond LEO orbital distances requiring the discovery of new techniques to detect GEO and GTO space objects.

Detection of small objects at night is accomplished routinely with ground-based electro-optical telescopes around the world. Techniques have been established for detection, follow up, and establishing tracks. However, favorable maneuver geometry will happen regardless of time of day. During the day, high background levels from scattered light limit the ability to detect and track space objects. Techniques are needed that allow for remote sensing of space objects beyond low earth orbit (LEO) through the high background levels present in the visible wave band. Tracking during the day would provide verification of maneuvers during the day and would expand the capability to observe and track objects through GEO insertion. Detection of 1m objects in a geosynchronous orbit during the day using a 1.6m telescope would advance state-of-the-art in space surveillance and tracking capability.

Solutions should be capable of demonstration at Maui Space Surveillance Site at Haleakala, HI, and may use existing assets at that facility.

There are an abundance of solutions that could solve the problem with a significant investment. Priority will be given to techniques that
1. Will use existing government infrastructure
2. Are low cost to operate and maintain
3. Detect more man-made objects in a greater volume around the geo belt

PHASE I: Identify sensor configurations and collection techniques for daytime detection culminating in a preliminary design review for a detection system.

PHASE II: Prototype demonstration of sensitivity limits in lab with known daytime target signal/background levels to approximate sky conditions. Following successful lab tests, a daytime demonstration of sensitivity at Maui Space Surveillance Site may use government or contractor equipment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Worldwide detection and tracking of space objects near the GEO belt during the day.
Commercial Application: Dim signal detection and camera optimization in high background conditions can apply to many remote sensing applications for detection of specific small dim targets such as security, locating specific plants and animals, and overhead imaging.

REFERENCES:
1. Dahm, W.J.A, USAF Chief Scientist Report on Technology Horizons: A Vision for Air Force Science & Technology during 2010-2030, Volume 1, AF/ST-TR-10-01-PR, 15 May 2010.

2. R. Sridharan, A. F. Pensa, "U.S. Space Surveillance Network Capabilities," SPIE vol 3434, pp 88-100, 1998.

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KEYWORDS: Daytime, Geostationary, Geosynchronous, Tracking, Transfer, Orbits

AF121-012 TITLE: Characterization of GEO Insertion Maneuvers Utilizing Spectral, Photometric, and Image Analysis Techniques coupled with High Precision Orbit Determination Algorithms

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: The development of an algorithm that determines future orbital elements of a satellite from initial orbital elements given the observable characteristics of thruster plumes.

DESCRIPTION: Space technology needs are driving requirements in directions that conflict with design considerations for space and ground sensors. Dim object detection and characterization conflicts with our need for detecting the multitude of objects in a wide area from low earth orbit (LEO) to geosynchronous earth orbit (GEO) and detecting space object changes. It is challenging for sensors to look in all directions at all times and detect anything other than the brightest signal. Fortunately, thrusting objects emit a signature that is often very bright providing an opportunity for change detection in a sensor optimized for covering a large volume of space. This will allow us to detect a change that would otherwise go undetected because of inherent system design limitations for detecting dim objects and providing sufficient repeated coverage over the sky.

However, detecting the change is only the first part of the problem. Embedded in the thruster firing are clues about the characteristics of the object and where it is going. Techniques are needed to determine space vehicle orbital elements immediately after an exoatmospheric maneuver given a known initial trajectory but no a priori thruster knowledge. Solutions may use spectral, spatial, or photometric plume characteristics in any wavelength that can be readily tested using ground-based telescopes. The observable phenomena must be sufficiently understood to come up with a reasonable collection scheme. Propulsion dynamics may be modeled using time-resolved observational data including particle size/density, temperature distribution, and resolved spectral signatures as a function of spatial extent over the evolving plume area. Particle size/density determination could be deduced from observed scattering phenomena with respect to viewing geometry and illumination conditions. Temperature can be determined via calibrated infrared measurements over the plume area. Highly resolved spectroscopic information within the plume may be obtained and used. Given the possible available data, the modeling tools should be able to predict, with confidence, the orbital elements of the satellite body.

Research is needed to develop extensive modeling and simulations to characterize radiometric parameters to estimate acceleration profile and trajectories from plume measurements and models of common satellite materials. This includes:
- Analyze viewing geometries and sensor locations
- Simulate all potential observation opportunities including daylight, terminator, and nighttime
- Investigate optical assets and sensor(s) for line-of-sight (LOS) tracking and plume capture, and spectral and spatial sampling capabilities gauged with respect to signal to noise ratio. Validate radiance models of selected orbit insertion kick motors
- Develop an inversion algorithm to fuse all data sources to determine new orbital elements

Proposals should build upon existing research of space thruster firing. Modeling and simulation experience should be detailed including evidence of maturity of the models to be used for conducting the research.

Evaluate sensors at the Advanced Maui Optical and Supercomputing Site (AMOS) that can be utilized in the effort to demonstrate capability.

If requested, AMOS will facilitate data collection on cooperative objects with AMOS ground-based sensors including the SPICA-II spectrometer on AEOS (3.6m telescope). Other data collection locations and sensors may be requested and will be provided as available. Access to data will require a secret security clearance. Resulting data will be used to refine predicted performance.

Phase I: Identify one or more postulated methods for determining orbital parameters utilizing LOS and plume information following a maneuver. Identify the associated modeling, simulation and data collection to support/refute/develop the technique. List assumptions, requirements, error tolerance and the resulting expected uncertainty of the calculation. Predict performance and identify a plan to validate models. Identify risks.

Phase II: Conduct modeling and simulation eliminating overly challenging approaches and refining applicable models. Reduce risk and mature models by validating models with experimental field data of relevant space objects. Demonstrate robustness of algorithms by predicting space vehicle orbital elements immediately after an exoatmospheric maneuver given a known initial trajectory but no a priori thruster knowledge for at least 3 cooperative maneuvers.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Worldwide deployment of daytime detection techniques for space situational awareness for the DoD.
Commercial Application: Understanding and verification of space physics out to 36,000 km in Phase II will allow contractors to be prepared to propose new ideas for scientific discovery.

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KEYWORDS: Space Situational Awareness (SSA), maneuver characterization

AF121-016 TITLE: Curved Flat Panel Microdisplay (CFPM)

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a thin, curved image-generating microdisplay with simplified optics for use in digital visualization applications including near-eye advanced helmet--mounted systems, 3D, and other projection designs.

DESCRIPTION: Displays, including miniature and microdisplays, are typically fabricated as rectilinear flat image-generating surfaces on glass plates or silicon wafers due to the limitations imposed by current manufacturing and available substrate technologies. Such displays generate a rectilinear flat image that must be transformed into a curved image wavefront representation for projection to the eye. The optical design problem is compounded by the

need for an optical system with low étendue that efficiently uses the emitted light. The overall optical efficiency is limited due to the fact that the initial image is rectilinear flat rather than curved to begin with. Flat images force the design and use of a complex eyepiece optic (expensive train of lens elements) that efficiently collect s and converts the flat image initially generated into a curved field-of-view (e.g. 40º solid cone) of optical flux relayed to the eye. Volume, weight, and expense of the display optics often prevents the integration of microdisplays into applications where weight and space are critical. Increases in field of view and acuity are also restricted. Recent bio-inspired work has taken note that the retina of the eye is curved, which accepts the curved FOV optical flux arriving at the aperture (the pupil), which, in turn, enables a very simple lenses for sensors. The objective of this topic is to apply the same techniques to microdisplays. The recent advances fabrication techniques of curved focal plane arrays for sensors could be equally well applied to microdisplays. Current digital microdisplays and sensors both involve the fabrication of microelectronics circuits at each pixel (display or sensor) of an NxM pixel array with die dimensions on the order of 10mm. Curved device fabrication strategies include 1) array formation on a flat substrate that is then curved once into the final shape and 2) direct fabrication in the desired shape. This topic is focused on the use of the techniques developed for curved microsensor devices to microdisplay devices. High efficiency, yet simple near eye optics are required as well for integration and CFPM system evaluation.

PHASE I: Design CFPM near-eye vision system with optics capable of being integrated to small form factor applications to provide visualization capability to pilots and other warfighters. Novel materials, microdisplay pixel structures, array readout schema, and fabrication techniques should be addressed via proof-of-principle experiments. Develop roadmap.

PHASE II: Fabricate CFPM and demonstrate performance in laboratory environment. Perform evaluation experiments and compare performance to comparable state-of-the-art classical, rectilinear flat, panel microdisplays. Demonstrate synergistic capabilities of CFPM in support of HMS and other gear now worn or used by warfighters. Evaluate potential of CFPM in commercial applications to create an industrial base for affordable production. Deliver three units.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include helmet mounted display (HMD) systems for pilots (all aircraft), tankers, and dismounted combatants, other digital projection and near-eye digital vision systems, and dynamic holographic 3D display systems.
Commercial Application: Commercial applications include high resolution displays (near-eye virtual image and projected real image) embedded in consumer electronics (computers, cell phones, camcorders), homeland security, and police.

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2. From the system point of view, the étendue is the area of the entrance pupil times the solid angle the source subtends as seen from the pupil. http://en.wikipedia.org/wiki/Etendue.

3. Helmet mounted display, http://en.wikipedia.org/wiki/Helmet_mounted_display.

4. Design of Head mounted displays, www.optics.arizona.edu.

KEYWORDS: Curved flat panel microdisplay, étendue, helmet mounted display, HMD, 3D display, projection systems

AF121-017 TITLE: Adaptive Gaming and Training Environment for Maintenance Operations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate an adaptive game-based approach to training for maintenance operators.

DESCRIPTION: Recently there has been a growing recognition of the potential role that interactive games may have as environments for training and rehearsal for military personnel. The growth of the military's interest in gaming is exemplified by the Defense Advanced Research Project Administration (DARPA) DARWARS initiative and the US Army's collaboration with the University of California Institute for Creative Technology. Further, significant advances in software agents to support learning that are based on either computational or cognitive modeling architectures or machine learning makes the development of lower costs, adaptive learning environments possible. Games, however, are not typically designed with either a research or training focus. This effort will explore the potential for applying gaming technology and agent architectures to the training of maintenance personnel. At the present time, the USAF maintenance community relies on very expensive part task trainers that in many cases are minimally interactive, and require human instructors to provide much of the content through hands-on demonstrations. These part task trainers are not flexible or tailorable to either differing contexts/situations for learning or to the learning needs of those who are the targets of the training. A gap exists between the instructional adaptability and fidelity of these static devices and the complex demands of learning how to troubleshoot and maintain modern aircraft systems and subsystems. This effort will explore the training utility of developing gaming environments that incorporate adaptive approaches to tailoring learning where complex maintenance tasks can be trained in realistic scenarios and simulations. By using a gaming approach, access to any classified system data would be eliminated, but the training that is provided could be conceptually valid and of sufficient fidelity to support the specific system tasks desired. In addition, this effort could permit a number of other, more research- and training-centric issues, to be examined in detail as they relate to gaming environments and to future commercial applications in the maintenance domain. First, more efficiently develop specific system or subsystem representations for the specific parts of the aircraft to be trained and that are associated with specific maintenance tasks. Second, identify and validate training strategies and scenarios that support the development and refresh of skills associated with maintenance performance in the operational environment. Specifically, what are characteristics of strategies and scenarios embedded in the game that support development and refresh of critical knowledge and skills? Third, develop specifications for performance measures and protocols for assessing proficiency and decay for the gaming environment and to inform the adaptive agents; Fourth, what are some preliminary guidelines for refresher training intervals for different classes maintenance skill and levels of expertise; Fifth, explore ease of incorporating Interactive Electronic Training Manuals (IETM). Finally, demonstrate real-time scenario authoring and skills tracking that can be integrated into other gaming/training environments.

PHASE I: Develop specifications for using gaming approaches to train maintenance tasks. Identify key features of the environment and explore alternative methods for adapting content based on performance and level of underlying knowledge about the system or subsystem. The Government will coordinate field visits and will make subject matter experts and maintenance tasks available to the vendor.

PHASE II: Demonstrate a game based approach to training, rehearsal & exercise for maintenance ops. Develop and validate authoring methods, event management, tools, & trainee performance tracking and learning adaptation capabilities inside the gaming env. Explore connectivity feasibility among the gaming environment & a distributed mission training simulation environment. The Government will coordinate site visits and will make subject matter experts available for a field eval of the gaming environment with operational maintenance personnel.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Maintenance training is very expensive and typically requires access to real aircraft or other operational systems or very expensive mock ups. Game based environments offer a way to get higher fidelity training for maintenance tasks at lower costs.
Commercial Application: Key tasks for mx ops could be applicable to a variety of commercial trng requirements where gaming is also a plausible env choice. Key components of the gaming env developed would have application in virtually any complex systems mx environment.

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KEYWORDS: gaming, maintenance operations, training environment

AF121-018 TITLE: Color symbology in helmet mounted visors and heads up displays

TECHNOLOGY AREAS: Human Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and demonstrate a prototype next generation multi color symbology for use in helmet mounted displays and HUD.

DESCRIPTION: For a day helmet mounted display or HUD system, high ambient illumination can desaturate colors to a point that there are color recognition errors (e.g., confusing yellow and green). For a night vision system, the colors are in front of a night vision goggle and this shifts all colors toward green. Varying natural backgrounds will further limit consistency in recognizing the color presented. Assuming it's possible to come up with a set of colors that are easily distinguishable, the question is, which colors and how many to use at one time?

In addition, the use of color facilitates applications for tactical symbology that have not yet been explored, optimized, or standardized, especially air-to-ground, combat search and rescue, and Global Information Grid data links.

PHASE I: Perform a technology feasibility assessment and deliver a description of the conceptual solution, data to support the feasibility of the next generation of visor and HUD color symbology solution, and a brief outline of a Phase II effort.

PHASE II: Construct and demonstrate a next generation of visor and HUD color symbology in a laboratory environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Adapt the laboratory next generation of visor and HUD color symbology to an airborne prototype with complete operational compatibility to validate this new color symbology system's performance characteristics.
Commercial Application: Commercial aircraft and automobile head up displays.

REFERENCES:

1. Wyszecki, G and Stiles, W.S. (2000). Color Science. Concepts and Methods, Quantitative Data and Formula 2nd edition -Wiley Classics Library, Wiley & Sons, Inc. New York.

2. Havig, P., Martinsen, G.I., Post, D. L., and Ellanwanger, H., (2004) Effects of saturation contrast on color recognition in night vision goggles. Proceedings of the International Society for Optical Engineers: Helmet Mounted Displays.

KEYWORDS: Head up display, helmet visor, color symbology, helmet mounted display

AF121-019 TITLE: Wide Spectral Response Focal Plane Array (FPA)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research/develop low-cost solid-state focal plane array detector technology with high sensitivity, broad spectral response, and high spatial resolution to replace current night vision imaging technology.

DESCRIPTION: Multiple airborne and ground-based mission applications would benefit by the capability of using a single FPA detector to sense and image objects and terrain scene content spanning a broad spectral band extending from the violet end of the visible spectrum to wavelengths of 5 microns or longer, with the flexibility to electronically select narrower spectral bands of interest (e.g., spectral binning) within the overall broad band of spectral sensitivity. (Front-end optics suitable for spectral bands within this overall bandwidth are a separate issue not considered or covered by this topic.) Multiple bands at discrete frequencies should be selectable to allow multi-spectral or hyper-spectral imaging of a target. Such FPA technology should be entirely solid-state in nature, avoiding the need for (and fragility of) high-vacuum envelope packaging and sealing. Such FPA technology should have reduced weight, physical volume and power consumption compared to current technology approaches. Such FPA technology ideally should have a variable gain function allowing operation across a dynamic range spanning overcast starlight to noon daytime conditions without saturation; such gain adjustment ideally could be simultaneously and independently variable within multiple zones of the FPA down to cluster areas comprised of less than 10 pixels each to allow clear imaging of areas closely surrounding high flux point sources. Such FPA technology ideally would exhibit rapid temporal response allowing discrimination of pulsed sources down to the sub-microsecond level. Within the band of spectral sensitivity of current intensifier tube technology, the FPA technology would offer gain, radiant sensitivity, equivalent background input and resolution performance levels at least matching those of current state-of-the-art GaAs-based image intensifiers. Within the bands of spectral sensitivity of current thermal imaging technologies, the FPA technology also would offer minimum resolvable temperature difference and resolution performance at least matching that of current thermal imaging technology. The output of such FPA technology would be a video signal or data stream adhering to a standard nonproprietary format to facilitate the driving of head-mounted or hand-held displays, aircraft avionic displays, or other sensor fusion or video processing devices. The FPA technology approach would adhere to an architecture readily lending itself to mass production and associated low costs.

PHASE I: Research, define, compare and document technical options. Determine a FPA technology concept capable of meeting all requirements in the description section.

PHASE II: Prototype the proposed Phase I design concept and demonstrate initially in ground and air environments. Submit a complete technical report documenting all work under the effort.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Ground/airborne mission applications that require day/night-time imaging of scenes, objects, continuous wave/pulsed sources in spectral bandwidths encompassing visible spectrum through long-wave IR.
Commercial Application: Industrial machine vision for high power laser material cutting and processing applications; also imagers for first-responder and search-and-rescue personnel.

REFERENCES:
1. SPIE OE Magazine: April 2004. Tuning in to Detection.
http://spie.org/documents/Newsroom/Imported/oemApr04/detection.pdf.

2. Rotor and Wing Magazine: 01 June 2004. Opening Night.
http://www.aviationtoday.com/rw/products/missionequip/1580.html.

3. Military and Aerospace Electronics: 01 March 2005. Scared of the Dark?
http://www.militaryaerospace.com/index/display/article-display/223589/articles/military-aerospace-electronics/volume-16/issue-3/features/technology-focus/scared-of-the-dark.html.

KEYWORDS: focal plane array, image intensifier, FLIR, thermal imager, dynamic range, high sensitivity, broad spectral response, spectral binning, multi-spectral, hyperspectral, temporal response, low power

AF121-020 TITLE: Performance-Based Simulation Certification (SIMCERT) System

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and validate an integrated human- and system-performance-based technology for accessing the perceived fidelity (system credibility) of live, virtual, and constructive combat mission training and rehearsal systems.

DESCRIPTION: Until recent years, flight simulators were principally used to train instrument flight, takeoff and landing, and limited combat tasks. The critical subsystems needed to train, including the internal cockpit environment, instruments, avionics and control systems, closely mimic the real world aircraft. The military has recently started to use simulators for full mission combat training in the form of distributed mission operations (DMO) training. For the purposes of this topic we will focus the work on current generation modest to high fidelity fast-jet, air combat distributed simulation environments. The environments of focus are composed of a cockpit with instrumentation and interfaces, a visual system and visual database of different parts of the world, a constructive player/forces generator, an instructor/operator station, and some type of debriefing or after action review station. It is widely believed that DMO requires a more accurate and complete simulation of the environment, especially the out-the-window visual. It has proven difficult to measure the effects that reduced (or differences in) environmental realism has on training. As an example, the effect of limitations in out-the-window field-of-view and image resolution is difficult to quantify. Another example is how much the addition of different force cues might enhance training compared to simulation without such cues or with cues at a different level of fidelity.

The typical approach for simulator assessment focuses on measuring the physical fidelity to replicate the flight environment. A flaw to this approach is that physical fidelity provides no limitations to design (i.e., if physical fidelity can't be achieved completely, what is a lesser degree's value?). Physical fidelity is an attractive approach because it gives a clear and unambiguous reference point, but the most common design limitation in simulators is cost. A better approach may be to assess for perceived fidelity, or the simulator's success providing the pilot with a perceptual, perceptual-motor and cognitive environment that yields no conscious distinction between simulator and airplane. The scientific approach to describing perceived fidelity is more similar to key elements of human-system integration, including: 1) user profiling, 2) task understanding, 3) task environment, or the attributes directly or indirectly affecting pilot operations, and 4) purpose of the design, for example, instruction vs. proficiency training. To be truly cost effective, it is important to be able to measure the quality of the simulation and how improvements benefit training. The amount of realism required in specific areas and the most effective compromises are difficult to determine. Although some data on overall training effectiveness may be determined by comparing simulator-trained

pilots with control groups, such data is usually collected with little or no knowledge of the quality of the simulation. Therefore, the results provide no insight as to why transfer did or did not occur since the process does not isolate the effects of differences in system performance and how they affect pilot behavior and performance. Current methods of Simulator Certification (SIMCERT) are highly subjective, and do not isolate specific training problems and relate them to specific engineering solutions. New processes are needed to determine the effects of simulator subsystem performance objectively and specifically. This new process may include measurement techniques for determining changes in pilot behavior and performance. The processes must be able to isolate the effects of changes such as reduced or increased visual field-of-view or resolution or adding capabilities such as various types of force cues. Comparisons of pilot performance at a specific and objective level could be essential for determining whether simulator changes are needed and whether proposed solutions will solve specific identified problems.

PHASE I: Phase I will define a process for determining simulator system effectiveness for training transfer. It will include developing metrics and tools for determining the effectiveness of the simulation. The process will address critical tasks associated with combat that might be trained in DMO.

PHASE II: Phase II will define the process and develop the algorithms used to conduct effectiveness evaluations. It will verify these by conducting simulator effectiveness evaluations of typical combat training scenarios. Examples of validated scenarios will be provided by the Government. Finally, it will demonstrate the utility of the process and tools to isolate the effects of simulator system performance on pilot behavior and performance. This tool will permit transfer of training studies on training simulations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The ability to isolate the design characteristics of combat mission simulators which most efficiently facilitate transferred learning will greatly enhance the requirement development process in simulator acquisitions.
Commercial Application: The ability to isolate the design characteristics of commercial simulators which most efficiently facilitate transfered learning will greatly enhance the requirement development process in simulator acquisitions.

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

2. Department of the Air Force (2001). AFHDBK 36-2235, Information for Designers of Instructional Systems, Vol. 3, Application to Acquisition (Chapter 5). Washington, D.C.: HQ United States Air Force.

3. Alfred T. Lee (2005). Flight Simulation. Ashgate Publishing Company, Burlington, VT.

4. List of FAQs from TPOC, 12 sets of Q&A, posted in SITIS 12/5/11.

KEYWORDS: flight simulation, combat mission training, distributed mission training (DMT),distributed simulation

AF121-021 TITLE: Correlated Weather Visual and Sensor Effects for Distributed Mission Operations

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: Develop correlated visual, sensor, and threat weather effects for Distributed Mission Operations (DMO) based on authoritative weather data with directional visibility and volumetric clouds.

DESCRIPTION: Investigate and create a capability for common and correlated visual and sensor weather effects for DMO. An algorithm or numerous algorithms will be developed to ingest authoritative real world time-phased weather data from the Air Force Weather Agency and to output standard directionally dependent visibility and volumetric cloud data usable across modern DMO visual and sensor image generators and the XCITE threat

simulation system. This capability will seamlessly use/interact with the existing DoD owned Cloud Scene Simulator (CSS) software. The weather data will be provided to the offeror, as well as CSS and XCITE software (or equivalents). The intent is to support variable directional visibility based on sun/moon direction and local weather conditions as well as individual clouds, groups of clouds, fronts, thunderstorms, and layers of clouds supported by volumetric approaches. Dust and dust storms will be considered. Extensions or modifications to existing volumetric algorithm approaches can be considered as necessary to achieve this capability. Resulting sensor visibilities and cloud interaction should be unique per sensor and different, as appropriate, from each other and from unaided visual scenes. Weather effects on laser and laser markers will be investigated and solution paths will be proposed. 3D cultural features, moving models, and special effects visibilities as affected by weather will be considered and solution paths will be proposed.

PHASE I: Investigate weather, image generator, and threat system formats. Propose solution paths. Propose modifications and/or extensions to formats. Develop algorithms for directional visibility/volumetric clouds. Document algorithm code. Demonstrate results. Develop users guide.

PHASE II: Refine Phase I capabilities as necessary to develop a robust automated capability. Deliver a detailed user manual in hard copy and soft copy (Word document). Deliver highly documented source code. Demonstrate real-world time-phased weather based on authoritative data and interactions with CSS and XCITE in a DMO typical multiple image generator vendor visual and sensor scenarios.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This capability will benefit military and civilian programs, to include Homeland Security applications, that require correlated real world time-phased weather.
Commercial Application: This capability will benefit military and civilian programs, to include Homeland Security applications, that require correlated, real-world, time-phased weather.

REFERENCES:
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2. Lerman, D. “Correct Weather Modeling of Nonstandard Days”, Simulation Interoperability Standards Organization Summer 2010 Conference, Sep 2010.

3. Rietze, S. “Distributed Mission Ops Shape USAF Training Projects”, National Defense Magazine, Nov 2003.

4. Stephens, S. “Rehearsal Enabling Simulation Technologies”, The TSPG Journal, Nov 2009.

5. Stephens, S. “Correlated Realtime All Sensor Distributed Mission Operations”, The TSPG Journal, Nov 2010.

KEYWORDS: weather, sensors, DMO, correlation, clouds, correlation

AF121-022 TITLE: Debrief and After-Action Review Technologies for Electronic Warfare Simulation and Training

TECHNOLOGY AREAS: Information Systems, Electronics, Human Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop next-generation technologies/methodologies for debrief of Electronic Warfare (EW) training simulations in simulators, Distributed Mission Operations, and Live-Virtual -Constructive domains.

DESCRIPTION: Robust, realistic, and validated EW and counter-threat training has become critical to warfighter preparedness. Practice engagements accomplished in training are often difficult to recreate accurately in after action reviews limiting the effectiveness of the training received.

Current debrief methods and support technologies do not yet provide adequate debrief of EW, Electronic Attack (EA), threat detection/deception, communications, threat encounters/evasion, end game tactics/countermeasures, and weapons effects. This limited debrief capability reduces the training effectiveness of hybrid training scenarios which include operational real-world systems (live), real operators in simulators (virtual), and computer generated forces (constructive), or any combination thereof, in interactive LVC training scenarios. The entire engagement history: early detection, Integrated Air Defense System (ADS) interaction, target detection, target tracking, target engagement, reactions to countermeasures, specific threat tactics and adaptable threat tactics, re-engagement must be understood and analyzed to maximize training effectiveness.

The Air Force is seeking highly innovative solutions for the development of next generation methodologies and support technologies for debrief of EW training simulations which greatly enhance overall training/debrief effectiveness. Solutions should be compatible with, or adaptable to, distributed debrief capabilities.

Particular questions which must be addressed include (but are not limited to): What information/parameters must be collected and stored for effective Electronic Warfare debrief? What is the best way to format and store this data? What are the optimal protocols for (non-Distributed Interactive Simulation (DIS) compatible data) to transmit for distributed debrief? What simulator system functions and network data need to be collected and at what data rate or frequency to support robust debriefing? What simulator system improvements may be required to support robust debrief of EW simulations? What is the optimal, most intuitive debrief and presentation format for pilots and other system users to get the most training value from mission debriefs? What visualization and EW effects can be used during engagement for operators as well as for debrief? What methods can be used to show electronic counter-countermeasures (ECCM) effects or EA effects both by and against the trainee?

This task is intended to include members of the computational linguistics and informatics disciplines.

Innovation, feasibility, and training/debrief effectiveness are critical requirements for the technology being proposed for this solicitation. This technology is not required to interface with any specific training simulation systems, but should rather develop new innovative EW training/debrief methodologies and technologies. Access to specific government simulators is not required.

PHASE I: Provide a technical report determining the feasibility of the concept and anticipated training benefits, and provide a feasibility demonstration. The phase I task must include communications information analysis to feed a full requirements analysis to be performed in Phases II and/or III.

PHASE II: Phase II will result in developing/prototyping, demonstrating, and testing the concept proposed under Phase I and a technical report detailing the Phase II effort, including a full requirements analysis based upon phase I findings.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Technology would used by joint aircrews in live range and distributed simulation training practicing survival tactics in hostile EW environments.
Commercial Application: This work would provide direct applications to training debrief for law enforcement and homeland defense personnel in addition to widespread application to military training systems.

REFERENCES:
1. David W. Galloway, Patrick G. Hefferman, E. Allen Nus and Charles M. Summers, Electronic Combat Simulation in a Networked, Full Mission Rehearsal, Multi-Simulator Environment, TRW Avionics and Surveillance Group, Warner Robins Avionics Laboratory, ITSEC 1993.

2. Linda Viney A1, Tom McDermot A2, Craig A. Eidman A3, Susan McCall A4 , Networked Electronic Warfare Training System (NEWTS), The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC) Volume: 2007.

3. Michael R. Graham A1 and Glenn D. Cicero, Validating the Electronic Combat Environment in Aircrew Training Devices, The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC) Volume: 2007.

4. Wayne R. Philp, Modelling and Simulation of Electronic Combat, Electronic Warfare Division, Defence Science and Technology Organisation (DSTO), PO Box 1500, SALISBURY SA 5108.

KEYWORDS: electronic, warfare, modeling, mission debrief, simulator debrief, electronic warfare training, flight simulation training, after action review, training event visualization

AF121-023 TITLE: Cognitive Measures and Models for Persistent Surveillance

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate wide area, airborne-persistent surveillance imagery data exploitation analysis techniques with new approaches and integration methodology based on human cognitive task analysis. Focus is on real-time analysis and reporting. The Government does not intend to provide any Government Furnished Data (GFD) in support of either this Solicitation or of any contracts which may be awarded in response to it.

DESCRIPTION: The Department of Defense is developing and fielding new wide area, airborne, electro-optical, and infrared surveillance capabilities. These capabilities bring with them new challenges with regard to the PCPAD (planning and direction, collection, processing and exploitation, analysis and production, and dissemination) required to achieve their implicit warfighter benefits. To date, consolidated operations centers, collection managers and analysts are struggling to effectively exploit wide area persistent surveillance data to its full potential. Current operational practice usually ignores the cognitive demands experienced by the intelligence analyst. Fresh approaches from a human centered perspective are needed for working with the wide range of sensors and the Gbps motion imagery data they collect. The research and development of new analyses techniques and approaches for persistent wide area motion and other sensor imagery that produces terabytes of information, leading to technique demonstration, refinement and incorporation into exploitation and analysis toolsets is the desired end-state of this SBIR.

War-fighting tasks which are expected to benefit from enhanced persistent surveillance capabilities would include near real-time data analysis and exploitation activities for mission operations support including intelligence for predictive battlespace awareness and operations planning; combat identification; course of action decision-aiding; targeting; and battle damage assessment.

Cognitive modeling research is required to better understand the cognitive (human mental thought processes, thinking and reasoning) demands inherent in exploitation and analysis of persistent surveillance feeds for time-dominant (i.e., phase 1) in-theater data analysis and exploitation. Based on these demands, measures of effectiveness (MOEs) are required to better understand the performance of both exploiters / analysts and their supervisors. The MOEs shall be used to develop new wide area EO/IR and other sensor motion imagery data analysis techniques and approaches including addressing the level of motion imagery data fidelity sufficient for intelligence analyses from an analyst perspective. Additionally, the MOEs shall be used to assess progress toward the development of an effective analyses capability.

Exploitation and sensor management capabilities are expected to both benefit from and to contribute substantially to persistent surveillance capabilities. The impact of dynamic sensor cross-cueing and “tip-offs” and the integration of non-imagery products and data bases (e.g., social networks) can be expected to enhance the accuracy/pedigree, completeness, timeliness, and relevance of persistent surveillance-based intelligence products. Sensor cross-cueing (regardless of sensor type) would entail passing of spatial and temporal type of information to tactical operations centers, intelligence analysts and operators. Cognitively-based research is also required to better understand the

impact of persistent surveillance capabilities on human operator attributes to include confidence, avoidance of premature closure, and better information integration.

Analyst-aiding technologies which address data overload and/or multi-source integration will require research into the application of theory-based trust in automation models and metrics. These models and metrics are to be extended as necessary to meet the requirement of persistent surveillance.

PHASE I: Conduct applied cognitive-based research to define analyses approaches and techniques for wide area motion imagery (WAMI), and identify and define opportunities for analyst-aiding technologies where appropriate. Develop and apply MOEs to assess research progress and effectiveness.

PHASE II: Develop and demonstrate new WAMI data analysis approaches and techniques, and develop appropriate tools and capabilities integrateable into motion imagery exploitation and analysis tool suites like AFRL's Pursuer. Apply the cognitively-based MOEs to assess progress and effectiveness.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Near real-time intelligence, surveillance and reconnaissance exploitation; mission planning, target nomination, counter insurgency operations.
Commercial Application: Disaster response planning, management and execution; land use management; urban planning; disease management; multinational collaboration.

REFERENCES:
1. Deptula, D. A. and Francisco, M. (2010). Air Force ISR Operations: Hunting versus Gathering. Air & Space Power Journal, Winter 2010, pp. 13-17.
http://www.airpower.au.af.mil/airchronicles/apj/apj10/win10/2010_4_04_deptula.pdf

2. Price, S. C. (2009). Close ISR Support: Re-organizing the Combined Forces Air Component Commander's Intelligence, Surveillance and Reconnaissance Processes and Agencies. Naval Postgraduate School, Monterey, California. https://0-ww.hsdl.org/?view&doc=117677&coll=limited.

3. DARPA/IPTO (2010). Autonomous Real-time Ground Ubiquitous Surveillance - Imaging System (ARGUS-IS). http://www.darpa.mil/ipto/programs/argus/argus.asp.

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

5. Parasuraman, R., Sheridan, T.B., & Wickens, C.D. (2000). A model for types and levels of human interaction with automation. IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, 30 (3), 286-297.

KEYWORDS: situation awareness, near real-time intelligence production, analyst-aiding, persistence, surveillance

AF121-025 TITLE: Flexible Semi-Conformal Displays for Data Access in Military Field Operations

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop a precious metal-free, soft, thin paper-like flexible display that has fast color switching rate and is viewable under sunlight, for rapid data display in field operations: air/sea/land.

DESCRIPTION: Conductive polymer-based electrochromic devices have many attractive attributes such as being flexible, light weight and having low power consumption. Among their uses are sensors, smart windows, and flexible displays [1]. One of the most attractive electrochromic polymer conductive materials are Poly (3,4-ethylenedioxythiophene) (PEDOT) and its derivatives due to the high-contrast ratios and availability of many colors [2]. As demand for flexible displays for military use has increased [3], we focus on research for suitable nano-based materials for display application. Three challenging problems to address in developing materials for conductive

polymer-based flexible electrochromic displays are their slow color switching rate, governed by slow diffusion of counterions into the electrochromic material [4], color contrast [2], as well as the use of precious metals (e.g., gold) in the material's electrochemical synthesis process [1,4]. Ref.[5] has proposed a mechanism to synthesize PEDOT nanotubes that could achieve very fast switching rate/electrochromic responses (<10 ms) and simultaneously provide high color contrast. The PEDOT nanotubes were synthesized electrochemically in the pores of the alumina template film using this mechanism. The thin nanotube wall provided a very short diffusion pathway and thus reduced the diffusion time of the counterions dramatically. This method directly addresses the first 2 problems for this particular nanotechnology-based approach, but a weakness lies in the fragility of the alumina template used in the fabrication. Moreover, there's not a good solution shown in literature to address the third problem of avoiding use of precious metals for electrodes. Gold was a popular electrode choice in a number of studies in literature, but it is infeasible to use for large scale manufacturing and deployment for all practical purposes. This topic will investigate nanotechnology-based approaches that SHOULD NOT BE LIMITED to above-mentioned electrochromic-based methods, to obtain fast color switching, high color contrast and flexible displays that do not contain precious metal electrode such as gold/platinum. The flexible displays should afford economical manufacturing on a large scale.

Innovative solutions should therefore include the following properties: ability for base material (integrated with a low cost electrode) to provide flexibility without brittleness, for example, rolled up/out as desired without losing functionality; human-perceived acceptable contrast under different brightness of sunlight; screen transparency (applicable for window-type applications only); low power consumption; strength; light weight, and switching speed performance. Display should be able to withstand common field-encountered weathering effects, and view-ability should be night-vision compatible. The minimum acceptable thresholds for resolution should be: 320x240, and 4 bits per pixel for color resolution. Flexible displays will find applications such as augmented reality when displayed on aircraft windows, within pilots' cabin rolled out when displaying certain information/maps needed by the crew, and rolled up into thin tubes to be stored when not used; integration into pilots' garments, e.g., in sleeve areas/special eye goggles for convenient and quick retrieval/review of data during field operations, search and rescue missions, e.g., showing GPS information on garment sleeve as evader landed; and uses in night vision to facilitate data viewing under night flying/driving conditions.

PHASE I: Develop innovative flexible display material that integrates low cost electrodes with a flexible base material such as, but NOT LIMITED TO electrochromic/PEDOT. Contractor shall demonstrate comparable/better physical properties (property details are shown in "Description" Section) than similar devices containing precious metal electrode.

PHASE II: Contractor shall 1) select the best performing electrode material from Phase 1 for fabrication/testing of a bread board prototype flexible display; 2) develop a scalable manufacturing approach to fabricate pixilated displays of >= 3 by 3 inches on pilot scale, address issues related to scale-up and include cost for making/manufacturing the display; 3) fabricate small # (~12) of fully pixilated displays for AF testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Flexible display will support quick data viewing in field ops, night flying/driving conditions, on aircraft windows, rolled up/out as needed, in pilot garments, e.g., sleeve areas, goggles.
Commercial Application: Flexible display may support GPS screen in car windows, low powered electronic books/bill or ad boards, rolled out/up TV screens, info display in garments/shoes in front/back/sleeve areas.

REFERENCES:
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3. Chemical and Engineering News Magazine, Jan 10, 2011, pp. 20 – 21.

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KEYWORDS: nanotechnology, conductivity, display, polymer, flexible, resolution, contrast, viewable under sunlight

AF121-026 TITLE: Flightline Boundary Sensor

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a flightline intrusion detection sensor (IDS) delivering high probability of detection and low-nuisance/false alarms.

DESCRIPTION: The security of military aircraft at airfields has long been an important component of military forces around the world. One might think that since many of these sites are permanent facilities in the CONUS, then this issue could be easily addressed using today's advanced electronic security equipment. Unfortunately, the physical constraints associated with an active flightline make this problem difficult to solve. Ported coaxial cable sensors have been used in this application since their introduction in the 1970's. These sensors can be installed completely below grade, giving them a significant advantage over other technologies that require the installation of equipment above ground. Never-the-less, even ported coaxial cable sensors have encountered difficulties in maintaining acceptable nuisance/false alarm rates.

In most cases, critical assets are surrounded by a red line painted on the tarmac with onerous warning signs. The objective of the red line is to discourage unauthorized people and vehicles from crossing the red line. The objective of the IDS is to detect, in near real time, intrusions into the protected area on the flightline.

Typically, service vehicles and people have free access along a service road on one side of a huge rectangular perimeter surrounding the mass ramp containing all of the aircraft. Perhaps the most significant problem with flightline security intrusion detection is the fact that vehicular traffic moving along the service road can create a high number of nuisance alarms.

The primary objective is to correctly identify personnel and/or vehicles crossing the red line with a very high probability ($p>.97$) while minimizing false alarms potentially generated by personnel and/or vehicle movement within the protected area and/or external to the protected area. The false alarm rate should be $p<0.1$).

Other capabilities sought include deployment in distances greater than 100 meters, ignoring movement within the protected area, non-detection of targets moving from the protected area to the non-protected area, ability to adjust the size of the detection zone, and allowing certain areas to be designated as access points.

PHASE I: Prototype design and feasibility study of existing technology and commercial-off-the-shelf equipment to meet the requirements. Allow for minor modifications to COTS equipment to meet requirements. Testing of possible candidates and risk reduction studies relative to a potential Phase II.

PHASE II: Develop and demonstrate a full-scale prototype system in field conditions. The system shall be capable of operating in a working flight line environment and shall be electromagnetically compatible with the flight line environment. Special attention should be given to RF emissions and susceptibility.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Security Forces to use sensor on flightlines where it is needed.
Commercial Application: Possible use at nuclear power plants or other high asset facilities where perimeter abuts busy roads or thruways.. Perimeter security at industrial facilities, commercial airports, public transportation centers, etc.

REFERENCES:

1. Title: A Rapid Deployment Guided Radar Sensor-Presentation at International Carnahan Conference on Security Technology, October 2009 Zürich Switzerland. Authors: K. Harman, W. Hodgins, J. Patchell, M. Maki.

2. Title: Unattended Ground Sensor Technologies and Applications V, Edward M. Carapezza, Editor, Proceedings of SPIE Vol. 5090 (2003) © 2003 SPIE · 0277-786X/03/$15.00.

KEYWORDS: Intrusion Detection, Flightlines, Nuisance Alarms, False Alarms, Red Line, Ported Coaxial Cable Sensors, Perimeter Security Sensors, Perimeter Security Systems

AF121-027 TITLE: 3D Stereo Binocular Head Mounted Display (HMD) Technology for Joint Strike Fighter (JSF) Aircraft and Simulation

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Demonstrate the potential for 3D stereoscopic symbology to aid in decluttering dense information displays, calling attention to time critical information, and develop a proof of concept simulation.

DESCRIPTION: Head-mounted displays (HMDs) although in use for several decades now, have generally not taken advantage of 3D stereo capability to aid in decluttering of dense information displays. Although 3D stereo has been used successfully to some extent for visualization and entertainment purposes, this success has not carried over to military or commercial flight applications. The JSF HMD is a binocular, but non-stereo, HMD that could potentially be modified to exploit the use of 3D stereovision. The results of research on the use of 3D stereo for these types of applications has been mixed; thus, the objective of this topic is to identify specific applications where 3D stereo results in improved performance, experimentally demonstrate improvement in performance, and develop a proof of concept device. To be successfully implemented, it must also be demonstrated that the proof of concept device does not introduce eye-strain or discomfort.

PHASE I: Provide a technical report and preliminary experimental data demonstrating the feasibility of the concept.

PHASE II: Phase II will result in prototyping, demonstrating, and testing the concept proposed under Phase I and a technical report. The prototype device will be delivered to the Air Force for further research and evaluation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include both training and simulation as well as operational weapon systems, notably the JSF.
Commercial Application: Commercial applications include commercial aviation training & operational systems, as well as the entertainment and visualization industries.

REFERENCES:
1. Melzer, J. E., and Moffitt, K. "HMD design – Putting the user first". In J. E. Melzer and K. Moffitt (Eds.), Head mounted displays: Designing for the user. New York: McGraw-Hill, 1997, pp. 1–16).

2. Steiner, B. and Dotson, D. (1990). The use of 3-D stereo display of tactical information. Human Factors and Ergonomics Society Annual Meeting Proceedings, pp. 36-40.

3. Velger, M. (1998). Helmet-mounted displays and sights. Boston, MA: Artech House.

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KEYWORDS: Head-mounted display, HMD, 3D, stereoscopic, displays, declutter, information display, JSF, simulation

AF121-028 TITLE: Measurement of Interpupillary Distance for Binocular Head-Mounted Displays (HMDs)

TECHNOLOGY AREAS: Biomedical, Human Systems

OBJECTIVE: Research and demonstrate the effectiveness of incorporating automated measurement of interpupillary distance for rapid individual customization of binocular Helmet-Mounted Displays (HMDs) used in the Joint Strike Fighter and simulated flight trainers.

DESCRIPTION: The development of technology to quickly and easily customize an HMD based on an individual's interpupillary distance (IPD) would reduce the time it takes to fit an HMD to a user, and would aid in the implementation of both dynamic vergence, and 3D stereoscopic information display using HMDs. Proper adjustment based on an accurate measurement of IPD may reduce the potential for eyestrain and discomfort, and would improve the accuracy of perceived depth for imagery displayed on the HMD. An individual's IPD is typically measured using a pupilometer, which requires a 2nd individual to perform the measurement on the subject. Current methods of implementing dynamic vergence correction require pupilometer measurements to be made manually for each individual user, greatly increasing the time required to fit an HMD to a user. This problem is compounded when multiple users with different IPDs are required to use the same simulator in succession. The objective of this topic is to research innovative methods for rapidly measuring IPD, incorporating that measurement into the adjustment of a binocular HMD, and generating imagery which is properly adjusted for stereoscopic depth for a particular individual. It is preferred that this method be fully automated and rapidly implemented by a single user, and require no additional/specialized training to implement, such that a user may don the HMD and rapidly begin using the system without concern for IPD measurement (i.e. a user's IPD would be immediately and automatically measured, and the system would adapt accordingly). Accuracy of the proposed solution should be comparable with the accuracy achieved by standard pupilometer measurements; the required frequency of measurement will likely depend on the solution proposed. There are currently no known solutions which meet this intent. Human factors experimentation will be required to demonstrate the effectiveness of the proposed solution (e.g., fitting time of the HMD, effect on user comfort, and accuracy of dynamically adjusted HMD imagery).

PHASE I: Provide a technical report demonstrating the feasibility of the concept. The report should detail the proposed methods & technology implementation, and include a description of the human factors experimentation proposed to demonstrate effectiveness of the solution. It is highly desirable that a technology demonstration and/or preliminary experimental data be presented at the conclusion of phase I.

PHASE II: Phase II will result in prototyping, demonstrating, and testing the solution proposed under Phase I, to include human factors experimentation using the prototype device. A technical report will also be produced describing the technology implementation and detailed analysis of the human factors data collected. The prototype device will be delivered to the Air Force for further research and evaluation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Customization of binocular HMDs based on individual IPD would have military aviation applications in both simulation and training as well as operational weapon systems.
Commercial Application: Applications include commercial aviation for both training and operational systems, as well as additional applications in the entertainment and visualization industries.

REFERENCES:
1. Dodgson, N., "Variation and extrema of human interpupillary distance," Stereoscopic Displays and Virtual Reality Systems XI, Proceedings of SPIE, Vol. 5291, 2004, pp. 36-46.

2. Melzer, J. E., and Moffitt, K. (1997). HMD design – Putting the user first. In J. E. Melzer & K. Moffitt (Eds.), Head mounted displays: Designing for the user (pp. 1–16). New York: McGraw-Hill.

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4. Browne, M., Moffitt, K., and Winterbottom, M. (2009). Improving the Utility of a Binocular HMD in a Faceted Flight Simulator. Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

5. Browne, M., Moffitt, K., and Winterbottom, M. (2008). Vergence Mismatch Effects in a Binocular See-through HMD. Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

KEYWORDS: head-mounted display, HMD, interpupillary distance, IPD displays, information display, dynamic vergence

AF121-029 TITLE: Network Threat Monitoring, Intrusion Detection, and Alert System for Live, Virtual, and Constructive (LVC) Operations for Space Training

TECHNOLOGY AREAS: Information Systems, Space Platforms, Human Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: To develop an embedded network threat monitoring system that can be used to constantly detect intrusion attempts across LVC network enterprises and provide alerts and protection for integrated live systems partners and players.

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

The capability to provide real time network intrusion and attack detection, diagnosis and inoculation of ongoing network threats during an interactive simulation to live systems lash up does not exist today. Phase III Dual Use potential is significant since both the military and commercial sectors have devoted considerable resources to the development of highly complex operational systems based on network architectures. Reengineering systems to have the capabilities proposed to be developed in this effort is cost prohibitive, whereas developing this capability as one that can be added to existing LVC network systems is much more cost effective and flexible and will result in substantial savings to units in the field. The capability to provide real time network intrusion and attack detection, diagnosis and inoculation of ongoing network threats during an interactive simulation to live systems lash up does not exist today.

PHASE I: Phase I will develop a prototype intrusion detection and alert tool for a DIS-compliant LVC space environment and provide a demonstration and report.

PHASE II: Phase II will result in a fully integrated network monitoring, intrusion detection, and attack avoidance capability which is usable in real time in a space LVC environment and which provides the capabilities outlined above. It will also result in test and evaluation of the developed tool and will provide documentation of results in a technical report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Phase III Dual Use potential is significant since both the military and commercial sectors have devoted considerable resources to the development of highly complex operational systems based on network architectures.
Commercial Application: Reengineering systems to have the capabilities proposed to be developed in this effort is one that can be added to existing LVC network systems and is cost effective and flexible and will result in substantial savings to units in the field.

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KEYWORDS: live, virtual, and constructive (LVC) training, distributed mission operations, network threat assessment, network enterprise alert, LVC training effectiveness, LVC network enterprise security, DMO training effectiveness, DMO network security

AF121-030 TITLE: Agent-Based Objective Performance Measurement Brief/Debrief and After Action Review Suite for Cyber Warfare Training

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop an agent-based brief/debrief suite that provides cyber operators with objective feedback and after action review (AAR) capabilities for team and individual training.

DESCRIPTION: The recent STUXNET virus that disabled an Iranian Nuclear Power Plant, limiting Iranian nuclear capabilities, provides a current example of the far-reaching ramifications of cyberspace warfare and foreshadows the digital conflicts to come. Cyberspace operations are the virtual front line in the way the Air Force currently does and will fight wars for generations to come. Recognizing this, the mission of the United States Air Force now includes flying, fighting and winning in the cyberspace domain. In order accomplish this mission, the Air Force is quickly building a cadre of cyber warriors. Robust training capabilities like those in place in other air and space platforms need to be developed and applied to this vital war fighting domain. Training capabilities are needed for briefing, debriefing, and providing AAR in the cyberspace domain. This effort will develop a tailorable brief, debrief, and AAR tool suite that captures team and individual performance from cyber training events. Furthermore, an agent-based model built into the architecture of the suite will aide instructors with trend analysis, recommendations and improvement of future training scenarios. Tools to be developed in the suite should include, but are not limited to, visualization and playback capabilities, real-time scoring and post-event data analysis to aid instructors in

developing and leading AAR, as well as an information repository for future reference. This suite of tools will facilitate improved training performance, decision making, and knowledge sharing across the cyberspace career field.

PHASE I: Will focus on one cyber mission area. Agent-based objective measures of learning and performance will be defined and developed. Preliminary design specifications for the major components of the suite will be defined and demonstrated in a proof-of-concept.

PHASE II: Will fully develop, apply, test, refine, and validate the suite of tools to include the assessment methods for the mission area identified in Phase I. Additionally, two more cyber mission areas will be identified and measures and interfaces will be developed and demonstrated. The common approach, methods, and metrics will be fully documented to show how the tool suite could be modified and applied to remaining cyber teams.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The success of the Military is directly tied to the success of its networks. Cyber warfare training is not service specific; an objective performance measurement tool for cyber warfare training could be deployed throughout the Department of Defense.
Commercial Application: The Banking, Utility, and Telecom industries suffer from a lack of cyber warfare expertise. An objective performance measurement tool for cyber warfare training could be used to prepare a workforce to protect commercial networks.

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2. Cyber Space Policy Review (2009). “Assuring a trusted and resilient information and communications infrastructure.” The White House, Washington, D.C. Retrieved from: http://www.whitehouse.gov/assets/documents/Cyberspace_Policy_Review_final.pdf

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KEYWORDS: cyber training, agent-based models, after-action review tools, knowledge and skill assessment, embedded performance assessment, performance measurement, readiness evaluation, individual and team effectiveness

AF121-031 TITLE: Enhancing Decision Making through Adaptive Trustworthiness Cues

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To develop a capability to enhance decision making through the application of trustworthiness cues embedded in adaptive user interfaces.

DESCRIPTION: During military operations, there is a need to make quick decisions to uphold a tactical advantage, maintain safety, and accomplish mission directives. Nowhere is this more pressing than in cyber operations where

operators need to assimilate large amounts of information and make decisions where the subsequent consequences may not be fully understood. These decisions can be based on complex and dynamic information sources for which uncertainty exists about the quality of data presented. It is these types of situations that knowledge is needed about what data to trust (Wang and Emurian, 2005) because of the ability of perceived trustworthiness to act as a strong cue that influences the quality of decision-making (Van't Wout & Sanfey, 2008). Unfortunately, decision makers are presented with information in such a way that this vital information is rarely portrayed. Similarly, decision-aiding systems can provide recommendations about a course of action to take, but more sophisticated aids are aware of their confidence in their recommendations and need to convey this to the human operator as well.

Strategies and interface tools are needed that provide effective conveyance of trustworthiness information in order to build accurate and reliable human + machine trust and behavior (Hoffman et. al., 2009). Simply conveying the machine's confidence level or perception of information certainty and trustworthiness may be neither the most efficient nor the most effective means of obtaining accurate trust and improved performance from the human and machine team, regardless of the innovativeness of the user interface. Instead, recent research on the creation (and destruction) of trust in machine systems must be taken into account to close the loop—and thereby provide an adaptive system which takes into account the human's potential over or mistrust response in how it conveys recommendations (Bisantz & Seong, 2001).

Trust is a complex concept that can be influenced by many different factors, thus requiring a multifaceted approach (Oleson, Billings, Kocsis, Chen & Hancock, 2011). The addition of trustworthiness information will clarify the relevance and limitations of information used to support a decision by diminishing cases where action is based on incomplete or uncertain information, and suggesting ways to improve the provision of data to support the decision.

PHASE I: Provide design and demonstration of the methods, strategies, or tools for adapting a presentation to yield effective and calibrated trust. May include application and scenario development to support the identification and metrics for assessing trust. Methods for assessing the benefit of information trust levels should be documented, including measures of effectiveness and measures of performance.

PHASE II: Develop and demonstrate a prototype system based on the preliminary design from Phase I. All appropriate testing will be performed along with a critical review to finalize the design. Evaluate trust, workload and usage decision impacts in experimental trials with reasonable face validity.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications of this technology range from high tempo and criticality situations such as command and control and weapons release to situations of comparatively reduced criticality such as intelligence interpretation and cyber security.
Commercial Application: Commercial applications can be as critical (commercial aviation, industrial processing, energy generation and transport) as well as more ubiquitous (e.g., deciding whether a given email is a phishing attempt or not).

REFERENCES:
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KEYWORDS: trust,decisionmaking,human-machinecollaboration

AF121-032 TITLE: Efficient Computational Tool for RF-Induced Thermal Response

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a fast approach for predicting whole-body and localized thermal response of tissue due to RF exposures.

DESCRIPTION: Electromagnetic devices are used increasingly in society, with applications in communication, medicine, security, and defense, among other disciplines and technology areas. This has led to a great deal of research regarding the safety and potential health hazards of such devices. To aid in this study, sophisticated computational electromagnetic software tools have been created. These tools have been crucial to the development of international safety standards, and for compliance testing of new technologies with respect to these standards. For radio frequency (RF) exposures, the standard is typically a limitation on the specific absorption rate (SAR) in units of watts per kilogram. Alternatively, electromagnetic power density limits may be used for simplicity. The rationale behind SAR-based exposure limits is to minimize the risk of thermally induced adverse biological effects.

To further study RF-induced thermal effects, researchers have recently developed modeling tools capable of predicting temperature effects in realistic digital human models. These tools are useful for high-fidelity and high-resolution analysis of core-body and localized temperatures during RF exposure. These simulations, however, can be very computationally expensive and are generally useful for only a small subset of possible exposure conditions. Specifically, high fidelity voxel models may be used to predict the temperature evolution within the body while accounting for non-uniform SAR distributions. To fully capture SAR "hotspots" and therefore maximum local temperatures, a voxel resolution of 2 mm or finer is often required, resulting in simulation runtimes of up to several hours for many cases. Therefore, predicting the range of potential thermal outcomes due to thermoregulatory variability across a population of people may be time prohibitive.

To mitigate the computational burden of whole body thermal simulations, several approaches may be taken. These approaches can be broadly categorized into two primary methods: 1) Hardware acceleration techniques (such as GPGPU) may be used to create very high throughput thermal models and 2) heuristic or analytical approximation techniques may be used to estimate temperatures across a range of possible exposure/environmental conditions and human thermal capacities. A combination of these two approaches may also be considered. For example, computational models may be used to determine semi-analytical temperature response curves, and Monte Carlo-type simulations may then be used to predict the range of possible thermal outcomes.

The ideal solution should be able to simulate the evolution of temperature within digital human anatomical models at 2mm or finer resolution. For hardware accelerated techniques, such as porting computation to a Graphics Processing Unit, simulation speed should be on the order of 100x faster than comparable CPU simulations. Runtimes to simulate a one minute long RF exposure would therefore be on the order of seconds up to a few minutes. Analytical or semi-analytical techniques should seek to provide temperature predictions across a range of individuals or exposures in near real-time, i.e. a few seconds or less.

Biomedical scientists, health and medical physicists, and bioenvironmental engineers would all benefit from software that enabled efficient thermal simulations for RF exposures.

PHASE I: Determine the computational methods to be used, and develop prototype software that illustrates the effectiveness of the chosen method. The prototype software should illustrate the ability to predict both whole body and localized temperatures over time. Simulation runtime and model fidelity will be the metrics of success.

PHASE II: Extend the software created in Phase I to allow for a broad range of exposures. The software output should include both whole body and tissue specific thermal response. A user interface should be included for creating simulations and viewing results. Also during Phase II, the software should be fully developed and

optimized with respect to computational runtime. Finally, a validation of the developed software should be performed against empirical data.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Use by engineers and health physicists to study risks of accidental RF overexposure. Used by Air Force to predict potential of overexposure during engagement of novel directed energy systems.
Commercial Application: Use by engineers and health physicists to study risks of accidental RF overexposure. Use in hyperthermia treatment applications. Use in human thermal comfort research.

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KEYWORDS: computational modeling and simulation, radio frequency, thermal modeling, GPU, Graphics Processing Unit

AF121-033 TITLE: Discourse Analysis for Insights into Group Identity and Intent

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop techniques for improved extraction and interpretation of discourse related to social identity, social categorization, and moral disengagement.

DESCRIPTION: Discourse provides a window into the proverbial heads of an individual and a group, reflecting how they view themselves and how they view the world. As part of an integrated methodology to fully assess and exploit our understanding of the patterns of life, discourse provides a mechanism to identify leading indicators of hostility, and this, in turn, would provide a powerful mechanism to cue, collect and interpret other direct and indirect sensor data. For example, through discourse, individuals will provide signals related to the various mechanisms related to moral disengagement (e.g., use of language and images which dehumanize them).1 Discourse provides the understanding of values, attitudes and group norms (all key elements of how group social identity is constructed)2 critical for reasoning about current and likely future behaviors and ultimately group intent. Without this understanding, analysts will always be reactive versus proactive. While many people are focused on sentiment analysis (largely through an aggregated analysis of good and bad words as identified by Subject Matter Experts) as sufficient to assess mood or attitudes, this does not focus on group identity and thus does not provide the necessary information to reason about intent. However, previous efforts by both DARPA (under the "Automated Sentiment Analysis" seedling effort) and previous AFRL efforts: Analysis of Discourse and Discursive Practices for Indications and Warnings 3 and Taliban Pashto Discourse Analysis have resulted in some foundational capabilities in terms of automated approaches for extraction of sentiment based on the context of who is speaking about whom/what and methodologies for extracting and interpreting in-group/out-group discourse and assessing integrative complexity4,5 (integrative complexity can be used to assess the likelihood of conflict/hostility as well as cooperation, so applicability is throughout the spectrum of conflict). The former is semi-automated, but does not focus on group identity and intent while the latter provide techniques for both exploiting information related to group identity and inferring intent (integrative complexity).

Proposals are sought for innovative mixed initiative techniques (methodology and semi-automated processing) to combine the ability to extract information related to group identity, attitudes with the ability to support reasoning about group intent. Proposals may focus on improving techniques in semi-automated processing (text analytics) individually; however, novel ideas that would lead to the development of a mixed initiative (human/computer) with

both semi-automated processing of discourse and improved methodologies for interpretation, inference and analysis is not only encouraged, but desired. Note that this topic is in the key technology areas of human systems (system interfaces and cognitive processing) and information systems technology (knowledge and information management) with the human systems technology area being primary.

The evaluation should evaluate both the semi-automated processing, but the ability to support improved analysis. The mechanism to do that will be to have a comparative analysis of the processed output, a manually coded output for analysis with and without the integrative complexity scoring method. Due to the short time period of Phase I, it is preferable that currently available databases be used in the evaluation.

PHASE I: Identify discursive mechanisms, techniques for extracting information about group identity, and indicators of moral disengagement. Develop innovative techniques for group identity centric text analytics and evaluate their performance for a single language and a single domain.

PHASE II: PHASE II: Further develop the proposed techniques and evaluate their performance for multiple languages and/or domains/groups to show the generality of the techniques. The evaluations should follow the same format as described under the Phase I description but for the new languages and domains. Any databases collected for development and/or evaluation should be delivered to the contract sponsor.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include, Anticipatory ISR (e.g, Indications and Warnings (I&W), COA analysis for Effects Based Approach to Operations, Stabilization and Reconstruction Operations (i.e., conflict resolution, negotiations).
Commercial Application: Commercial applications are similar to military applications but generally for different domains, such as: law enforcement, business (negotiations).

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KEYWORDS: social identity, moral disengagement, social categorization, text analytics, discourse analysis, sentiment analysis

AF121-036 TITLE: Ultra-Fast Transfer Techniques to Download Data

TECHNOLOGY AREAS: Information Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop technology for high speed transfer of data from solid state storage media to a secondary storage media.

DESCRIPTION: Numerous data acquisition systems are generating more and more data every year. This growth is exponential with both the greater bandwidth and acquisition speed of the devices increasing combined with greater numbers of these devices available for installation. Typical data rates are approaching 9Gigabytes per second. Large solid state disk (SSD) arrays are utilized to store this data. After a period of data acquisition, it is necessary to download the data for analysis. Presently, flash-memory-based SSDs are available with data transfer rates of 768 Megabyte per second interface data transfer rate. This results in a ratio of approximately 1.4 hours required for download of the original 1 hour data collection period accumulated data. There is a significant lag in data availability when accessing data collected by persistent acquisition system. In addition to the time lag, there is, with present practice of physically removing the SSDs from the acquisition system and installing into data extraction system there is a limited number of install/remove cycles possible. This is a material issue resulting from the handling involved.

This SBIR seeks to develop a novel approach, architecture, and design for transferring large quantities of collected data from the data acquisition system storage-area to post-processing storage-area and onto a network server at half the time it took to acquire and store the data within the acquisition system. Approaches may include, but are not limited to hybrid realtime and offline data downloading approaches, highly-parallel offline data transfer systems using novel hardware and software optimizations. A limiting factor is that in some instances, the realtime data extraction and transmission is necessarily of secondary priority to delivery of data to an end-user, i.e. may not be optimal data transfer rate at all times.Equally acceptable would be development of a new sustained high-speed read/write SSD chip architecture allowing increased interface data transfer rate.

PHASE I: Develop a novel approach with sufficient architecture and design detail (to include detailed analysis) to show approach feasibility.

PHASE II: Develop a detailed design and prototype of the hardware/software/algorithm constituting the approach and architecture and demonstrate its effectiveness in downloading imagery data to a storage facility and network server.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Near real time intelligence, surveillance and reconnaissance exploitation across multiple sensor domains; possible new anti-tamper implementation.
Commercial Application: Faster large volume movie copying, improved computer data storage and access systems, improved high performance data access layers and retrieval.

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2. F. Chen, D. A. Koufaty, and X. Zhang, “Understanding intrinsic characteristics and system implications of flash memory based solid state drives,” in ACM SIGMETRICS, Seattle, WA, Jun. 2009.

3. http://storageconference.org/2011/Papers/Research/2.Huang.pdf (paper title: Performance Modeling and Analysis of Flash-based Storage Devices).

KEYWORDS: high speed data transfer, data transfer parallelization, high performance data access layers

AF121-037 TITLE: Next Generation Mobile Ad-hoc Networking (MANET) for Aircraft

TECHNOLOGY AREAS: Air Platform, Information Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Development of next generation Mobile ad-hoc Networks (MANET) for airborne nodes in complex operating environments.

DESCRIPTION: Current military operating forces consist of a complex mesh of next generation unmanned aircraft, rapidly deployable advance strike and stealth capabilities, ballistic missiles and legacy aircraft systems. Combined with complex operating environments consisting of contested Radio Frequency (RF) communications and cyber intrusions, these situations are difficult to pre-plan from an RF mission preparation perspective and even more difficult to implement as intended. Users may be left to fend for themselves as static operating channels are lost to signal interference and protocols are non-existent for routing of mission-critical information back to the Global Information Grid (GIG).

Next generation airborne networking protocols and network management tools are needed to reduce the network overhead and pre-planning necessary for these complex missions while ensuring the reliability and bandwidth affordability necessary for modern military networks. A solution is needed which implements the MANET construct while minimizing network overhead for small to medium sized operational networks (10-100 participants). Such a protocol should consider memory and processing limitations of legacy aircraft while addressing needs of next generation wireless communications systems.

Such a network, in addition to being robust to interference, jamming and other complex operating environments, should also exhibit Low Probability of Detection / Low Probability of Interception (LPD/LPI). Such considerations may include dynamic power adaptation, multi-hop routing, spread spectrum, Multiple Input Multiple Output (MIMO) or other means which may be included in the MANET development. Each user's seamless entry and exit of the self-configuring multi-hop network must also be considered, including network management in a constantly changing topography.

This solution should support a DoD/USAF requirement for a networking waveform to allow connection of a large number of mobile/airborne platforms to the GIG and each other without being limited by pre-configurations or having network management utilize a high percentage of the available bandwidth.

PHASE I: Perform a technology feasibility assessment and deliver a simulation of the proposed MANET solution via OPNET, NS2, or other appropriate method. Also, develop a brief outline of a Phase II effort.

PHASE II: Construct and demonstrate a MANET solution system for airborne nodes in a laboratory environment. Use hardware-in-the-loop with simulation environment and prototype system to demonstrate scalability of solution.

PHASE III DUAL USE APPLICATIONS:
Military Application:
Adapt the MANET solution to an airborne prototype with complete operational compatibility to validate performance characteristics of the developed system.
Commercial Application:
Research could likewise improve robustness, bandwidth requirement, and network formation times for commercial aircraft MANETs.

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2. Mueller, S.; Tsang, R.; Ghosal, D., “Multipath Routing in Mobile Ad Hoc Networks: Issues and Challenges,” Performance Tools and Applications to Networked Systems, Volume 2965, 2004.

3. Szczodrak, M. and Dr. Kim, J., “4G and MANET Wireless Network of Future Battlefield,” Department of Mathematics and Computer Science, John Jay College of Criminal Justice, The City University of New York, New York, NY 10019 USA.

KEYWORDS: Mobile ad-hoc network, global information grid, radio frequency communications, network management

AF121-038 TITLE: Joint Aerial Layer Network High Capacity Backbone Antennas

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop directional antennas for installation on space, weight and power-constrained platforms to support high-capacity point-to-point and point-to multi-point communications in airborne networks.

DESCRIPTION: Future Joint Aerial Layer Networks (JALN) (Ref. 1) will be composed of airborne, surface and ground-based nodes interconnected by Line-of-Sight (LOS) omni and directional radio and satellite links. Many of these nodes will be mobile and constrained by available space, weight and power availability, especially in the case of small unmanned drones. In addition to point-to-point connectivity to a single neighboring platform, some nodes will be capable of simultaneous connections to multiple neighbors. Antenna configurations supporting persistent or virtual point-to-multi-point connectivity between network nodes will allow the formation of a rich set of airborne network connectivity topologies.

Technical challenges in this technology include size constraints, conformal profiling to the platform, operation over extended frequency ranges, and operation within acceptable co-site interference levels. The effort should first focus on directional antennas for the existing CDL frequency spectrum (14.5 - 15.5 GHz). However, providing High Capacity Backbone connectivity at data rates, e.g., 274 Mb/s, in networks with more than just a few nodes, will require investigation of operation into multi-spectral CDL regions (UHF, L, S, C, X, upper Ku, Ka). The Air Force is currently investigating approaches to multi-spectral CDL capability.

Antenna designs should be capable of supporting both persistent, synchronous (CDL-type) connections as well as virtual connections formed by directional time division multiple access (DTDMA) protocols. A tradeoff between these two technologies (synchronous, persistent CDL links vs. DTDMA time slot allocations) and their supporting technologies is required.

The contractor will explore and analyze antenna and diplexer technologies that will enable rapid pointing, acquisition, tracking, and frequency change agility while mitigating cosite interference effects. A family of directional antenna designs may be defined, each supporting its own frequency band(s) of the overarching multi-spectral CDL set of bands. The contractor will analyze the expected performance of each family member with estimates of their beam gain patterns, side-lobe structures, etc. over their assigned frequency range of operation. The contractor will illustrate the installation of antenna family members, based on frequency selection, on selected airborne and ground vehicles. These antennas should be interoperable with existing synchronous (e.g., Common Data Link) and directional TDMA (e.g., Highband Networking or C4ISR Radio) radio terminals. This interoperability will enhance the probability of technology transition to a prime contractor.

PHASE I: Analyze shortcomings of past directional antenna efforts to achieve high-bandwidth, long-range, low SWAP directional antennas. Evaluate recent advances in antenna technology to achieve the objectives described above. Propose novel concepts for antenna design and evaluate performance characteristics by simulation.

PHASE II: Develop , test and demonstrate prototype directional antennas operating over the CDL frequency range plus multi-spectral (UHF, L, S, C, X, upper Ku, Ka) bands where feasible. Make modeling modules (e.g., STK, Opnet) available for third party analyses. Collaboration with directional terminal developers is desirable to facilitate transitioning of the technology.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: There are numerous military applications for lightweight, directional, frequency agile, conformal antennas on land, air and sea vehicles for communication networks as well as point-to-point links.
Commercial Application: Directional antennas will find commercial application the area of networking between commercial airliners and airborne internet access (especially over oceans).

REFERENCES:
1. Initial Capabilities Document for Joint Aerial Layer Network, v1.65, 26 March 2009.

KEYWORDS: directional antennas, airborne networking

AF121-040 TITLE: Cloud/Grid/Virtualization Architecture for Air Force Weather

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Evaluate advanced cloud technologies against the variable performance needs of Joint Environment Toolkit to provide an elastic deployment of Air Force Weather Servers and be a pilot for other DoD enterprise-based programs.

DESCRIPTION: Perform a study of the application of cloud computing, utilizing concepts drawn from grid computing progress and taking advantage of advances in virtualization techniques, to address the variable performance needs of globally distributed system configurations such as the Operational Weather Squadrons (OWS). Use the requirements and architecture/design of Joint Environment Toolkit (JET) to determine what is the optimum cloud computing strategy and related technologies that would address the variable performance needs by providing an elastic deployment of Air Force Weather Servers. Direct access to the JET database will not be necessary, though more detailed information about the JET architecture can be made available after contractor selection.

The current proposed implementation for JET Increment 2 requires that servers at six globally distributed Operational Weather Squadrons (OWS) be able to each handle peak demand of weather analysis and forecast information from the 30-40 Weather Flights plus potentially 1000 or more other operational users within their area of responsibility. For this scenario, either enough computer servers must be purchased for each OWS to meet their peak demand or the capabilities provided to the users reduced. Another option is to consider shared resources among the different OWS sites. This option will be examined by evaluating the potential application of distributed databases and private/hybrid cloud computing systems for producing and disseminating Air Force weather information across the enterprise, in order to efficiently size the hardware requirements for JET at the OWSs and also provide for limited or no degradation of capabilities to the Weather Flights and other operational users in the event of the interruption of services at an OWS.

This approach will match well with the recent Air Force Chief Scientist’s Report on Technology Horizons, which emphasizes a switch in emphasis toward more agile, composable, and fractionated or distributed systems for the future, with a need for cyber resilience. A cloud computing platform could also address the need to switch from a platform emphasis to a capabilities emphasis.

A successful solution to this topic would allow Air Force Weather to purchase a more economical number of JET servers by leveling their demand across the globe while maximizing capabilities provided to the users. It is unlikely that all six OWSs will be subjected to maximum demand of their services at the same time. For example, if during the morning in Germany the 21st OWS needs more server capacity than is locally available it could seek to use spare servers at another OWS, such as the 17th in Hawaii where it would be the middle of the night. Additionally such a computing architecture could allow the OWSs to easily adapt to the locally changing levels of user demand based on strategic and tactical demands (e.g. hurricane rescue operations, unexpected threat events in different parts of the world). In addition to addressing pressing Air Force Weather needs, results from this effort could serve as a pilot study for implementation in other enterprise-based programs at the Electronic Systems Center (ESC) and across the DoD.

PHASE I: Document preferred cloud computing strategy for multiple data processing/storage hubs such as JET OWSs based on potential cost savings, mission enablement, information technology operating efficiencies, and optimization of resources. Examine the potential benefits of commercial-off-the-shelf and open-source solutions.

PHASE II: Develop the applicable reference model and architecture aligned to industry standards; design a cloud solution for a system of data processing/storage hubs addressing security, interoperability, and portability issues; provide a proof of concept prototype; and finally provide appropriate test results and quality assurance that the architecture could be successfully implemented for an operational system.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Proposed architecture would be implemented for a future JET Build and adapted for other similar ESC enterprises (e.g., Mission Planning). JET implementation could be expanded to other Air Force Weather product generation and dissemination systems.
Commercial Application: Proposed architecture would have application to enterprises that monitor weather data or are involved in the collection and dissemination of information through several hubs to and from many users such as transportation and utility companies.

REFERENCES:
1. Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R. H., Konwinski, A., et al. (2009). Above the clouds: A Berkeley view of cloud computing. University of California at Berkeley Technical Report No. UCB/EECS-2009-28. Retrieved from http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.html.

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3. Greenfield, T. (2009). Cloud Computing in a Military Context. DISA Office of the CTO. Retrieved from http://www.au.af.mil/au/awc/awcgate/disa/cloud_computing_military_context.ppt.

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KEYWORDS: keyword1: cloud computing, keyword2: weather, keyword3: distributed computing, keyword4: distributed system economics

AF121-041 TITLE: Directional Partial Mesh Airborne Networking

TECHNOLOGY AREAS: Information Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of

foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an Airborne Mesh Network capability that;
Utilizes directional antennas, utilizes Time Division Multiple Access (TDMA) and potentially Frequency Division Multiple Access (FDMA), maintains backward compatibility with legacy terminals.

DESCRIPTION: Within airborne networks, directional links are desirable due to their increased range, capacity, and Low Observable (LO) capabilities. In order to form a network from these point-to-point links, past waveforms have utilized a linear network topology with each network participant having just two links (i.e. MADL, CDL). This topology is well suited for a network with a limited number of nodes. However as the network size increases, this topology is undesirable due to the linear increase in latency and the amount of bandwidth consumed by relaying traffic over multiple hops. Additionally because each point-to-point link is critical in preventing network segregation, a linear topology can pose network reliability issues.

There is a push to create a more fully connected airborne network. However, it is unfeasible for all platforms to simultaneously abandon their existing air-to-air communication capabilities in favor of a more scalable directional mesh waveform. Therefore, it is desirable to explore methods to evolve current linear topology networks into partial mesh networks. A critical part of this evolution is backwards compatibility with existing terminals which are only capable of linear networking. These existing terminals should be capable of existing anywhere within the partial mesh network and not be limited to the network edge.

PHASE I:
1. Identify conceptual approaches to a Directional Partial Mesh Network.
2. Identify and define the preferred approach through modeling, simulation and analysis.

PHASE II: Develop, demonstrate and validate protocols, algorithms, and simulation software to implement the selected Phase I approach. Technical data will be provided to the offeror if needed for successful completion.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Increase the number and types of platforms able to connect into the airborne network. Improve the throughput, latency, and reliability of existing airborne networking technologies.
Commercial Application: Results from this work have applicability to cellular telephone and data networks, to vehicular networks, and to WiFi networking technologies.

REFERENCES:
1. Padjen, Robert, and Todd Lammle. "Chapter 1 - Introduction to Network Design". CCDP: Cisco Internetwork Design Study Guide. Sybex. 2000.

2. Adibi, Sasan, Amin Mobasher, and Mostafa Tofighbakhsh (eds). "Chapter 8 - Fourth Generation Networks—Adoption and Dangers". Fourth-Generation Wireless Networks: Applications and Innovations. IGI Global. 2010.

KEYWORDS: tactical networking, MANET, airborne networking, directional datalink, mesh networking, distributed decision-making,directional mesh waveform

AF121-042 TITLE: V/W Band Airborne Radomes

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors

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foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Development of a low loss, high reliability radome for V/W band frequencies suitable for airborne communication systems.

DESCRIPTION: Communication systems are faced with the challenge of congested and decreasing spectrum. To address this concern there is increased interest in the use of higher frequencies for communications. A radome at these frequences is a technical challenge and will need maturation.

The radome mechanically protects the antenna and terminal electronics from the outside environment. In addition it has critical electrical performance parameters to ensure the communication signals pass through unperturbed. Careful trade-offs must be made between the mechanical constraints on the aircraft and the electrical performance of the radome at these high frequencies. This development effort focuses on the development of an airborne radome and its associated material properties for operation at 71 to 76 GHz (receive) and 81 to 86 GHz (transmit). The radome could be used for such ISR collection platforms such as Global Hawk, U2 and Predator. However use on fast movers should also be considered.

The mechanical properties of the materials are an important consideration. Typically a fiber/resin composite is employed. The mix of fiber to resin is important as well as the thickness. For airborne applications, at altitude, any moisture in the radome will freeze and expand leading to micro cracking in the radome. Advanced materials may be an option, but they must be resilient to bird strikes, etc. The durability of the material over the life is a consideration that is often overlooked, and will be addressed under this effort.

The dual frequency band nature of the radome enables the designer to optimize one band over another. For this high frequency application, losses are greater at the transmit band and therefore minimizing the losses through the radome at the highest frequencies is the most critical. Additionally the radome curvature is a factor in both the mechanical integrity of the radome as well as the electrical losses. Typically the radome has curvature for aerodynamic performance. The antenna underneath, as it turns, will impinge on the radome at different incident angles. Multiple techniques have been employed to improve the electrical performance through high curvature regions of the radome, including tapering the radome wall thickness. Innovative approaches will need to be explored to meet the desired insertion losses at these frequencies.

Finally, the manufacturing processes are continually advancing. The frequency of operation is high, and therefore the manufacturing tolerances for this radome development will be very tight. Consideration will be given to whether the processes are in place to support a radome design at these frequencies.

PHASE I: Study/design the radome that is optimum for the goal of low cost in production. The study will include both large and small radomes (assumes reflector antenna). Detail the design in the final report. Prototyping of material coupons will be required, along with material tolerance requirements and ability to extend to large design.

PHASE II: Further develop the proposed technology for air to space applications. Demonstration of the loss of the radome at V and W band will be required over the full scan. It is intended that AFRL will eventually incorporate this antenna on an airborne fuselage and obtain full antenna patterns.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Improve the manufacturability to drive costs down and improve reliability. Verify the performance of the system on several military platforms.
Commercial Application: Establish technical and business alliance with defense contractors and commercial system vendors to commercialize the technology.

REFERENCES:

1. Moneun, M.A.A et al, Hybrid PO-MoM analysis of large axi-symmetric radomes, Antennas and Propagation, IEEE Transaction on; Volume 29, Issue 12, p. 1657-1666.

2. Meng, Hongfu et al,Analysis and Design of Radome in Millimeter Wave Band;State Key Laboratory of Millimeter Waves, Southeast University.

3. Hiuliang Xu: 'Microwave and millimter Wave Near-Field methods for Evaluation of Radmoe Composites', AIP Conference Proceedings; Volume 975, Issue 1, 976-981.

KEYWORDS: W-band antenna, V-band antenna, airborne, radome

AF121-043 TITLE: Software Isolation from Evolution of Hardware and Operation Systems

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate a method to adapt legacy software to open system architectures compatible with evolving, net-centric information technology platforms.

DESCRIPTION: The Space Surveillance Network (SSN) consists of dish radars, phased array radars and optical systems whose primary mission is to track and identify space objects. These aging systems consist of hardware and software no longer supported by industry where sustainment is becoming cost prohibitive. Each site has unique interface applications used to control the sensor, correlate data and send communications. Each interface is unique to the sensor and not cross-compatible with other sensors. Outdated operator workstation repair costs currently exceed the purchase price of a commercial off-the-shelf system. Sustainment projects or upgrades currently require a major investment of capital to re-host or rewrite the software to continue to operate the workstation on a newer, supportable platform. Unfortunately, due to the length of the process, the platform is typically obsolete by the final delivery date. The current system prevents capitalization of the benefits of newer, faster, and less expensive hardware and software. Typical legacy software for operator workstations cannot be upgraded unless the hardware is upgraded. However, the necessary hardware upgrade does not exist, because the workstations in any form are no longer in production, and the original operating system is no longer supported. Space situational awareness mission requirements have also changed. As space becomes a more contested environment, surveillance systems must be able to react dynamically and synergistically to rapidly evolving events. This will require legacy systems to be utilized in ways which they were not originally designed for.

This research seeks novel approaches that modernize the space surveillance network to meet future needs. Solutions must employ designs that enable cost effective sustainment and upgrades to ground station hardware and software. Development of a net-centric modular architecture with standard interfaces enables responsiveness to dynamic events, efficient hardware/software sustainment, plus intelligent data pre-processing. Responsiveness to rapidly developing space-based incidents requires SSN sensors have the automated capability to respond to taskings from either the control node or peer sensors, enabling the best observations and object identification on potentially troublesome satellites. Future needs of the SSN include on-site data reduction and processing (data fusion) on Metric Observations (METOBS) and Space Object Identification (SOI), to provide better Space Situational Awareness (SSA) more quickly in a cluttered space environment. Modular design of both hardware and software components creates a cost effective solution in ground station sustainment and upgrades. As with any modernization effort, a balanced solution finds the optimal combination of legacy and new components to meet mission needs and fiscal constraints.

Proposed solutions can focus on either net-centric ground station concepts capable of responding to dynamic space tracking events, or focus on data preprocessing and data reduction to enable data fusion, or both. All proposals must incorporate cost-effective and sustainable concepts.

PHASE I: Design a cost effective, sustainable sensor ground hardware/software concept that not only incorporates existing functionality but also dynamic tasking and/or on-site data preprocessing/reduction for both METOBS and SOI data fusion.

PHASE II: Design, develop, and demonstrate a concept prototype for critical portions of the sensor ground station.

PHASE III DUAL USE APPLICATIONS:
Military Application: A portable GUI system allows low cost upgrades and technical refresh of the platforms requiring only minor software changes if any, and provides more robust systems for evolving net-centric SSN.
Commercial Application: Three areas have commercial applicability for this topic. The first is development of innovative techniques to upgrade legacy systems, especially for either radar or electro-optical (EO) sensor sites. Secondly, dynamic tasking techniques will have wide applicability to any dispersed, networked systems. Finally, the data pre-processing techniques apply to any radar or EO system transforming data to relevant information.

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1. POSIX.4 Programmers Guide, by Bill Gallmeister, O'Reilly Media, January 1995.

2. X Windows System Administrator's Guide, Vol 8, First Edition, by Linda Mui, Eric Pearce, O'Rielly Media, October 1992.

KEYWORDS: GUI, Open-system-architecture, platform-independent-applications, Net-Centric SSN, Space Situational Awareness, Data Fusion

AF121-046 TITLE: W-band Transmitter

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an efficient, lightweight W-band (81-86 GHz) transmitter to support communications links between RPA's, satellites and terrestrial terminals.

DESCRIPTION: As the number of Remotely Piloted Aircrafts (RPAs) and associated battlefield sensors proliferates, requirements for additional military satellite communications capacity will likely continue for the foreseeable future. In order to provide Airborne Intelligence, Surveillance, and Reconnaissance (AISR) data communications between the RPA, warfighter and data analysts, and to transfer command and control (C2) communications to the RPA from the operator using a satellite communications link during periods in which the RPA is operating BLOS (Beyond Line of Sight), the Air Force would like to explore utilization of frequency spectrum available at W band (81-86 GHz).

The Air Force would like to develop a RF (Radio Frequency) transmitter designed for operation on an airborne platform with output power greater than 50 watts and with power added efficiency of greater than 30 percent to meet these emerging SATCOM (Satellite Communications) requirements. This research should support adjacent channel

power ratio of less than -40 dB for a typical quadrature phase shift key modulation scheme in an effort to minimize spectral regrowth. Additional challenging performance goals of interest include a center frequency of 83.5 GHz with a bandwidth range of +/- 3 GHz, a power input of less than 1 mW, a power output of greater than 50 W, harmonics of less than 10 dBc, amplitude ripple of less than .4 dB, a Voltage Standing Wave Ratio (VSWR) of less than 1.3:1, a total system weight of less than 10 lb, a total system efficiency of greater than 30 percent, an operating temperature range of -40 degrees to +55 degrees centigrade, and reliability consistent with typical airborne terminal life of 10^5 hours.

PHASE I: Investigate design approaches leading towards the W-band transmitter objectives stated above. Select a promising technology alternative and demonstrate viability through modeling and simulation.

PHASE II: Fabricate, prototype, and characterize for operating frequency, bandwidth, power consumption, output power, amplitude ripple. Conduct accelerated life testing to estimate reliability.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Both commercial and military satellite communications data rates are expanding and could benefit from millimeter wave communications links.
Commercial Application: Commercial as well as Military data rates will benefit.

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1. Smith, Matthew, C.; Dunleavy, Lawrence P., “Comparison of Solid State, MPM, and TWT Based Transmitters for Spaceborne Applications”, IEEE, 1998.

2. Trew, R.J.; Shin, M.W.; and Gatto, V., “Wide Bandgap Semiconductor Electronic Devices for High Frequency Applications,” IEEE GaAs IC Symposium, 1996, pp 6-9.

KEYWORDS: Microwave, Power Module, W-band, Power Amplifier, Gain, Bandwidth

AF121-048 TITLE: Dynamic Reallocation and Tasking

TECHNOLOGY AREAS: Information Systems, Space Platforms

OBJECTIVE: Develop and demonstrate advanced decision support technology with the potential to provide dynamic reallocation and tasking in planning and conducting air-space-cyber activities across rapidly changing environments.

DESCRIPTION: A wide array of physical and information resources can be called upon when responding to a severe weather event, such as a hurricane or winter storm. The major challenge, when such a disruption occurs, is deciding how to effectively use available resources to preserve life and recover economic well-being. Organizing and directing such a response has many similarities with the command and control function exercised over military operations. With the growth in space-borne and computer network capabilities, the Air Force has an opportunity to combine these capabilities with its traditional aircraft capabilities to meet Service, Joint, and Coalition mission objectives. Exploiting the strengths and relationships among air, space, and cyber assets has the potential for achieving greater effects. These multiple assets however can be difficult to synchronize, owing to differences in time response, reliability, covertness, and a variety of other factors. Additionally, the very nature of conflict confronts commanders with constantly evolving adversaries and uncertainty about the operating environment. To prevail in future conflicts, commanders must be able to perform dynamic reallocation and tasking of air, space, and cyber capabilities within and across those domains, on a time scale ranging from milliseconds to days. This implies the need for varying levels of automation in both adaptive planning and dynamic reallocation of assets. Meeting the allocation challenge may also require novel approaches to optimization, applying techniques such as Genetic Algorithms, Simulated Annealing, A*, Heuristic Search, Iterative Repair, Linear Programming, Branch and Bound, Hill-Climbing, intelligent software agents, or hybrid approaches. Combined with near real time situational awareness and adaptive planning of operations, technology advances in Dynamic Reallocation of assets and efficient Tasking of air, space, and cyber resources could play a key role in achieving future national security objectives.

PHASE I: Generate representative scenarios using open-source data, to assist analysis and identification of potential solutions. Establish metrics and perform a trade study to recommend promising solutions. Design a concept for the prototype dynamic reallocation and tasking capability.

PHASE II: Develop, demonstrate, and validate the prototype for a representative command and control scenario, clearly demonstrating its ability to meet the desired capabilities within a Service Oriented Architecture (SOA).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This research would enhance network operations for DoD information technology systems, with potential extension to integrated command and control systems for synchronizing air-space-cyber operations.
Commercial Application: Follow-on uses for the technology are expected in numerous fields including Emergency response planning; Homeland security; Transportation logistics; Energy production/distribution; Financial market transactions; Industrial manufacturing.

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KEYWORDS: decision support, automated planning, scalable efficient allocation, dynamic re-tasking, optimization, robust command and control

AF121-049 TITLE: Emerging Software Algorithms for Autonomous Sense Making Operations

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop scalable emerging computing algorithms capable of performing autonomous and sense making operations based on learning and/or training. Operations can include but are not limited to: complex semantic association, surveillance, and navigation.

DESCRIPTION: Today’s computing information systems are continuously bombarded with sensor, machine, and user generated data. This data can originate and travel through multiple communication channels such as airways, wires, optical links, radar, radio, and/or cyber space. Thus, the main challenge information analysts face today is how to deal with the vast amounts of data available given that in order to process all this information would require beyond human abilities as clearly described in the recent Technology Horizons report by the Air Force chief scientist Dr. Dahm. “Although humans today remain more capable than machines for many tasks, natural human capacities are becoming increasingly mismatched to the enormous data volumes, processing capabilities, and decision speeds that technologies offer or demand; closer human-machine coupling and augmentation of human performance will become possible and essential”. As a result, this applied research topic seeks innovative ideas where emerging computing algorithms can be applied to intelligent information processing or autonomous sense making operations. The basic goal is to develop information software platforms capable of performing autonomous

operations that would enhance the performance, operation, and decision making capabilities of the user by enabling autonomy to the system itself.

PHASE I: Research and develop an innovative approach to meet the SBIR Topic objectives, and assess its feasibility. Develop the initial paper design and simulation prototype that demonstrate basic autonomous sense making application. A proof of concept is required to demonstrate feasibility of approach.

PHASE II: Develop large-scale prototype demonstration, per Phase I requirements. Demonstrate sense making and autonomous operations for example but not limited to monitoring activities and navigation in denied environments using performer generated real-world and/or synthesized data. A working large-scale prototype is required that demonstrates increase in the complexity and autonomy of functionality performed by the system architecture.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Deliver scalable software tool able to fulfill a wide range of DoD needs for autonomous systems operations such as continuously monitoring information from various sources for situation awareness, navigation in denied environments, and sense making.
Commercial Application: Business intelligence, persistent surveillance, data and trend analysis for example continuously monitoring information from various sources, competitors' pricing, background screening, and DoD contractors enabling autonomous decisions and analysis.

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KEYWORDS: Computational Intelligence, Neuromorphic Computing, Neural Networks

AF121-050 TITLE: Link Analysis of Knowledge Derived from Social Media Sources

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: The objective of this research is to develop information technology to provide link analysis of knowledge extracted from social media communications. Relevant research approaches must address scalability, temporal analysis, and entity resolution.

DESCRIPTION: Social media have become increasingly important for communication with intent to affect public opinion, political results and social behavior. (Ref 1) Traditional knowledge extraction techniques have either focused on exploiting full-text written in natural language sentences, (Ref 2) or on deriving schematic and instance assertions from structured data repositories such as relational databases. (Ref 3) Social media differ significantly from these data sources in a number of ways. A complete communication may be created and disseminated in under a minute, allowing for many more communications from an individual author than in traditional full-text writing. Many social media mechanisms allow anonymity, such that the care with which a communication is prepared and released is frequently less than what a fully attributable mechanism would warrant. Social media communications are often retractable via deletion, and many are automatically deleted after a set period of time. Archiving is common, but generally not for public consumption. Many social media mechanisms limit the size of a

communication, both reducing the amount of information available, and increasing the amount of linguistic innovation employed by authors to express the maximum amount of information. Traditional text processing techniques such as word sense disambiguation and pronoun resolution, frequently thought of as intra-communication tasks, likely become dependent on time-delimited 'sessions' of multiple communications for proper handling.

The scope of the topic includes the development of link analysis techniques tailored to knowledge derived from social media communications (ontology, expert system, etc.). The type of knowledge may be, but is not limited to, the identification of active entities (humans, organizations, software agents); the identification of plans; the identification of attributes; the identification of roles and role holders. This link analysis capability must be highly scalable and able to manage datasets of 1,000,000 nodes and greater. Further, this capability must conduct entity resolution with current databases and future entries to manage this data. The offeror may provide a 'seed' knowledge base with which to align. Measurement of Receiver-Operator Characteristic (ROC) metrics for extracted knowledge is critical.

There exists a strong military need to visualize knowledge extracted from social media communications with the same fidelity available from more traditional sources. Specifically an end user has identified the requirement to exploit social media to correlate between networks of various types. Social media of interest include blogs, Twitter-like messages, social networking posts, and bulletin board threads. Proposed methods must automatically analyze social media communications, extract relevant assertions made in them, derive attribution metadata and analyze new relationships of extracted knowledge temporally.

Proposers are encouraged to utilize open architecture and standards as well as provide how the approach will mitigate risk and minimize information assurance concerns.

PHASE I: Complete a feasibility effort that provides an analysis framework design for knowledge extraction from social media communications. Conduct a proof of concept demonstration against a dataset with known characteristics. Demonstrate the proposed algorithms and architecture can be matured during follow on phases, while mitigating technical risk.

PHASE II: Produce a prototype system that is capable of extracting knowledge from social media communications automatically, and aligning that knowledge with an existing knowledge base. The prototype should show statistically significant knowledge extraction accuracy (precision of 95%, recall of 95%) when tested on real-world samples of social media communications. Open architecture and standards are encouraged.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Produce a fieldable system that can operate on social media sources that is highly scalable (>100000 communications per day) allowing users to visualize and analyze, while performing with high accuracy levels for extraction and entity resolution.
Commercial Application: Successful development of the prototype capability would be of great interest to law enforcement, market analysts, polling organizations and social media mechanisms themselves.

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2. Sekine, Satoshi; Nadeau, David (2006). A survey of named entity recognition and classification. University of New York.

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KEYWORDS: Link analysis, knowledge representation, social networks analysis, information extraction, scalability, social media, entity resolution

AF121-051 TITLE: Remote Attestation and Distributed Trust in Networks (RADTiN)

TECHNOLOGY AREAS: Information Systems

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Remote Attestation and Distributed Trust in networks are required to enable secure and trusted transactions in a future, distributed NCO environment. Secure and trusted transactions are multi-agent, where an agent may be human or a remote device.

DESCRIPTION: The Common Access Card (CAC) is a United States Department of Defense (DoD) smart card issued as the standard identification for personnel. The CAC is used for authentication of personnel and to enable access to DoD computers, networks, and certain DoD facilities. The CAC enables encrypting and cryptographically signing email and official documentation, facilitating the use of PKI authentication tools, and establishes an authoritative process for the use of identity credentials. With the DoD's increase reliance on networking (e.g. Network Centric Operations) and mobile computing technologies, authentication concerns extend beyond just personnel and include both the network and remote device(s).

Remote Attestation and Distributed Trust in networks are required to enable secure and trusted transactions in a future, distributed NCO environment. The transaction may be multi-agent, where an agent may be human or a remote device, and a device can be anything on the network from the network itself (including gateways and routers), desktop or server computers, or a smart phone, tablet, or Personal Digital Assistant (PDA) type device.

Authorization and authentication in distributed systems are very different from those in centralized systems. The simplest way to achieve distributed security assurances is to close the system to outside agents. This approach neither solves the problem of insider threats nor allows the potential of NCO to be maximized. For this topic, it is assumed that cyber operations are being conducted in an open and contested cyber environment.

This topic seeks novel ways to establish trust in distributed computer networks in a multi-agent environment. Solutions may be software based, hardware based, or hybrid. Solutions should address horizontal trust (i.e. peer-to-peer systems) and vertical trust (i.e. systems outside the immediate network and/or enterprise). Solutions must also address both static trust (i.e. from system boot to the final operating environment loaded) to dynamic trust (i.e. continually evaluated during system operation). For this topic, use of advanced CPU features such as Intel VPro is allowed, but proposals are not limited to existing processor architectures. Proposals should also address the entire scope of information technology from ARM architectures in low power mobile devices, up to large server farm type systems.

PHASE I: Design and develop techniques and technologies for remote attestation and distributed trust in networks, 2) Conduct a complete comparative analysis of possible approaches, and 3) Proof-of-feasibility demonstration of key enabling concepts.

PHASE II: Develop and demonstrate a prototype that implements the Phase I methodology, 2) Identify appropriate performance metrics for evaluation, 3) Generate a cost estimate and implementation guidance, and 4) Detail the plan for the Phase III effort.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Computer and network defenses for the GIG and all other IT systems. DoD components and Department of Homeland Security can benefit from this research.

Commercial Application: The growing importance of computers and networks to the nation's economic well-being and national security is dependent on a cyber defense strategy with the greatest opportunity for mission assurance.

REFERENCES:
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2. Trust Establishment in Mobile Distributed Computing Platforms http://www.isg.rhul.ac.uk/~allan/dtrust/.

3. DTT: A Distributed Trust Toolkit for Pervasive Systems http://www.ioc.ornl.gov/publications/lagesseDTT.pdf.

KEYWORDS: Remote attestation, distributed trust

AF121-055 TITLE: Graphene Memory Device

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate a radiation-hardened graphene memory device suitable for long-term geosynchronous orbit space missions.

DESCRIPTION: The rapid proliferation of satellite communications applications, such as Communications-On-The-Move and others, will likely necessitate the introduction of a new generation of digital processing technologies. Because memory devices are ubiquitous in any digital processing system, the Air Force is interested in supporting the advancement of emerging memory technologies. Recent research suggests graphene memory has several attributes that could make it attractive as a high-density space memory device. In particular, the large on-off ratio of graphene memory supports reduced bit error rates. In addition, as a two-port memory device, graphene lends itself to stacking, with potential for use in three dimensional (3-D) memory. The purpose of this topic is to support research to design and demonstrate a graphene memory device suitable for use in long-term geosynchronous space missions. Goals include immunity to destructive latchup, total ionizing dose tolerance to 1Mrad (Si), Single Event Effect (SEE) immunity to 60 MeV, operating temperature range from -40° C to +80° C, endurance > 1E9 read/write operations, retention > 20 years, access time < 10ns and component reliability consistent with 15-year, on-orbit satellite mission life.

PHASE I: Design graphene memory device meeting goals identified above and validate through modeling and simulation.

PHASE II: Fabricate prototype and characterize for access time, operating temperature range, reliability and radiation tolerance to total dose and single event effects. Expectations for this phase would include a working prototype that could be evaluated in a relevant environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include combat vehicles, Unmanned Aerial Vehicles and satellites.
Commercial Application: Graphene memory could find application in the commercial aerospace industry, including avionics and consumer electronics.

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KEYWORDS: graphene memory, non-volatile memory, endurance, retention, access time, radiation-hardened

AF121-056 TITLE: Integrated Li-Ion Battery Interface Electronics for Spacecraft

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop innovative spacecraft power system interface for standardized Li-Ion battery package.

DESCRIPTION: The state-of-the-art for the design of spacecraft battery and power electronics for interfacing the battery to the spacecraft bus are custom designed for each spacecraft. This leads to increased cost over the life cycle of a spacecraft due to the requirement to maintain the production facilities to produce replacement batteries for each satellite program for launches, which are delayed beyond the shelf life of the batteries purchased for the original launch date. Current practice for satellite programs that have batteries that age out is to replace them with new batteries and not fly over-age batteries. Because the battery structural, thermal and electrical interfaces are custom one-of-a–kind for each satellite program, the DoD must procure and maintain spare batteries for each program. With standardization, it may be possible for different satellite programs to establish a joint battery procurement strategy, which would reduce the number of batteries that are required to be purchased for spares and to replace over-age batteries.

The innovation required is to develop a standardized battery module that would have a common structural, thermal and electrical interface for a number of different satellite programs. To reduce the long-term costs associated with maintaining custom designed batteries, there is a desire to develop a smart, standardized battery module that could be used by many different DoD satellites. This battery module would be designed to interface with a nominal 28 VDC regulated spacecraft power bus. The battery module would be both intelligent and flexible, with the capability of providing between 200 and 400 watt-hours of stored energy to the spacecraft power bus, with a maximum depth of discharge in the Li-Ion batteries of 40% for low-earth-orbit applications and 60% for geosynchronous-orbit applications. It would also be inherently scalable--for spacecraft with requirements for energy storage greater than 400 watt-hours--by adding additional battery modules.

The battery module bus interface electronics package should be capable of drawing power from the regulated spacecraft 28 VDC bus for charging the battery, providing cell bypass circuitry to prevent overcharging individual cells in a series string, and delivering power to the 28 VDC bus whenever power demand from spacecraft loads exceed the power-generating capability of the solar arrays. The battery module should have the capability of supplying the required energy to the 28 VDC bus with one cell either open circuited or shorted.

The battery module should be radiation-hardened and be capable of supporting a 15-year mission in Geosynchronous Earth Orbit (GEO) or Medium Earth Orbit (MEO) and 5 years in Low Earth Orbit (LEO) after storage on the ground for 5 years.

PHASE I: Perform preliminary analysis and conduct trade studies to validate innovative battery module concepts. Acquire test results and related performance information, either in-house or through external test resources, in support of payoff estimates.

PHASE II: Fabricate and deliver engineering demonstration unit. Show the flexibility of delivering reliable power with variable loads. Identify radiation-sensitive components and methods of shielding for spacecraft applications.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The availability of a standardized battery module, which could be applied to a wide range of spacecraft, will reduce life-cycle cost of satellite systems for military applications.
Commercial Application: Commercial communications satellites and NASA interplanetary missions could use this technology.

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KEYWORDS: DC-DC converters, spacecraft power system, power management and distribution, Li-Ion batteries

AF121-057 TITLE: Novel Environmental Protection for Multi-Junction Solar Cells

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a flexible, space-protective coating for flexible, thin, multi-junction solar cells that enables practical application in high-performance-solar-array deployment and support systems.

DESCRIPTION: Advanced multi-junction space solar-cell technology with efficiencies (>35%) is expected in the near term for devices based on an Inverted Metamorphic (IMM) structure. In addition to high efficiency, the IMM device design results in a thin, flexible structure. The thin, flexible nature of these devices allows them to be stowed in a rolled configuration, which opens up the possibility of using innovative solar-array deployment and support structures. Innovative solar array configurations could achieve quantum-leap levels of solar-array specific power (W/kg) and stowed volume efficiency (kW/m3). An innovative space environmental protection scheme is therefore sought to maintain the flexible nature of the bare cell in the working array. The desired coating must maintain its

flexibility while protecting the solar cell from ionizing radiation, Low-Earth-Orbit (LEO) atomic oxygen, pre-launch humidity, and high-voltage discharge. The entire coating stack (Adhesive, "Cover Glass", Anti Reflective, and Conductive Electrostatic Discharge) must have high transparency in the wavelengths that the solar cell is active (300 nm to 1800 nm), and maintain this high level of transparency (>90%) when subjected to space environment exposure. Desired design life is 5 years in LEO and 15 years in Geosynchronous Earth Orbit (GEO). The coatings must also have high thermal emissivity and resist cracking during flexing and thermal cycling of the solar cells.

The solar array environmental protection technology should be capable of operation in a LEO for 5 years and in a GEO or Medium Earth Orbit (MEO) for 15 years after storage on the ground for 5 years.

PHASE I: Design a representative prototype for the proposed coating technology. Demonstrate coating compatibility with the IMM solar cell being developed by mainline space solar cell manufacturers. Limited pathfinder space environmental exposure testing of the coating is encouraged.

PHASE II: Using the lessons learned from fabricating and testing prototype articles in Phase I, continue work to optimize and increase the Technology Readiness Level (TRL) of the advanced coating. The prototype should be subjected to a complete complement of pathfinder space environmental testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: All DoD Spacecraft use multi-junction space solar cells for electric power generation. Thin solar cells with high efficiency will increase the power-producing capability of military spacecraft.
Commercial Application: Commercial communications spacecraft and NASA spacecraft would use this technology.

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1. Liu, S., et al, "Space Radiation Environmental Testing on POSS Coated Solar Cell Coverglass," Proc. 33rd IEEE PVSC, 2008.

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KEYWORDS: solar cells, coverglass, coatings, space

AF121-058 TITLE: High-Strain Conductive Composites for Satellite Communications (SATCOM) Deployable Antennas

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate hardware capable of withstanding large strains when folded with high-strain fiber-reinforced deployable composites.

DESCRIPTION: Deployable structural systems are now capable of supporting significantly higher strains enabling for Satellite Communications (SATCOM) deployable Radio Frequency (RF) components such as antennas and mesh reflectors. Fiber-reinforced polymers (FRPs) can be used as the structural backbone of deployable components as they are able to store strain energy when packaged and then release the energy in a controlled manner to perform the deployment function. The electrical conductivity in FRPs is orders of magnitude less than metals; for use as an RF component, conductive modifications are thus emplaced to improve electrical performance. However, in the rolled or otherwise packaged state, FRPs experience strains up to 4%—well beyond the elastic limit of typical conductive materials, such as copper (Cu). If subject to such high strains, plastic deformation, separation, necking or breaking of the conductor could occur; such issues could degrade the conductivity--or even generate open circuits between the composite interlayers. Some Cu alloys can increase strain thresholds, but the resulting conductivity drops as much as 55-78% (ref.1). To realize these deployable RF components, this topic seeks solutions that provide additional conductivity to an FRP strain-energy structure without failing during storage or deployment.

Current research in this area has focused on making the structure itself a sensor by embedding conductivity into a flexible polymer in various approaches. The use of polymers as the matrix of a high-strain, conductive fiber-reinforced composite, however, is not addressed. Other research towards flexible printable electronics for conformal sensing applications, conductive thin-films, and carbon nanotubes in FRPs to improve conductivity has not proven useful in high-strain applications (ref. 2,3,4).

The key technology challenge is to provide requisite mechanical strength and conductivity associated with transmit/receive antennas while not hindering deployment function. Conductivity threshold is to exceed that of beryllium copper (BeCu) alloys (>22-45% International Annealed Copper Standard1) with an objective of 100% IACS. Both elastomeric and load-bearing FRP solutions are of interest, but preference is for a material that meets Young's modulus for aluminum (~70 GPa threshold) and can elastically strain greater than space-grade BeCu alloys (threshold; objective is 3%). Preference will also be given to FRP solutions that minimize size and weight while permitting large cycle lifetimes. Furthermore, solutions should address susceptibility to electrostatic discharge (ESD)—which is the #1 cause for failure in space systems—as well as space environmental effects. Contractors are strongly encouraged to work closely with AFRL personnel and potential transition partners to ensure technical efforts are consistent with overall goals.

PHASE I: Design high-strain, conductive FRP concept. Perform analysis of design electrical/thermal properties, strain profile, and effects of solution implementation with FRP, e.g., degradation of mechanical properties. Address methods/designs for interconnection. Perform bench-top testing of small-scale prototype for concept demonstration.

PHASE II: Refine concepts and designs from Phase I. Conduct comprehensive testing and analysis with focus on electrical and mechanical performance, interconnectivity, and survivability/reliability in the appropriate operating conditions. Prototype should demonstrate both strain-energy deployment and subsequent antenna functions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A wide variety of military space systems are expected to benefit from more compact, lightweight, deployable RF components.
Commercial Application: This research would benefit commercial SATCOM programs and other systems with design sensitivity to size and mass in the RF subsystem.

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KEYWORDS: conductivity, fiber reinforced polymers, composites, deployable structures, antennas

AF121-059 TITLE: Wide Temperature Optical Transceivers

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a space-qualifiable, optical-transceiver technology that operates over a -55 C to 125 C temperature range and is suitable for high-data-rate satellite communications applications.

DESCRIPTION: The Air Force is planning to develop a new generation of communications satellites with the capability of processing data at significantly higher rates. Fiber optic infrastructure for intra-satellite communications will be required, including the development of space-qualified transceivers. Vertical Cavity Surface Emitting Laser (VCSEL)-based transceivers offer power-efficient optical communications at data rates that will be of interest for the foreseeable future. VCSEL-based transceivers are offered as single channel or multi-channel components, offering scaling through data rate and number of channels. Current VCSELs are designed to operate in commercial environments, with a limited temperature range. At high temperatures, the VCSEL performance and reliability are degraded.

To achieve minimal signal distribution weight and power overhead, the Air Force seeks innovative small-business research in the area of space-qualified VCSEL-based transceivers that support high-data-rate signal distribution within the satellite and that operate over a wide temperature range. Goals include serial data transfer rate of at least 10 Gbps, operating temperature range between –55 deg C and + 125 deg C, optical link margin of 15 dB, operation over multi-mode fiber, radiation-hardened to total dose level greater than 1Mrad (Si), and reliability consistent with a 20-year, Earth-orbit satellite mission (including single-point failure immunity).

PHASE I: Demonstrate the feasibility of a VCSEL-based transceiver operating over -55 C to +125 C. Analyze and model innovative alternatives for packaging for a space environment. Take into account transceiver dynamic range, ease of optoelectronic packaging and manufacturing, and ruggedness. Validate design using modeling and demonstration.

PHASE II: Utilizing data from Phase I, fabricate prototypes and test a wide-temperature transceiver for 10 Gbps data transmission over 50 micron core multi-mode fiber. Demonstrate and measure performance at room temperature and temperature extremes (–55 to +125 ºC). At a minimum, measure the overall power consumption and link margin over temperature range.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Virtually all military satellites and avionics data processing subsystems could benefit from this research.
Commercial Application: Virtually all commercial satellites and avionics data processing subsystems could benefit from this research.

REFERENCES:
1. Jonghyun, Park, Kim Taeyong, Kim Sung-Han, and Kim Sang-Bae, "A Passively Aligned VCSEL Transmitter Operating at Fixed Current over a Wide Temperature Range," Opt. Express 17, 5147-5152, 2009.

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KEYWORDS: satellite fiber-optic components, Vertical Cavity Surface Emitting Laser (VCSEL), optical signal distribution

AF121-060 TITLE: High Conductance Thermal Interface Material for Use in Space Applications

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a space-qualifiable, high-conductance, passive, Thermal Interface Material (TIM) for use in space-based flanged heat-pipe-to-heat-pipe joints or for mounting relatively small area units with stiff baseplates and high power loads.

DESCRIPTION: To meet emerging demands for high-capacity satellite communications, digital and radio frequency (RF) waveform processing requirements are anticipated to grow for the foreseeable future; implementationof these requirements will lead to generation of increasing amounts of waste heat. To minimize the thermal impact of waste heat on digital and RF component performance as well as improve component reliability, this effort is focused on providing a high-conductance thermal interface material (TIM) to be used for space-based flanged heat-pipe-to-heat-pipe joints or for cooling high dissipating, small area unit baseplates, such as Traveling Wave Tube Amplifiers (TWTAs).

Goals of this research include a heat transfer coefficient >45,000 W/m2-K over an area of 2.5 inches x 3.0 inches, when conventionally fastened to the baseplate. To facilitate ground testing, the thermal conductance should not be impacted by environment (e.g. vacuum, humidity) or orientation. The TIM should be capable of operating over a temperature range of -40C to 125C along with 30,000 thermal cycles with a temperature difference of 15 C per cycle. In addition to the high conductance required, the TIM should be easily separable, debris-free, and require no significant cure time or elevated temperature. The TIM should be workmanship independent by utilizing materials, processes and controls that minimize the thermal vacuum testing required for recurring designs.

PHASE I: Develop concepts to provide a robust, reliable TIM that has the potential to provide a heat transfer coefficient >45,000 W/m2-K. Demonstrate by analysis and/or test the feasibility of such concepts to meet all requirements stated above, including surviving the temperature range and thermal cycles, debris-free.

PHASE II: Optimize and fully demonstrate a TIM capable of providing an effective heat transfer coefficient of >45,000 W/m2-K. Perform thermal performance testing and thermal cycling to confirm all above requirements have been met.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This research would benefit all military satellite programs, including Wideband Global Satellite Communications (SATCOM) and global positioning satellite programs. TIMs are required for all high power electronic components used on military systems.
Commercial Application: This research benefits virtually all commercial satellite programs requiring thermal management. Additionally, high conductivity TIMs have applications for computer processor heat sinks, commercial electronics, and personal/portable electronics.

REFERENCES:
1. Liu, J., T. Wang, B. Carlberg, and M. Inoue, "Recent Progress of Thermal Interface Materials," ESTC (2008), 2nd, pp. 351-358, 1-4 Sept. 2008.

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KEYWORDS: thermal management, thermal interface material, TIM, heat pipe joints, TWTA mounting

AF121-061 TITLE: Spacecraft Autonomy

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop software solutions supporting autonomous spacecraft operation.

DESCRIPTION: The command and control link between a satellite and the ground station can occasionally experience periods of outage from events ranging from high intensity space weather to periods in which the satellite is repositioned to a new orbital slot to accommodate changing mission requirements. The capability to autonomously implement an operational plan, which is a set of commands scheduled for execution at predetermined moments in time, ensures critical spacecraft operations can be carried out in the event the ground station-to-spacecraft communications link is lost. Recent research, principally by NASA, has shown artificial intelligence research has matured to become a viable means of maintaining short-term autonomous spacecraft control. The purpose of this topic is to support research towards increasing spacecraft autonomy while maintaining a high level of confidence in the spacecraft’s operational availability and, at the same time, minimizing the consumption of

spacecraft resources. Research should seek compatibility with the existing command and control infrastructure such as the Air Force Satellite Ground Link System (SGLS) and the Air Force Consolidated Space Operations Center (CSOC). SGLS interfaces are available through the Internet. The introduction of autonomous operations into the spacecraft poses a significant risk and, therefore, research should strive to develop a progressive autonomy approach that can be gradually introduced to provide mission management with confidence in the technology and to evaluate benefits before fully committing to autonomous control.

PHASE I: Develop a fully-supported autonomous spacecraft concept and conduct feasibility for such a satellite system, including most major systems' self-supporting operation for a suitable Ops life. A limited scope, proof-of-concept of some aspect of that autonomous system is desired.

PHASE II: Address two threats, proposed solutions, tradeoffs, and scalability. For at least one of those threats, develop an autonomous-spacecraft prototype. Characterize for reliability. Demonstrate in a relevant environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: All military satellite programs, including Wideband Global Satellite Communications (SATCOM), Global Positioning System (GPS) and Mobile User Objective System (MUOS) could benefit from this research.
Commercial Application: All commercial satellite programs could likewise benefit.

REFERENCES:
1.Chien, S., B. Smith, G. Rabideau, N. Muscetolla, and K. Rajan, “Automated Planning and Scheduling for Goal-Based Autonomous Spacecraft,” IEEE Intelligent Systems, Vol. 13, No. 5, pp. 50-55, 1998.

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KEYWORDS: spacecraft, autonomy, intelligent agent, command and control, progressive autonomy, artificial intelligence

AF121-062 TITLE: Light Weight Shielding for Satellite Protection from Severe Space Weather

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop cost-effective, lightweight shielding materials to protect satellites from severe space weather effects.

DESCRIPTION: Both military and commercial satellites are at risk from large solar radiation events. High-energy-charged particles produced by the sun can cause geomagnetic storms in the earth’s upper atmosphere, creating current surges within the satellite spacecraft that overstress microelectronics and lead to premature failure of the

satellite as a result of latch-up and single event effects. In addition, high-performance commercial microelectronics will play an increasingly critical role in future generations of communications satellite if they are to meet user demands for greater performance. Advanced microelectronics provide substantial performance benefits relative to microelectronics from radiation-hardened foundries if ways can be found to address space environmental hazards through system design measures such as shielding. In addition, shielding can serve multiple applications, such as structural support, thermal management, electromagnetic interference isolation, and radiation protection over 4-pi-steradian coverage. The purpose of this topic is to develop innovative ways of shielding spacecraft from severe space weather that permit the use of advanced commercial microelectronics through the utilization of a systems-engineering design approach meeting multiple objectives, thereby minimizing overall weight by comprehensively addressing structural, electrical, radiation, and thermal issues.

PHASE I: Review current spacecraft shielding practices. Explore space weather radiation & other radiation sources as discussed in references. Explore shielding materials to materially reduce weight for a standard level of shielding & develop spacecraft-shielding design. Consider design approaches to be integrated into the structure for symbiotic performance

PHASE II: Fabricate and demonstrate shielding designs and/or materials.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military satellites--communications satellites, in particular--would like to leverage commercial microelectronics performance while minimizing weight associated with shielding their use.
Commercial Application: A large variety of commercial sateliites could derive lifetime and mission-assurance benefits from this technology.

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2. Mukati, A., "A survey of memory error correcting techniques for improved reliability," Journal of Network and Computer Applications, Vol. 34, pp. 517-522, 2011.

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KEYWORDS: shielding, microelectronics, bremsstrahlung, high Z materials, electron scattering, cosmic rays, spacecraft

AF121-063 TITLE: Joint Processing of Multi-band Signals with Information Assurance

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate advanced signal processing algorithms to enhance military Global Positioning System (GPS) receiver performance with information assurance.

DESCRIPTION: Multiple radio navigation signals are, or soon will be, available from each Global Positioning System (GPS) satellite (L1, L2, and L5) and from other Global Navigation Satellite System (GNSS) constellations.

Current GNSS receiver design utilizes traditional separate code and carrier tracking loops, one for each signal, which are designed and operated separately. There are benefits to tracking all signals from each satellite using a joint tracking loop to mitigate frequency-dependent disturbance and interference, such as ionospheric and multipath effects. A joint-tracking filter is more realistic to implement than a vector-tracking filter, which involves multiple satellites and lengthy times to get the tracking loop closed. The same idea can be extended to working with multiple constellations. However, offsets in clock and reference standards must be taken into account to ensure interoperability.

However, civilian signals are more easily spoofed than military P(Y) and/or M-code. It would be even easier for an adversary to spoof signals from other, non-US controlled constellations. There is a clear need to address Information Assurance for position, navigation and time (PNT) solutions.

It is relatively easy for a single frequency signal to be spoofed. However, it would be more difficult to spoof two or more frequency signals in exactly the same way at the same time. As a result, joint processing of multi-frequency signals provides a means for integrity check prior to combining them to formulate a solution. In the same vein, cross-validation of solutions from different constellations may also serve as a means against spoofing. Such a joint processing will make it costly, if not impossible, to deploy a spoofing scheme attempt against all GNSS constellations. In addition, other means and techniques may be used for GNSS signals for information assurance. One example is signal characteristic-based intruder detection used in wireless communications networks.

PHASE I: Determine the feasibility of developing advanced multiband signal processing algorithms that improve navigation accuracy in the presence of ionospheric and multipath effects and also develop an approach to validate signal integrity.

PHASE II: Develop a prototype of multiple frequency GNSS receiver and demonstrate the candidate algorithms on the prototype in realistic environments and signal conditions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Develop the hardware and software modules for transitioning the technology to current and future military receivers.
Commercial Application: Technology developed under this effort will have potential applications to commercial GNSS receivers in surveying markets and urban environments and also in aviation applications, particularly as concerns about spoofing civilian signals arise.

REFERENCES:
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2: Hurskainen, Heikki, Tapani Ahonen, and Jari Nurmi, “Interface Specification - Navstar GPS Space segment/User segment L1C Interfaces,” IS-GPS-800, 04 August 2007.

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KEYWORDS: GPS information assurance, joint processing data fusion, multi-band signal methodology

AF121-064 TITLE: A Small Satellite-based System for Active and Passive Sounding of the Ionosphere, Direct Current (DC) through High Frequency (HF)

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a novel satellite sensor for double probe electric field sensing and radio Topside Ionospheric Sounding (TIS).

DESCRIPTION: The radio sounding of the ionosphere from space (TIS) has been established as a powerful technique for specifying the Electron Density Profile, EDP, of the topside ionosphere. In spite of EDP being a top Air Force Space Command (AFSPC) priority in Space Situational Awareness Environmental Monitoring, SSA-EM, this technique has yet to be advanced to an acquirable technology because of a number of shortcomings in technology readiness level (TRL), such as Electromagnetic Interference (EMI), practical size weight and power (SWAP), antenna technology, and, most importantly, onboard data processing. Early demonstration with the Alouette 1 & 2, and ISIS 1 & 2 missions (1970s), while scientifically successful, resulted in raw data files that took years to analyze and process. The more recent IMAGE mission improved significantly on data conditioning, weight, power, and EMI, but was still limited by a spinning wire boom deployment system that cannot provide continual nadir sounding as needed for operational EM, nor be expected to survive in the Low Earth Orbit (LEO) micro debris environment. TIS uses a radio transmitter to emit a swept or stepped range of frequencies and a receiver to analyze the reflection from points where the plasma frequency equals the radio frequency, thus giving the density at a range determined from delay. Two orthogonal dipoles are needed to transmit and detect the desired polarization, and a third axis can provide angle of arrival information that can be useful in sensing a turbulent and structured ionosphere. The optimal dipole lengths are about 15 meters tip-to-tip (tuned for 10 MHz).

Another important ionospheric parameter is the electric field, which specifies the dynamic state of the ionosphere and is vital to early detection of RF signal scintillation, another key AFSPC SSA-EM objective. The Double Probe (DP) technique for measuring the electric field is relevant to this topic as it uses booms similar or identical to the TIS. This topic calls for any or all components of a system that would ideally combine both the TIS and DP techniques in an instrument suitable for flight on small dedicated satellites or operational missions, in combination with other EM sensors, although a combined instrument is not required. The envisioned platforms would accommodate slow rotation for sensor calibration, sun pointing, communications, and navigation requirements, but spin deployed booms are not expected to meet requirements. Boom development is not the focus of this effort, although boom specifications are anticipated. The desired sensor will meet or beat as many of the following objectives as possible: TIS and DP sounding period between 0.5 and 5 sec. Size as small as a 3U cubesat 10x10x30cm, or multiples of that format. Power and weight < 10 W avg and 10 kg (excluding booms). Electric field range = ±500 mV/m with a sensitivity and precision of 0.1 mV/m. EDP at 5% from 104cm-3 to 107cm-3. It is also expected that all parts will be capable of surviving the thermal, vacuum and radiation environment of low Earth orbit, or have functionally direct replacements that will meet survival requirements without redesign.

PHASE I: The Phase I effort will perform requirements analysis to determine the optimal sensing strategy consistent with current technology. A system block diagram should be developed, critical engineering challenges identified, and limited breadboard testing accomplished to demonstrate system feasibility.

PHASE II: The Phase II effort should build and deliver a complete breadboard system with simulated booms suitable for bench-top evaluation, and a design suitable for subsequent fabrication for spaceflight.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Air Force Space Situational Awareness. This system will address Key Performance Parameters, EDP and ionospheric turbulence leading to disruption of communication and navigation satellite signals.

Commercial Application: Environment monitoring architectures being planned now suggest a minimum of 3 to 30 orbiting platforms. A successful design would enjoy commercial success in supplying AFSPC, NOAA, and NASA needs.

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1. Bilitza, D., "Topside Models: Status and Future Improvements," Adv. Space Res., 47(12), pp. 12(17) to 12(26), 1994.

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KEYWORDS: double probe, topside sounder, radio sounding, ionosphere, topside ionosonde

AF121-065 TITLE: Space Particle Radiation Sensor

TECHNOLOGY AREAS: Sensors, Battlespace, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Development of miniaturized (<1U), low-power, and relatively low-cost space radiation sensor(s) that provides local situational awareness about the space radiation environment, as well as inputs to global and/or theater-level space weather models.

DESCRIPTION: The recent anomaly on the Galaxy 15 satellite highlights the need to have an understanding of the immediate space particle environment. Having a sensor capable of characterizing the medium energy electron fluxes would have helped indicate the possibility of spacecraft charging and provided an early warning to the operators. The space particle environment causes other environmental effects, such as total integrated dose, dose rate, single event effects, and displacement damage that are also of interest to the spacecraft operator. In addition, recent efforts to improve radiation belt models for spacecraft design rely heavily on sensor input that is currently only sparsely available. In both cases, particle flux as a function of incident energy and particle type (proton or electron) is needed. For model improvement, angular resolution is also desired.

To address this issue, a highly miniaturized, space-radiation sensor(s) that can be placed as a secondary payload for monitoring the space particle environment is desired. This sensor should focus on the medium energy range (50 keV – 10 MeV electrons, 1 MeV-100 MeV protons) trapped particle fluxes in earth orbit. It should possess sufficient resolution to determine the energy spectrum and should have good dynamic range. It is also highly desirable to obtain particle flux as a function of incident angle. A variety of technological approaches are encouraged to apply, such as novel magnetic spectrometers, folded particle telescopes, time-of-flight detectors,

imaging detectors, particle track detectors, etc. The ultimate sensor, including its power supply and processing unit, should fit into a less than 1U (10 cm x 10 cm x 10 cm) box that could be easily integrated onto existing satellites. In addition, this unit should be lightweight, and low-power so that the payload imposes minimal requirements on the host spacecraft. It would also be desirable to have a high-data-rate mode and low-data-rate mode so that it could be accommodated on satellites with limited telemetry, while also being capable of providing high-quality data on missions with more bandwidth.

PHASE I: Develop and model sensor concept, as well as plans for sensor prototype, and path to a space qualified instrument. Possibly demonstrate in the laboratory key elements necessary to complete the prototype design.

PHASE II: Assemble and test prototype instrument design to demonstrate its suitability for monitoring the space environment in a small form factor.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The availability of small, low-cost, space-radiation sensors would enable satellite operators to assess the hazards of the local space environment and provide inputs to radiation belt modeling that is used for spacecraft design and optimization.
Commercial Application: Commercial communications satellites and NASA missions could use this technology in a similar manner to assess the radiation hazards of the environment to their satellites and spacecraft.

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KEYWORDS: space particle sensor, space radiation sensor, particle telescope, magnetic spectrometer, time-of-flight detector, particle imaging detector, particle track detector

AF121-066 TITLE: Miniaturized Neutral Wind Sensor

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and build miniaturized neutral wind instrument to measure vector winds in Low Earth Orbit (LEO) under all solar and magnetic conditions.

DESCRIPTION: Neutral winds have two significant impacts on the ionosphere and thermosphere: (1) they are a driver for scintillation and Electron Density Profile (EDP) in the ionosphere; and (2) they transport energized neutrals, which affect satellite drag forecasting. Scintillation, which causes communications outages in the equatorial region, and EDP are the two Key Performance Parameters in the DoD requirements for space weather. Scintillation and orbital drag are high-priority items in the list of required environmental impact products for Air Force Space Command (AFSPC). The Communications/Navigation Outage Forecasting System (C/NOFS) satellite was launched in 2008 to specify and forecast scintillation. To this end, the mission measures neutral winds and electric fields, the two primary drivers for irregularities that cause signals to degrade in the ionosphere. The operational follow-on to C/NOFS is the Space Situational Awareness Environment Monitor (SSAEM). It was planned to duplicate the C/NOFS payload, and included neutral wind sensors. However a decision was made to fly 6 satellites at higher altitudes than is optimal for neutral wind measurements, and hence there will be no wind instruments on SSAEM. To supplement this and future missions that will follow SSAEM, we solicit designs of miniaturized neutral wind instruments that can be flown on small standalone platforms. During magnetic storms, large amounts of electromagnetic energy are deposited at high latitudes in the ionosphere. Immediately, this energy is converted into Joule heat and wind energy. Winds transport heated neutrals, raising thermospheric densities globally. One major consequence is an increase in satellite drag. In order to meet requirements for drag forecasting, it is essential that the winds be monitored and observations provide input to global circulation models.

This topic is directed at development of small, low-cost neutral wind instruments that could be flown as ionospheric or thermospheric monitors. The miniaturized neutral wind instrument should be capable of operating between 90 and 500 km altitude, and measure in-track and cross-track winds between 10 and 1500 meters per second with a maximum uncertainty of 10 m/s or 5%, whichever is greater. Temporal resolution should be 1 Hz or better. Desirable size should be compatible with cubesat missions, though not necessarily required to fit within a 1U cubesat. Mass should be less than 2 kg, and power consumption less than 6W. The proposed instrument should be capable of measuring global winds under all levels of solar and magnetic activity. It is desirable that proposers include approximate cost estimates of the final instrument after development as an aid in future mission planning.

PHASE I: Develop conceptual design of miniaturized neutral wind instrument. Deliverable: laboratory test or simulation of performance of conceptual design.

PHASE II: Build miniaturized neutral wind instrument. Deliverable: laboratory test results from instrument demonstrating that design will meet requirements.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Air Force operational monitors of scintillation will be launched which lack neutral wind observations. This topic addresses that need.
Commercial Application: Global forecasting of the IT system requires input on neutral winds, which are important during magnetic storms.

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KEYWORDS: winds, scintillation, storms, models, drag

AF121-067 TITLE: Broadband High Temperature Focal Plane Array (FPA)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a high-sensitivity room temperature focal plane array (FPA) that responds over the visible to long-wave infrared (LWIR) spectrum.

DESCRIPTION: There are many systems in which it is necessary to detect radiation over the entire visible to infrared spectrum. To obtain high sensitivity over the visible-to-long-wave spectrum, the usual approach is to use multiple detectors, each operating at its optimum temperature, often on separate FPAs that complicate the optical system. The need is to cover the full spectrum (visible to LWIR) with as high as possible sensitivity. One solution might be using multiple parallel linear arrays chosen to achieve maximum sensitivity in their respective spectral bands, all mounted as close as possible. Ideally, the various detecting materials would be mounted on a common readout integrated circuit (ROIC) to minimize spacing between the arrays and to have a single processing system. The desire is to have the maximum room temperature sensitivity while limiting the number of detector array materials. The array might consist of a silicon array, mounted next to an InGaAs array, next to a microbolometer array to cover the visible wavelengths and out to 11 um. The selected materials should be responsive to pulsed light (should have a <100us response time). Other solutions including compositional gradients of HgCdTe, followed by substrate thinning or removal for visible response, or strained-layer superlattice architectures that achieve lower-than-bulk levels of dark current, might be particularly attractive for this topic. Resulting FPAs must survive over the typical military environment and temperature ranges. Linear arrays of about a centimeter long are expected and spacing between separate detector materials should be less than one or two pixels (i.e. < 60um).

PHASE I: The optimum detecting material(s) for a wide spectrum FPA shall be studied and their mounting, separation and connection to ROIC designed. FPA mechanical integrity over the military temperature range should be demonstrated.

PHASE II: During this phase, a ROIC design should be completed with an option of fabricating a complete FPA. The functionality and mechanical integrity over the military temperature range and background-limited infrared photo-response against calibrated illumination should be demonstrated for the device.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The detector arrays could be used to measure and characterize transient phenomena that have a broad spectral content such as a gun flash, or measuring and characterizing an unknown laser in the battlefield.
Commercial Application: The detector arrays could be used in a portable low cost laboratory instrument to measure transient phenomena that have a broad spectral content.

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2. Shao, H., W. Li, A. Torfi, D. Moscicka, and W. I. Wang, "IEEE Photonics Technology Letters", Vol. 18, No. 16, August 15, 2006.

KEYWORDS: detectors, focal planes, ROIC, sensors, FPA

AF121-068 TITLE: Innovative Technologies for Operationally Responsive Space (ORS)

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop technologies for satellites or space lift that increase their capability, reliability, and responsiveness. Develop smaller and more operable satellite and launch systems that maintain the capabilities of current larger systems.

DESCRIPTION: The DoD is actively pursuing the capability to assemble and launch a satellite within days, or even hours, of a battlefield commander"s notification. This capability is essential to meet the operational needs for a variety of Operationally Responsive Space (ORS) missions. Enabling technologies to achieve this goal involves miniaturization of the various satellite and space lift systems and components without loss of current capability. Smaller satellites are easier to store, integrate, and launch. In addition, smaller satellites are generally less expensive and can be easily duplicated to support multiple mission needs, while similar improvements to space lift components directly affect mass margin and launch capability.

The ORS Office is pursuing the development of miniaturized systems that include, but are not limited to: reconfigurable bus and payload components, standardized payload configurations, compact sensors, compact bus systems, flexible operations schemes, space lift components and rapid integration and calibration techniques. It is necessary to investigate creative solutions to avoid the need to develop custom hardware, software, and interfaces. The ORS Office will also consider novel modification endeavors to existing commercial-off-the-shelf (COTS) components to meet the needs of this solicitation.

Contractors are strongly encouraged to work closely with the ORS Office and its contractors, if necessary, to ensure technical efforts are consistent with overall responsive satellite and space lift development goals. Proposed concepts should strive for designs that can eventually achieve a component fabrication and system integration time of a few days for the widest range of relevant satellite and space lift capability. In the near term, these techniques should cut integration time and component/mission costs in half.

The technical objective is to reduce the size of current satellites and space lift to one-half of their current mass and volume without loss of capability. This effort involves development of innovative advances in structures, power systems, propulsion, attitude knowledge and control, space lift, and sensor systems that maintain capability while reducing volume and mass for an ORS-class mission. These systems should use standardized interfaces and integration schemes that make the launch of the satellite more responsive and operable for missions and launch campaigns associated with the ORS-class missions.

PHASE I: Complete initial design, modeling and simulation (M&S) and possibly bench scale experiments to demonstrate feasibility of concept. Utilize test results and M&S to identify key technical challenges, develop a mitigation strategy, and develop a Phase II program plan.

PHASE II: Design, fabricate, and test a prototype-level (Engineering Development Unit – EDU) concept that achieves the functional and interface specifications of the ORS Office’s mission configurations that mitigates the identified technical risks.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The proposed effort would develop satellite component technologies that are applicable to both commercial and military satellites. Demonstrate an integration strategy that will enable the assembly and checkout of a small satellite within a few days.

Commercial Application: The contractors that develop subject technologies will also market their products to commercial satellite vendors. Demonstrate an integration strategy that will enable the assembly and checkout of a small satellite within a few days.

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KEYWORDS: satellite bus, modular satellite, standardized satellite interfaces, spacecraft, payload, satellite, responsive space, responsive bus, space lift

AF121-069 TITLE: Advanced Space Energy Storage that Incorporates Long Cycle Life at High Depths of Discharge

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an energy storage system with high specific energy density > 200 Wh/kg that is capable of 5+ years of ground storage and 60,000 cycles at depths of discharge > 60% and showing a pathway to 100%.

DESCRIPTION: Military communications satellite payload power consumption is trending higher to meet exponentially increasing satellite communication capacity requirements in support of tomorrow's warfighters. The U.S. Air Force is interested in supporting advanced battery development that is capable of undergoing 5+ years of ground storage followed by 15 years of operational lifetime. This can be up to 60,000 cycles for low Earth orbiting satellites. To meet typical mission needs, current state-of-the-art Li-ion batteries use shallow depths of discharge (< 30%) to improve cycle life.

To facilitate efficiency improvements in the energy storage system of space vehicles, improvements in energy density, depth of discharge, and cycle life are desired. This proposal seeks innovative materials for use as electrodes and electrolytes in Li-ion batteries that can demonstrate beginning-of-life specific energy density > 200 Wh/kg and cycle life of 60,000 at >= 60% Depth of Discharge (DOD). Demonstration of a pathway towards 100% DOD and 60,000 cycles is also desired.

PHASE I: Develop, evaluate and validate innovative materials for use in Li-ion batteries that show promise for 60,000 Low Earth Orbit (LEO) cycles and demonstrate high specific energy density.

PHASE II: Optimize the materials and processes learned from Phase I to produce a prototype Li-ion cell with specific energy density > 200 Wh/kg, and demonstrate long cycle life under 60-100% DOD LEO conditions.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: All Department of Defense spacecraft require some form of energy storage. The use of high-energy-density, high-depth-of-discharge batteries will improve power system efficiency and lifetime.
Commercial Application: Commercial communications spacecraft and NASA spacecraft would use this technology.

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KEYWORDS: energy storage, batteries, long cycle life, high depth of discharge

AF121-070 TITLE: Compact Type I Space Encryption Hardware

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: To establish an ultra-compact, ultra-low-power encryption/decryption certifiable solution for embedded space applications.

DESCRIPTION: Space systems necessarily employ encryption/decryption on their communications links, usually through dedicated box-level components referred to as encryption control unit (ECU). The ECUs for routine use in spacecraft command, communications, and control must be certified by the National Security Agency (NSA) as "Type 1" (literally approved for use in spacecraft to protect classified communications). While ECUs are in common use, they have excessive size, weight, and power, which is a significant impediment to dimensionally-constrained spacecraft, and compete for limited resources even in larger, tactically oriented spacecraft. We are keenly interested in more effective solutions, specifically the creation of stand-alone ECUs capable of supporting multiple encryption/decryption channels at 100 megabits/sec in less than 250-mW and within a 70x70x12.5-mm envelope with traditional space environment (i.e. > 100-krad(Si), no latchup, < 1 upset/year due to single event effects over a worst case temperature range of -55 to +125 deg C). Solutions must be Type 1 certifiable. We believe these specifications admit a large range of creative technology innovations, such as advanced radiation-hardened microelectronics, and advanced microelectronics packaging. Proposers are encouraged to explore the use of commercial algorithms, such as AES, and to devise effective architectures for integrating ECUs with other communications equipment.

PHASE I: Develop a design that meets the requirements for a Type 1 certified encryption device as outlined above. The effort should include a plan for Type 1 certification of the final design.

PHASE II: Finalize the design, fabricate the design, and test the design developed in Phase I for proof of operation and ability to be certified. Finalize the steps necessary for Type 1 certification.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Work with other industry partners and DoD offices to obtain NSA certification and develop a low-cost product line for AF or other DoD customers.
Commercial Application: Although the target customer will be DoD spacecraft with secure tactical links to theater warfighters, additional markets include next generation micro-satellites for secure commercial communications.

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KEYWORDS: space communications, encryption, radiation-hardened electronics, fault-tolerant electronics, secure communication

AF121-071 TITLE: Multi-function Laser Module (MFL) for Enhanced Space Surveillance

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop innovative laser-based technologies and design concept that can provide flexible capabilities in high-precision tracking and characterization of Low Earth Orbit (LEO) space objects.

DESCRIPTION: Laser tracking of remote objects can provide enhanced surveillance capabilities in terms of detailed characterization of the object, including the range, velocity, structural dynamics, coherent imaging and other parameters essential for object discrimination. Active laser tracking (ALT) has been successfully demonstrated with a cooperative object on the ground and in the air. Bringing the ALT technology to the level adequate for characterization of LEO space objects will require a significantly up-scaled laser module of the tracking system. The required operational performance of such a laser module should include the ability to combat losses along an extended propagation path, mitigation of the effects associated with atmospheric turbulence, and use of the object-scattered light for object characterization. In addition, the multi-function laser module (MFL) should harmonize the operation and performance of other on-board surveillance elements, including imaging and non-imaging sensors (subpixel processing, photometric, polametric, etc.) in order to derive orbital elements, known object parameters, etc. MFL should also provide these sensors with the reference signals and correction factors to improve their performance, fusing and analyzing the sensor signals to derive the data complimentary to that of the coherent sensor. Such operational requirements transform the laser-tracking unit into a MFL.

The objective of this topic is to develop an innovative laser-based technology and design concept of a ground-based MFL in support of the operation and control of an integrated multi-sensor space surveillance system. It is expected that the proposed MFL should enable the down-range resolution of 1 cm and velocity measurement accuracy of 1m/sec, while supporting the operation of other incoherent passive sensors by providing information essential for correcting the received signals. The MFL should support, control and synchronize the performance of a suite of passive sensors, to provide an enhanced space surveillance pattern. Distinctive MFL features should enable a high-resolution estimation of the object's orbital parameters, and its velocity, while a suite of passive sensors provide a rich set of multi-band imaging data. The module should be capable of delivering a steady signal/data stream for detection and tracking of the object in a cluttered environment for its characterization, discrimination and identification. Besides laser tracking, the multi-functional operations include support of the fusion of the various passive sensor modalities (imaging, subpixel and parametric) to extract the situation and significance information derived from these data streams.

PHASE I: Develop novel conceptual designs of the MFL to sufficient detail to allow accurate estimation of its performance and risk analysis. Deliverables include the preliminary prototype design of a selected MFL design and a final report.

PHASE II: Based on the findings from Phase I, develop a prototype MFL ready for assessment in a realistic operating environment. Detailed assessment should be accomplished through a field-test.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Tracking of low observable aerial targets, test flights, and test launches of missiles will benefit from the results of this research.
Commercial Application: The precise tracking and illumination of satellites and aerial platforms have the potential to greatly enhance geodesy, navigation, and aerial photography.

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KEYWORDS: space surveillance, laser tracking, long range, coherent sensor, data fusion

AF121-072 TITLE: Dual-mode Wavefront Sensor for Space Surveillance

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate innovative dual-mode (passive and active) wavefront sensing technology capable of characterizing the optical wavefront in the image-resolved operational scenario.

DESCRIPTION: Adaptive optics (AO) methods are typically used to mitigate atmospheric turbulence-induced aberrations, enabling imaging with the resolution close to diffraction limited. These systems require operation in

high scintillation environments where branch points occur in the phase of the propagating laser beam. AO systems are effective for compensating atmospheric turbulence at low scintillation levels, where the intensity variance is less than one that is typical for astronomical applications. However, for applications that involve imaging over a long path, the cumulative turbulence effects can easily defeat the conventional technologies for adaptive optics. In this regime, deep atmospheric perturbations result in high levels of scintillation, branch points, and small coherence length Fried parameter (r0), resulting in imagery with a considerable reduction in information content compared to a diffraction-limited system with the same size aperture. Improvement and enhancement of imaging quality of any ground-based space surveillance system requires innovative approaches that enable an express measurement of large-amplitude wavefront errors on imaged-resolved objects.

This topic calls for a ground-based, dual-mode wavefront sensor (WFS) that can operate with an active laser beacon, as well as in a passive regime using the object-scattered light for data recovery. Since the surveillance system may have a ground-based, marine or airborne deployment, the measuring cycle should be performed almost in real time. The errors in WFS data associated with the mechanical instability of such a mobile platform and rapidly changing atmospheric perturbations have to be accounted for in the analysis of the proposed WFS performance. The solution should include thorough analysis of requirements and performance evaluation of the proposed WFS and should demonstrate a good grasp of all realistic effects, such as signal-to-noise in high scintillation and all forms of anisoplanatism.

Develop a proof-of-the-concept breadboard of a dual-mode (passive and active) wavefront-sensing system capable of characterizing the wavefront in the extended-scene imaging scenario.

PHASE I: Conceptualize and design an innovative dual-mode wavefront sensor, and demonstrate in simulation that the proposed design is feasible for operation in a high-scintillation, branch-point environment. Provide a complete analysis of the proposed system, risk assessment, final report, including the initial system design and performance assessment.

PHASE II: Build, test and demonstrate a laboratory extended-scene large amplitude wavefront sensing prototype with both hardware and software. Perform complete testing of the laboratory prototype system under various (active and passive) lighting and atmospheric conditions. Investigate ruggedizing the design and developing a real-time operational implementation code.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The products can be used to improve the spatial-temporal resolution, lower the noise floor and readout of 3D image construction for military laser systems.
Commercial Application: The products can be used for collision avoidance, monitoring of Low Earth Orbit (LEO) space debris and aerial vehicles, free-space communication and air turbulence monitoring at airport.

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KEYWORDS: Sensing, Wavefront, Imaging, Adaptive Optics

AF121-073 TITLE: Anti-reflective Coating for High-Efficiency Solar Cells

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an advanced broadband antireflective coating active from ~300 to 1800 nm to enable high-efficiency solar cells.

DESCRIPTION: Currently used GaAs-based solar cells rely on a TiOx/Al2O3 coating to minimize reflection in the range of interest for energy conversion. The coating is sufficient for currently used triple-junction cells, but solar cells in development and future solar cells will suffer from inadequate antireflection of this coating in the longer wavelength (>900 nm) regions of the spectrum.

A new cell level antireflective coating (ARC) is needed that has reflectance less than 5% over the spectral range of 300 to 1800 nm and over a wide range of incident angles (+/- 45 deg). The coating must be optically matched and compatible with “inverted metamorphic” solar cell technologies and currently used adhesives/coverglass technologies.

The technology should be capable of supporting a 15-year mission in Geosynchronous Earth Orbit (GEO) or Medium Earth Orbit (MEO) and 5 years in Low Earth Orbit (LEO) after 5 years of ground storage with a degradation of less than 1% (< 1% solar cell power loss due to change in reflection and/or absorption in ARC).

PHASE I: Develop one or more candidate antireflective coating replacement materials. Show feasibility through modeling of candidate materials, at a minimum. Testing of some candidates would be of great interest if time and funding permit.

PHASE II: Using the lessons learned from Phase I efforts, develop prototypes and continue work to optimize and increase the Technology Readiness Level (TRL). The prototype should be subjected to a complete complement of pathfinder space environmental testing and characterization tests. Test conditions should be governed by AIAA S-111-2005. Coatings should demonstrate less than 5% reflectance loss over the spectral range of 300-1800 nm.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: All DoD Spacecraft use solar arrays for electric power generation. Development of coatings with superior properties will improve array operating performance.
Commercial Application: Commercial communications spacecraft and NASA spacecraft would use this technology.

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KEYWORDS: solar cells, multijunction, antireflective coating, space environment protection, coatings

AF121-074 TITLE: Wide Field of View (FOV) High Gain Pulse Optical Amplifier

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate a high-gain,Wide Field of View (WFOV) optical amplifier of a short pulse laser emission that satisfies requirements and needs of an active laser tracking sensor.

DESCRIPTION: Active Laser Surveillance (ALS) technique is an effective tool for tracking and comprehensive characterization of remote objects. Existing laser systems do not meet the criteria required to accomplish this function in terms of the optical gain, Field of View (FOV), pump efficiency and form factor, especially when the mobile space surveillance systems are of interest. In order to satisfy the Space Situational Awareness (SSA) needs and provide the amplification required for a steadfast detection of a low-intensity optical signal, the preferred ALS system should ensure: (1) Wide FOV > 50 mrad; (2) Optical gain (for a non-saturating signal) > 30 dB per a single path; (3) Spectral band max at 1 um, (4) Gain durability up to 5 msec; (5) Unaltered wave-front of the transmitted signal with M2 < 5; and (6) Size, Weight and Power (SWaP) design at nominal form-factor.

Development of an optical amplifier technology with the above-cited operational parameters requires optimization of multiple design factors, including suppression of the super-luminescence, lasing of spurious-modes and thermal management. While the first two effects result in a decreased gain coefficient, a typical outcome of the ineffective thermal management introduces volumetric thermal distortions of the gain medium, resulting in aberrations of the wavefront of the transmitted signal. The proposed design concepts should account for all these constraints and related issues and minimize their effect on the quality of the transmitted signal.

Through modeling, simulation and experimental verifications complete a preliminary assessment of performance of the selected techniques. Provide a preliminary design of the module to be developed during Phase II. Verify noise figure and bandwidth capability that can meet requirements for active laser tracking and pointing in real operating environment.

Successive increase of the Technology Readiness Level (TRL) of this concept through incremental development, demonstration and validation with SBIR support will facilitate the transition of the resulting SBIR technology to an acquisition program. The government will integrate this technology, together with other relevant technologies, to implement a separate system level demonstration and performance validation of the Transportable Advance Integrated Multi-Sensor System (T-AIMS) concept.

PHASE I: Explore alternative design concepts for an optical amplifier that combines wide-field-of-view, high gain at low level of noise and aberrations of the transmitted wavefront. Select a preferred approach and assess its feasibility.

PHASE II: Using the Phase I design concept, integrate the version of the imaging optical amplifier that meets most space surveillance needs and requirements. Test the devices to determine its output and efficiency over a range of operating conditions likely to be required for ALS applications and optical communications at LEO range.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The technology developed under this effort will be used to advance the maturity of a Government reference concept/design named Transportable Advance Integrated Multi-Sensor System (T-AIMS).
Commercial Application: The technology will be used to advance the maturity of the space surveillance laser tracking system, which has the potential to enhance military or commercial geodesy, navigation and aerial photography.

REFERENCES:
1. Koechner, W., "Solid-State Laser Engineering," Springer, 1999.

2. Koechner, W. and M. Bass, "Solid-state Lasers: A Graduate Text," Springer, 2003.

3. Brignon, A. and J. P. Huignard, "Phase Conjugate Laser Optics," Wiley-IEEE, 2004.

KEYWORDS: active laser surveillance, optical amplifier, wide field-of-view, optical amplification

AF121-075 TITLE: Rigid-Panel-Solar-Array Deployment Synchronization Mechanisms for Rapid Assembly and Reduced Cost

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop modular deployment synchronization technologies for rigid-panel solar arrays.

DESCRIPTION: Conventional rigid-panel solar arrays are typically deployed with either complex mechanisms or dynamically-tuned and damped hinges. Both approaches are typically engineered such that altering the number of panels incurs a significant amount of recurring engineering. For example, the mechanisms may only work with a specific number of panels, and adding two more panels would require a new mechanism to be designed, built, and qualified. With dynamically-tuned hinges, changing the number of panels requires new, uniquely designed hinges. A panel deployment synchronization technology that is not specific to the number of panels is needed. The technology must be unmodified and identical on each panel (i.e., not customized for a specific panel location) and allow for synchronization of a minimum of two panels and maximum of five panels. Unlike past arrays, this mechanism will enable solar arrays that are modular at the structural level as well as the panel level.

State-of-practice solar arrays are typically constructed based on point designs for specific missions. Designing, fabricating, and performing space-qualification testing on these arrays requires significant time and effort. In addition, conventional-array repairs during spacecraft integration caused by dropped tools or other integration mishaps require expensive touch labor and can delay the entire spacecraft integration flow. Delay of the spacecraft integration flow results in a schedule delay and high "stagnant" manpower cost (integration personnel being paid to

wait for solar-array repairs to be completed). An added disadvantage of the conventional in-line solar-panel repair is questionable qualification traceability that brings space survivability into question. With the stated conventional approach to solar-array design, fabrication, and integration, it is difficult to achieve low-cost, highly-reliable solar arrays that minimally impact spacecraft integration timelines. The goal of this topic is to identify and develop innovative, standardized, modular deployment synchronization concepts that enable quick array design, simple integration, and easy module replacement with qualification traceability. At a minimum, the solar-array performance metrics of the concept (specific power, stowed efficiency) must equal the current state-of-practice values (50 W/kg, 10-15 kW/m^3). However, it is anticipated that designs will exceed the conventional solar-array performance metrics. Modular solar-array designs are sought for state-of-practice space solar cells, high-efficiency inverted metamorphic solar cells, and thin-film photovoltaics (a-Si, CIGS).

The solar-array deployment synchronization mechanisms technology should be capable of operation in a Low Earth Orbit (LEO) for 5 years and in a Geosynchronous Earth Orbit (GEO) or Medium Earth Orbit (MEO) for 15 years after storage on the ground for 5 years.

PHASE I: Develop conceptual designs of the proposed approach based on preliminary analysis. Perform sufficient analysis and/or hardware demonstration of the kinematic functionality of the synchronization technology of the proposed design concept to show feasibility. Identify key technical challenges for Phase II.

PHASE II: Using the lessons learned from Phase I, design and fabricate a prototype that is clearly traceable to spacecraft integration. Rapid design, fabrication, integration, and line replacement should be clearly demonstrated on hardware at a system level.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Technology developed will be applicable to all military space platforms. Expected benefits include increased reliability (assured operation), reduced integration time, and reduced cost.
Commercial Application: Commercial applications will benefit from the developed technology through decreased solar array design, fabrication, and integration costs.

REFERENCES:
1. Weilun, C., et al, “Solar Array and High Gain Antenna Deployment Mechanisms of the STEREO Observatory,” Proc. AIAA SPACE 2007 Conference.

2. Barrett, R. et al, “Design of a Solar Array to Meet the Standard Bus Specification for Operation Responsive Space,” Proc. 48th AIAA Structures, Structural Dynamics and Materials Conference, 2007.

KEYWORDS: modular solar array, deployment synchronization, solar array standardization

AF121-084 TITLE: Automated Distributed Data Fusion of Correlated Space Superiority Events

TECHNOLOGY AREAS: Information Systems, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop technologies that would perform space system threat detection and data fusion using disparate space events.

DESCRIPTION: Numerous space-system decision-support tools are under development which focus on the monitoring and detection of events with satellite telemetry, space weather, intelligence, or the orbital catalog. Less mature are technologies focused on the aggregation of events that may be occurring across distributed heterogeneous data sources and the correlation of these activities for higher-level situational awareness; in the data-fusion literature this is often referred to as Level 2 fusion. The objective of this topic is to develop technologies to perform level 2 fusion for space situational awareness. Of particular interest are algorithm robustness and validation. Existing fusion systems, such as, but not limited to, the Joint Directors of Laboratories (JDL) and Endsley fusion models, exist and so enable the modular design of detection, correlation, assessment, and response components. Candidate proposals for this topic should consider one of the existing fusion architectures and document their selected approach. A realistic demonstration using a candidate set of data sources and threat scenarios should be used and/or developed. Compatibility with net-centricity would be of high interest.

PHASE I: Provide a detailed description of the proposed approach along with applicable threat scenarios, data sources, and output conditions. The offeror should also deliver a plan for demonstrating the approach.

PHASE II: Extend the approach developed in Phase I, using at least three data sources with a robust set of threat scenarios using a realistic test environment, The deliverable consists of a document for the architecture, plus advantages and disadvantages of the approach. Highly desirable would be a robust demonstration using live data sources.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Tools for more effective and efficient management of military spacecraft operations.
Commercial Application: More efficient and effective satellite operations at NASA centers and commercial satellite operators.

REFERENCES:
1. Lee, Robert, "Anomaly Detection Using the Emerald Nanosatellite On- Board Expert System," http://academic.research.microsoft.com/Publication/11969648/anomaly-detection-using-the-emerald-nanosatellite-on-board-expert-system.

2. Linas, J., and C. Bowman, "Revisiting the JDL Data Fusion Model II," http://academic.research.microsoft.com/Paper/2351314.aspx.

KEYWORDS: Space situational awareness, data fusion, satellite anomaly detection

AF121-085 TITLE: Advanced Algorithms for Space-Based Next-Generation Infrared Sensor Exploitation

TECHNOLOGY AREAS: Information Systems, Battlespace, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop advanced algorithms to improve multiple, closely-spaced object detection and state vector estimation for space-based, next-generation infrared (IR) sensors viewing cluttered scenes.

DESCRIPTION: This topic seeks innovative algorithms for closely-spaced object detection and tracking. Space-based sensors provide enhanced worldwide missile detection and tracking capabilities, as well as battlespace awareness and intelligence data. There is a need for development of advanced algorithms that can provide real-time

exploitation of this increased data volume using limited processing and bandwidth resources. There is potential for these algorithms to exploit improvements in resolution and sensitivity to detect and track closely-spaced objects over longer durations (enabling improved state vector estimation for trajectory prediction and multi-sensor hand-off), and to detect and track closely-spaced low-observables, such as midcourse ballistic missiles and lower altitude maneuvering targets, that cannot be detected with current wide field of view (WFOV) staring sensors. More specifically, a requirement is the development of algorithms to effectively detect and track large numbers of low-observable targets, which may maneuver in close proximity, and which may have intensities varying by two orders of magnitude or more. These closely-spaced objects may be unresolved, and only distinguishable with centroiding techniques or super-resolution methods. Additionally, a requirement is the development of algorithms to effectively suppress stationary and non-stationary background clutter, including solar scattering by clouds and aerosols, or from infrared airglow emissions, aurora, glint off sea surfaces and reflectance and emission from varied natural and man-made terrain features. This topic solicits development of innovative algorithms that can be shown to be implementable in an appropriate combination of satellite and/or ground-based enhanced processors, taking into account computation, storage, and communication resources.

PHASE I: Demonstrate feasibility of proposed algorithmic approach for providing significant improvements in low-observable, closely-spaced-multiple-object detection and state vector estimation using space-based IR sensor data. The deliverable shall be a report that documents the algorithmic approach, preliminary results, trade studies, and feasibility analysis.

PHASE II: Develop prototype algorithms into a tested software tool. Demonstrate ability to meet operational specifications for rapid detection and computing limitations. Validate with simulated and real-world data that demonstrates the potential for the developed algorithms to detect and discriminate closely-spaced objects in a cluttered background environment and near the Earth limb. The deliverable shall be software that demonstrates the implemented algorithm operating on simulated or real-world data.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: First use is envisioned for future enhancements of Space-based Infrared System (SBIRS), but could also be applied to the Space Surveillance Tracking System (STSS) operating in the wider-field of view (FOV) target acquisition mode.
Commercial Application: Concept may be useful for monitoring debris in lower-earth orbits, or for aircraft and traffic monitoring from higher-altitude aircraft.

REFERENCES:
1. Smith, M. “Military Space Programs: Issues Concerning DOD’s SBIRS and STSS Programs,” CRS Report for Congress, Congressional Research Service, The Library of Congress, Order Code RS21148, Updated January 30, 2006. http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=5514; http://www.mda.mil/mdaLink/pdf/stss.pdf.

2. Zacharias, N., S.E. Urban, M. I. Zacharias, G. L. Wycoff, D. M. Hall, D. G. Monet, and T. J. Rafferty, “The Second US Naval Observatory CCD Astrograph Catalog (UCAC2),” Astronomical Journal 127:3043-3059, 2004.

3. Ewart, R., J. Jacquot, and P. Lew, “Space Algorithm Testbeds - Small Business Pipeline for Technology Innovation,” AIAA Space 2009.

4. Fernandez, M., A. Aridgides, and D. Bray, "Detecting and tracking low-observable targets using IR," SPIE Proceedings: Signal and Data Processing of Small Targets, (O.E. Drummond, Ed.), Vol. 1305, pp. 193 (1990).

5. Korn, J., H. Holtz, and M. S. Farber, "Trajectory estimation of closely spaced objects using infrared focal plane data of an STSS platform," SPIE Proceedings: Signal and Data Processing of Small Targets, (O.E. Drummond, Ed.), Vol. 5428, pp. 387, 2004.

6. Tartakovsky, A., A. Brown, and J. Brown, “Enhanced Algorithms for EO/IR Electronic Stabilization, Clutter Suppression, and Track-Before-Detect for Multiple Low Observable Targets,” AMOS, 2009.

KEYWORDS: Space-based-sensing, closely-spaced objects, clutter suppression, low-observable-targets, multiple-target-tracking

AF121-086 TITLE: Omni-directional Adaptive Imaging Sensor

TECHNOLOGY AREAS: Sensors, Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an omni-directional imaging sensor with a reconfigurable architecture to characterize space objects.

DESCRIPTION: Space-based surveillance sensors for proximity protection should have the capability to acquire, track and characterize, on an effectively continuous basis, imminent threats posed by objects or space debris surrounding the space asset. An imaging sensor with spherical or complimentary hemispherical coverage is needed, with the capability to observe all directions simultaneously with appropriate resolution and frame rate. Once a set of threats has been acquired, the performance of the imaging sensor should rapidly adapt to higher frame rates and resolution to better characterize and track multiple objects moving at different angular rates relative to the space platform.

Considering the deployment of this sensor on a space platform, small form factors and no mechanical movement are essential architectural requirements. A wide-field-of-view capability is needed to search, detect and track an object in surrounding space, while a narrow-field-of-view system is required for reliable identification and characterization of the target. Acquisition time better than 30 frames per second, imagery with resolution better than 10 micro-radians, and scalable magnification factor from 1:1 to 1:25 are required due to the relative high speed of the objects of interest. Solutions should also display resilience to anticipated countermeasures.

The overall goal of this topic is to create a paradigm shift in developing an innovative modular Wide Field of View (WFOV) active/passive space surveillance module while being constrained to small form factors. Innovative approaches are sought that can satisfy all of the functional and operational requirements.

PHASE I: Demonstrate the feasibility of the proposed imaging module, employing a combination of simulation and testing with distant ground or air objects.

PHASE II: Fabricate and assemble a prototype of the imaging module and demonstrate ground based acquisition and tracking.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Space asset protection, tracking of rocket and mortar launches, UAV situational awareness, perimeter security of airbases, and first responders for homeland security.
Commercial Application: Situational awareness for maneuvering large vehicles, security for large areas such as airports.

REFERENCES:
1. Matuski, W., H. Pfister, A. Ngan, P. Beardsley, and L. McMillan, "Image-Based 3D Photography Using Opacity Hulls," In SIGGRAPH '02, 427.437, 2002.

2. Nagahara, Hajime, Yasushi Yagi, and Masahiko Yachida, "Super Wide Field of View Head Mounted Display Using Catadioptrical Optics," Presence, Vol. 15, No. 5, p. 588-598, 2006.

3. Li, Daqun, Jame J. Yang, and Michael R. Wang, "Wide Field-of-View Target Tracking Sensor," Proc. of SPIE Vol. 7307, p. 73070F, 2009.

KEYWORDS: Wide-field-of-view, narrow-field-of-view, spherical coverage, target search, detection and characterization

AF121-087 TITLE: Automation of Satellite On-orbit Checkout and Calibration Process

TECHNOLOGY AREAS: Sensors, Space Platforms

OBJECTIVE: Development of technologies that will enable automation and time minimization of the satellite on-orbit checkout and calibration process in support of Operationally Responsive Space class systems.

DESCRIPTION: In today's environment Air Force satellites require a lengthy on-orbit checkout process before being placed into operation. Depending on payload type, this period can last from weeks to several months. Prototypes have been developed that perform functional checkout of satellite bus components autonomously via on-orbit scripts. In the near term, and with the acceptance of some risk and good software engineering, functional checkout of a satellite can be implemented autonomously with on-board scripts or models. In general, more complex methodologies are needed to perform autonomous payload calibration. In particular, the calibration of imaging sensor payloads can be very labor intensive, requiring nonlinear processes that are difficult to automate. Autonomous calibration of these payloads requires more sophisticated reasoning systems that may require adaptive learning. In addition, in some cases, fundamental sensor designs may be limiting factors in achieving long-term requirements of being able to perform rapid on-orbit checkout in less than one day. It is still unclear how close we can come towards achieving the one-day requirement through intelligent software design and at what point fundamental sensor design changes are needed. The objective of this topic is to explore this boundary for a representative set of sensors which would include electro-optical/infrared (EO/IR).

Proposals are sought that will analyze this problem and develop technologies that will help perform autonomous calibration for the representative set of sensors. These proposals can be in the form of intelligent software algorithms and methodologies, fundamental design changes, or both. Careful consideration should be given to how the proposed calibration method would fit within the overall on-orbit checkout process of the satellite. Significant time savings may also be achievable by performing some level of calibration on the ground prior to launch. A strong proposal should contain a system-level approach in which ground checkout prior to launch flows into on-orbit checkout. Proposals that provide a solution that contains both bus checkout and payload calibration are strongly encouraged.

PHASE I: The objective of Phase I is to provide a detailed analysis of the problem described and to propose a design which would optimize the payload calibration process with particular attention paid to time required. If feasible, a prototype demonstration is strongly encouraged.

PHASE II: The objective of Phase II is to extend the work performed in Phase I and to provide a detailed design and demonstration of on-orbit sensor calibration working in conjunction with full bus checkout. Demonstrations using actual hardware are encouraged.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The proposed technology has high relevance to the spacecraft mission class Operationally Responsive Space (ORS).
Commercial Application: This proposed effort has equal applicability to the commercial satellite domain. NASA has spacecraft programs that could directly benefit from this research.

REFERENCES:

1. High Frontier: The Journal for Space and Cyberspace Professionals, Volume 6, Number 3, May 2010.

2. "Latest GPS Satellite Early Orbit Checkout Extended," GPS World, June 2009, http://www.gpsworld.com/gnss-system/news/latest-gps-satellite-early-orbit-checkout-extended-7108.

KEYWORDS: Satellite on-orbit checkout, satellite automation, satellite autonomy, satellite payload calibration

AF121-090 TITLE: Modeling of Synergistic Effects for Cooperative Strike

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Improve assessment methodology to consider multiple weapon effects on a diverse or sparse set of targets. Requires new assessment & visual analytics to address synergistic effects, collateral damage, cumulative damage & multiple engagement tactics.

DESCRIPTION: Current weaponeering and engineering-level effectiveness methodologies treat weapon target encounters as singular or area events. The targets are single entities (elements) with fixed properties or uniform distributions of fixed elements. Once the encounter is complete, the damage is tabulated and a Pk is assigned.

In many current weapon engagement scenarios or "vignettes" of interest, targets are distributed in the scene and can have changing properties or mitigation. They may be attacked by a single weapon, multiple weapons simultaneously, or with an array of weapons distributed in time and space. We call these cooperative strike vignettes. To produce a weaponeering solution or independent assessment of a vignette or engagement scenario of this nature, requires novel modeling approaches. Currently many of these vignettes are created using the sum of multiple 1-v-1 encounters. This approach is not very efficient or analytically inaccurate for mission planning.

If the same target is attacked again, it is modeled in pristine condition because the current tools do not save details about the state of the target once the encounter is complete. There is no accredited modeling approach with the means to attack a damaged target and determine the additional damage caused by the second attack. With the desire to employ smaller precision munitions, more targets may require attacks using multiple munitions to achieve the desired level of damage. Likewise, in most encounters, the assessment is only made against the single target, without simultaneously considering potential damage to neighboring elements or people (collateral damage) from multiple weapon engagements.

In order to be useful to the analyst or warfighter, the methodologies will need to be computed quickly. Most engineering level models may produce an output in a matter of minutes or hours. Answers in a warfighter (weaponeering) tool are expected in seconds. A capable progression for the modeling tools from an engineering level simulation to weaponeering level calculations will be desired. The new analytical product will need to consider multiple targets, multiple weapons, multiple attacks, with temporal (delays) and spatial (relocation) variations occurring during and between the individual attacks.

PHASE I: Leverage state-of-the-art M&S: digital simulation, animation, and advanced design-of-experiments methodologies to provide visual analytics with sound statistical modeling to assess multiple small munition engagement from potentially multiple platforms in a complex target scene or vignette.

PHASE II: Devise a means to determine and test the accuracy of these new methodologies. Adapt or integrate methodologies into accredited weaponeering or analytically accredited effectiveness models.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Improved weaponeering tools for the warfighter. Improved tools for the engineering community to compare and contrast weapon concepts and tactics.
Commercial Application: Potential applications for visualization techniques, statistical applications, accident investigations, and failure analysis.

REFERENCES:
1. www.ajem.com

2. http://www.ara.com/Projects/p_MEVA.htm

KEYWORDS: Combined effects, distributed attack, lethality, vulnerability, modeling & simulation, weapon assessment, vignette analysis, cooperative attack, irregular warfare, collateral damage, mitigation

AF121-091 TITLE: Miniature High-Altitude Precision Navigation Alternative

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Demonstrate a precision navigation system suitable for high altitude, high-speed applications without the aid of GPS. System performance should approximate currently available strategic navigation systems for munitions.

DESCRIPTION: Precision navigation without the use of GPS has received more attention from the warfighting community recently. The ability to maintain precision navigation without GPS is challenging. Current IMUs alone have too much drift to maintain necessary precision, unless aided by additional sensors or signals. For high altitude, EO/IR tracking of ground features becomes untenable when there is cloud cover. Other methods, or combination of methods, are required to achieve the necessary navigation precision for high-altitude, high-speed weapons in all-weather scenarios.

The Phase I effort should propose an innovative navigation system that meets the environmental and operational conditions below, with near-GPS precision without using GPS. The system is not limited to a single sensor. A combination of sensors and IMU devices is acceptable, as long as the software that filters/merges all information is included. Any components of the proposed solution that are not commercially available must be designed by the offerer as part of the SBIR effort. For Phase I, the new designs may be simulated for the purpose of demonstrating feasibility to meet the requirements, but for Phase II, the designs need to be developed into prototypes.

Vehicle operating environment:
1) weapon will be launched from an air vehicle;
2) no GPS is available during flight;
3) high altitude (up to 70,000 feet);
4) high speed (transonic through high supersonic);
5) all-weather

Navigation system requirements:
1) navigation system should weigh less than 20 pounds, but show a clear path to further miniaturization;
2) passive sensors are preferred, but sometimes-on active sensors may also be needed

The proposal needs to consider position initialization schemes. Initialization may be accomplished by information handoff from launch aircraft or from another source, early absolute position fix by the weapon itself, or a combination. For handoff, assume before launch that a quality aircraft navigation solution has been provided.

PHASE I: Develop models, code, and simulations to adequately demonstrate that proposed navigation solution meets the requirements. Compare the proposed concept to available GPS accuracies.

PHASE II: Build and demonstrate prototype hardware and software. Demonstration with surrogates, simulations, and scaled environment may be acceptable, provided analysis is presented that justifies testing assumptions. Deliverables include hardware and software prototypes, demonstration report and simulations used, comparison of prototype results to Phase I concept simulation and to GPS solution.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: As a GPS backup to any autonomous USAF air vehicle (weapon or UAV). Could also be a GPS backup to manned military aircraft.
Commercial Application: Potential application to a commercial supersonic passenger or cargo aircraft, or NASA air vehicle.

REFERENCES:
1. "United States Air Force Chief Scientist (AF/ST) Report on Technology Horizons: A Vision for Air Force Science & Technology During 2010-2030", Volume 1, AF/ST-TR-10-01-PR, 15 May 2010.

2. M. Jun, "State Estimation for Autonomous Helicopter via Sensor Modeling," Journal of the Institute of Navigation, vol. 56, no. 2, 2009.

KEYWORDS: navigation, non-GPS navigation, alternate navigation, IMU, passive sensors, all-weather navigation sensors

AF121-092 TITLE: High-Speed Weapon Radomes

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research innovative technologies for high speed weapon seekers to enhance survivability of radomes/windows while preserving sensing performance.

DESCRIPTION: A new class of weapons which travel in the Mach 3-6 speed regime require new and advanced seeker technologies for precision terminal guidance. Traditional RF/IR seeker sensor approaches may experience severely degraded performance by environmental factors due to weapon speed and terminal trajectories through the atmosphere. Aero thermal effects, boundary layers, rapid accelerations, vibrations, and flight envelopes all push bandwidth, range, and survivability limitations of conventional seeker systems. Particularly problematic is the survivability and functionality of seeker sensor apertures due to exposure to large thermal gradients and boundary layers. Depending on seeker window/radome configuration, very high temperatures can be experienced by the

seeker window. Expected temperatures for windows and radomes exposed to the airstream are up to 1250K. Current radome/window technologies and approaches are poorly equipped to handle these environments without further advancements. Therefore, direct or indirect approaches to survivable and durable windows/radomes while considering sensing performance in a high temperature and dynamic environment are needed.

Possible areas of study which directly address survivability and functionality through the environment are high temperature materials, multi-band/wide-band materials, more durable materials, active cooling concepts, and conformal phased array antennas. Indirect ways of protecting seeker apertures such as innovative mechanical shrouding for protection through mid-course and innovative optical layouts (i.e. multi-aperture) are of interest. With respect to functionality in the environment, techniques for imaging through boundary layers via mechanical designs or signal processing, and radar performance at high squint angles (as it is related to aperture design and placement) could also be considered.

Notionally, the weapons of interest will be air launched and both air-to-air and air-to-ground missions will be considered. For high speed engagements, the terminal phase starts at long ranges and has a very short timeline. Target phenomenology of interest is in the RF, MWIR, LWIR, multi-band RF/IR.

A portion of the results from a thermal analysis for a notional weapon can be requested by winning offerers. The thermal analysis utilized computational fluid dynamics simulations to assess stagnation point temperatures for common window/radome materials for different orientations in the flow field. Successful technologies developed under this SBIR could be utilized by seeker phenomenology experiments as early as FY13.

PHASE I: Demonstrate feasibility of approach through analysis of proposed technology. Research should capitalize on modeling and simulation for proof of concept. Develop a plan for phase II research.

PHASE II: Develop prototype(s) based on Phase I findings and perform proof of concept experiments utilizing those prototypes. Delivery of functional prototype(s) to government is desirable. Leveraging wind tunnels or other national assets for thermal and environment experiments should be considered in Phase II execution where possible/relevant. Where prototype development or testing is cost/schedule prohibitive, detailed modeling and corresponding experiments may be appropriate. Models will be deliverable to the government.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High speed weapon seekers for execution of air-to-air and air-to-ground missions. High speed aircraft requiring electromagnetic apertures.
Commercial Application: Any application where sensing in hostile environments is necessary such as high temperature manufacturing, instrumentation for the physical sciences, and the commercial space market.

REFERENCES:
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2. Klein, C. A., Gentilman, R. L., "Thermal Shock Resistance of Convectively Heated Infrared Windows and Domes", SPIE Vol. 3060, 1997.

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KEYWORDS: Seeker, High Speed, Hypersonic, Guidance, Radome, Aero-optics, Boundary layer, High Temperature

AF121-095 TITLE: Mobile Target Secondary Debris (MTSD)

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop instrumentation and a methodology to quantify and assess secondary debris when a mobile target (or collateral concern) is affected by a conventional weapon explosive event.

DESCRIPTION: With the concern over collateral damage caused by a conventional weapon explosive event, different types of damage mechanisms must be considered. One of these is secondary debris from the target or from nearby non-targets. Secondary debris has been widely known to cause damage/injury to collateral concerns but the capability to predict it is lacking must be determined.

Mobile targets or nearby mobile non-targets (i.e. cars, armored personnel carriers, etc) produce projectiles of concern when they are damaged by the detonation of a conventional weapon. There is a need to assess and quantify as a minimum the physics (shape, size, speed, and trajectory) of these debris projectiles originating from other than the weapon itself. Then the damage potential of these projectiles needs to be assessed versus nearby collateral concerns.

A methodology and instrumentation must be developed to measure the characteristics listed above for the secondary debris from mobile targets. This data must be collected accurately and economically from weapon tests and quickly reduced to be usable in models and weaponeering tools.

A model must be developed/modified to accept the test data. Then it must be capable of using the data to provide potential effects caused by similar conventional weapons against similar mobile targets or nearby non-targets. Then models must be developed/modified to account for these projectiles versus both targets and collateral concerns to support lethality, risk estimation, and collateral damage estimation. Any software developed must use good software engineering practices.

Finally an implementation plan must be developed to address how the Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS) tools must be updated or redesigned to take this information into account so that the warfighter effectively targets while accounting for these effects.

PHASE I: The contractor will 1) define/quantify the parameters, 2) design/propose an instrumentation suite to collect the parameters, 3) develop a preliminary design for any model(s) to incorporate the data and effects/damage caused by secondary debris, 4) develop an implementation plan, and 5) deliver a final report.

PHASE II: The contractor will 1) build and test the proposed instrumentation suite, 2) collect enough data to validate the equipment and support model development, 3) After data collection, any issues identified in the instrumentation suite will be corrected, 4) implement model(s) design(s) developed in Phase I, 5) update the implementation plan, 6) compare the collected data to the output from the model(s), and 7) deliver a final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The contractor will 1) deliver an instrumentation suite which will collect parameters defined in Phase I/II, 2) implement changes identified by the comparison from Phase II, 3) deliver a final implementation plan, and 4) deliver a final report.
Commercial Application: Commercialization potential exists through the use of these predictive capabilities in the designing of vehicles and buildings resistant to secondary debris from car bombings, IEDs, etc.

REFERENCES:
1. M. M. Swisdak, Jr., J. W. Tatom, and C. A. Hoing, “Procedures for the Collection, Analysis and Interpretation of Explosion-Produced Debris – Revision 1,” Final Report, 22-10-2007.

2. X. Ma, Q. Zou, D. Z. Zhang, W. B. VanderHeyden, G. W. Wathugala, and T. K. Hassleman, “Application of an MPM-MFM Method for Simulating Weapon-Target Interaction,” LA-UR-05-5380, 12th International Symposium on Interaction of the Effects of Munitions with Structures, September 13-16, 2005, New Orleans, LA.

KEYWORDS: secondary debris, JWS, test instrumentation, lethality, risk estimation, collateral damage, mobile targets, projectiles

AF121-096 TITLE: Next Generation Static Warhead Testing (NG-SWaT)

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and develop innovative instrumentation, diagnostic techniques, and methodologies to quantify and assess synergistic blast and/or fragment effects resulting from the static detonation of conventional weapons.

DESCRIPTION: With the concern over collateral damage by a conventional weapon explosive event, improved characterization of the explosive event is required. A better understanding of the damage mechanisms and weapon effects is critical and requires robust methods and accurate techniques. While techniques exist to collect gas pressure, that is not the only damage mechanism. Missing data collection capabilities include: 1) combination of blast and fragments resulting from detonation of most conventional weapons, 2) unique damage mechanisms such as reactive fragments, thermobaric explosives, and MBX type explosives 3) measuring fragment propagation in obscured environments (i.e. within or just outside the fireball associated with the detonation of the weapon), 4) measuring the velocity, weight, volume, and trajectories of free flying fragments without "soft catching" them (i.e. correlating specific velocity with a given fragment without loosing any fragment characteristics currently collected), and 5) measuring the time rate of change (via optical, electromagnetic, or other methods) of temperature, chemical composition, and physical state of warhead detonation products.

Models must be developed/modified to be able to use this data to estimate the same parameters for other similar weapons. The models must also be capable of estimating damage caused by the parameters collected against humans, fixed, and mobile targets to support lethality estimates, risk estimates, and collateral damage estimates. Any software development will be done using good software development processes.

Finally an implementation plan must be developed to address how the Joint Munitions Effectiveness Manual (JMEM) Joint Weaponeering System (JWS) tools must be updated or redesigned to account for this information so that the warfighter effectively targets while accounting for these effects.

PHASE I: The contractor will 1) define/quantify parameters to be collected, 2) design/propose instrumentation suite to collect the parameters, 3) a preliminary design for any model(s) to be created/modified to incorporate the data/effects of these parameters versus humans/fixed/mobile targets, 4) develop implementation plan, and 5) deliver final report.

PHASE II: The contractor will 1) build/test the proposed data collection instrumentation suite/methodologies, 2) collect enough data to validate the equipment/support model development, 3) after data collection, any issues identified in the instrumentation suite will be corrected, 4) develop software model(s) from the preliminary design, 5) update implementation plan, 6) compare data collected to output from software model(s), and 7) deliver final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The contractor will 1) deliver instrumentation suite, 2) implement any changes to the software model(s) indicated by data comparison in Phase II, 3) deliver final implementation plan, and 4) deliver final report.
Commercial Application: Commercialization potential exists in any industry that uses explosives including demolition, mining, tunneling, drilling, gas production through fracturing, and road construction.

REFERENCES:
1. Britt, J. R. and Ohrt, A. P., "The Design and Development of the AFRL Instrumented Blastpad and Analysis of Initial Test Programs," AFRL-MN-EG-TR-2004-7123, Air Force Research Laboratory, Munitions Directorate, Eglin AFB FL, December 2004.

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KEYWORDS: Air Delivered Weapons, Conventional Weapon Effects, Collateral Damage, Blast, Fragments, Synergistic Effects, Test Instrumentation, Diagnostics, Fuel Air Explosives, Thermobarics

AF121-097 TITLE: Weapon Burial Secondary Debris (WBSD)

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop methodology to quantify and assess additional damage or potential collateral effects from secondary debris when a conventional weapon detonation is partially or completely buried.

DESCRIPTION: With the concern over collateral damage caused by a conventional weapon detonation, different types of damage mechanisms must be considered. One of these is secondary debris from ejecta when a conventional weapon is partially or completely buried. Secondary debris has the potential to cause damage/injury to collateral concerns that must be determined and minimized for all soil types. Additionally, if the weapon detonates underground next to a buried wall or structure or under a slab like a floor, sidewalk or runway; failure of that structure could result in additional damage or undesirable collateral effects. Current analytic and weaponeering tools are unable to estimate these types of damage or undesirable side effects.

Buried or partially buried conventional weapons produce projectiles of concern from the earth itself, structures penetrated by the weapon (i.e. roadways, sidewalk, etc), and buried nearby structures (i. e. basements, bunkers). In addition, partially buried weapons also have fragmentation and blast characteristics that can create damage. There is a need to assess and quantify the quantity, shape, size, speed, and trajectory of possible projectiles resulting from a partially or completely buried detonation. With that data in hand, analysts can begin to estimate the potential for additional or collateral damage resulting from the detonation.

A methodology and instrumentation must be developed/defined to measure characteristics listed above (as a minimum) for secondary debris from weapon complete or partial burial. A means must be developed to quickly and accurately take this data and estimate the characteristics listed above for the secondary debris from weapon burial. The models must be developed/modified to account for these projectiles versus both targets and collateral concerns to support lethality, risk estimation, and collateral damage estimation.There may already be finite element tools available that can accurately predict and characterize the crater and wall debris, but these analytic tools run too slowly to be useful for the warfighter and most analysts; models simulating these detonations need to complete in a matter of seconds to a minute or two at most. To validate the accuracy of the new tools, debris data must be accurately and economically collected from live weapon tests and quickly reduced to be usable in models and weaponeering tools. Any software development will be written using good software development processes.

Finally, an implementation plan must be developed to address how the Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS) tools must be updated or redesigned to take this information into account so that the warfighter effectively targets while accounting for these effects.

PHASE I: The contractor will 1) define/quantify parameters to be collected, 2) design/propose collection instrumentation, 3) perform a preliminary design for all modeling efforts to estimate these parameters and the damage the secondary debris will do to targets and non-targets, 4) develop an implementation plan, and 5) deliver a final report.

PHASE II: The contractor will 1) build instrumentation suite, 2) generate software model(s) from the Phase I preliminary design, 3) update the implementation plan from Phase I, 4) collect sufficient data to validate the hardware/support software development, 5) compare the data collected to results from the software model(s), 5) after data collection, any modifications needed to the instrumentation suite will be corrected, and 6) deliver a final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The contractor will 1) make modifications required from the results of Phase II for software and hardware, 2) deliver an instrumentation suite, 3) deliver the software model(s), 4) deliver a final implementation plan, and 5) deliver a final report.
Commercial Application: Commercialization potential exists for any application of buried explosives. An example would be hazard predictions for blasting to clear a path for roadways and railways.

REFERENCES:
1. M. M. Swisdak, Jr., J. W. Tatom, and C. A. Hoing, “Procedures for the Collection, Analysis and Interpretation of Explosion-Produced Debris – Revision 1,” Final Report, 22-10-2007.

2. X. Ma, Q. Zou, D. Z. Zhang, W. B. VanderHeyden, G. W. Wathugala, and T. K. Hassleman, “Application of an MPM-MFM Method for Simulating Weapon-Target Interaction,” LA-UR-05-5380, 12th International Symposium on Interaction of the Effects of Munitions with Structures, September 13-16, 2005, New Orleans, LA.

KEYWORDS: secondary debris, JWS, test instrumentation, lethality, risk estimation, collateral damage, bomb burial, buried explosives

AF121-098 TITLE: Guided Munition Delivery Accuracy Methodology for Weaponeering Against Moving Targets (GuMDAM-AMT)

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop software to enhance weaponeering assessments for guided munition attacks against moving targets.

DESCRIPTION: The US military employs the Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS) software to conduct weaponeering assessments for guided munition attacks against moving targets. Current methodologies for generating and assessing delivery accuracy within JWS are limited in that the software is capable of only pairing a single munition against multiple moving targets and then assessing the best results i.e. weapon-to-target pair. Ideally, a more effective methodology would pair all guided weapons of interest against all targets of interest, assess performance for all combinations, and statistically determine the best munition to attack a given moving target. There is a need to research and develop a methodology to assess multiple guided munitions against moving targets.

There are multiple delivery accuracy parameters associated with assessing a guided weapon against a moving target, therefore, there is a need to research, characterize, and quantify these parameters which will then be incorporated into the new methodology. Additionally, research would be necessary to define, characterize and classify a moving target dataset. Key parameters to consider but not limited to would be target mobility, target maneuverability, and Target Location Error (TLE), for all environmental conditions.

Due to the expansive and dynamic nature of the simulation world inside the Air Force, the expected employment strategy envisions software that is not tightly coupled with a specific simulation. It should be flexible so that models developed for one simulation architecture will be usable in another with minimal effort.

As a baseline, the JWS model may then be used to compare the effectiveness of various combinations of guided munition vs. moving target interactions. The resulting research and methodology will provide adequate information to determine the best Standard Conventional Loads (SCL) for the XCAS/XINT (On-call airborne Close Air Support/INTerdiction) arena for moving targets.

Finally, the resulting software module must incorporate a user interface that accommodates the non-expert without hampering the productivity of the dedicated expert. The non-expert should be able to create or adapt models to a specific simulation or scenario without in depth knowledge of the system. However, the frequent user should be able to create new weapon sets quickly and efficiently.

PHASE I: Research and define target sets, develop methodology and parameter requirements, construct roadmap and schedule for the development of the new methodology and data collection toolset. A final report will be delivered detailing the research results.

PHASE II: The contractor shall identify the affected modules in JWS. Using the approach from Phase I, they shall develop the methodology and determine all parameter data required for those modules. The contractor shall develop additional modules as required.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Expand software to produce a weaponeering tool for assessing and optimizing guided munition and moving target pairing. A final report and briefing will be delivered.
Commercial Application: Demonstrate non-military uses of the resulting software in fields such as Homeland Security and border safety.

REFERENCES:
1. AAC/ENO, "Delivery Accuracy Working Group Roadmap for Modeling and Developing Delivery Accuracy Parameters For Munitions Attacking Moving Targets", 6 Aug 2009

2. JWS 2.0.1.

KEYWORDS: Delivery accuracy, weaponeering ,sensors, maneuverability, mobility, moving target ,JTCG/ME, JWS

AF121-102 TITLE: Detection of Hostile Fire from the Remotely Piloted Aircraft (RPA)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a lightweight RPA Wide Field of View (WFOV) sensor system to detect, classify, direction of discharge and geolocate weapons fire, with sufficient accuracy and timeliness to support both direct and indirect engagement.

DESCRIPTION: The Air Force has the mission to perform reconnaissance, surveillance, and target acquisition (RSTA) from RPAs. The challenge is to meet a large area of ground coverage in support of persistent Wide Field of View (WFOV) imaging motion detection sensor systems. WFOV imaging motion detection sensors are typically low frame rate (2-30 Frames/s) compared to a fire detection system (1000-1500 frames/s) and may miss weapon fire events. The goal of this effort is to provide an event (enemy and friendly weapons fire) detection system that can provide real-time notification that can be overlaid on WFOV motion imagery by sensor operators. Data to be provided to sensor operators is to include weapons class (i.e., rifle, mortar, RPG, and shoulder fire missile weapons), direction of fire, location/geocoordinates of fire or general explosive events, and high-heat events such as camp fires and building fires. This sensor must be designed such that it can detect from a minimum altitude of 25,000 feet under live fire captive carry test conditions on a benign battlefield.

Basic sensing technologies and signal processing subsystems must have reduced size, weight, and power (SWaP) for a hostile fire detection sensor on a current or near-term RPA platform to perform this mission. RPAs are becoming the primary platform for persistent battlefield surveillance. The requirement for extended time on station determines to a great extent the available weight allocation for any hostile fire sensor system. Future RPA hostile fire sensor systems will take the form of Line Replaceable Units for legacy sensor payloads currently in use on the RPA fleet; therefore, the SWaP consumption of hostile fire sensor systems must emulate that of previous generation sensor systems without hostile fire sensing capabilities.

The hostile fire sensor system must demonstrate the capability to operate with both low false alarm rates and relatively high probability of detection under operational conditions. The additional capability to perform threat geolocation in support of not only direct attack, but indirect attack, necessitate a close coupling between the sensor system and some form of inertial measurement capability either integral to the sensor or available as part of the mission flight package for the aerial platform. The feasibility of meeting various sensor performance metrics using trade-space analysis must be performed using sensor component characteristics and available field measurements of weapon signatures.

The determination of military utility of a hostile fire sensor will be heavily dependent on its capacity to distinguish between friendly and hostile fire in order to avoid fratricide. There are different levels of fidelity currently defined

for hostile fire sensor systems; most systems currently differentiate among weapon classes, but lack a significant capability to confidently declare a weapon type within a class.

Modeling and analysis is required to show the efficacy of the approach for different classes of threat systems. The prototype design is expected to be heavier and less capable than an operational sensor, but the design should address SWaP traceability between the captive carry prototype and an ultimate operational configuration for the hostile fire sensor. A Phase I/Phase II activity involving high fidelity scene generation, hardware-in-the-loop simulation (HWIL), operational tower and flight testing is desired. The objective is to demonstrate the technology can provide greater than 99 percent false alarm rejection rate and greater than 95 percent detection rate for urban and battlefield small arms and large arms settings. The hostile fire sensor system should be self contained, with the exception of external power, to operate and collect performance data for both ground and air live fire demonstrations.

PHASE I: Design, model, and analyze components for a WFOV hostile fire sensor system for detection of different classes of threat systems. Laboratory demonstration of the critical technology components is desired.

PHASE II: Develop and demonstrate a prototype hostile fire RPA sensor system to support a WFOV live fire evaluation under benign battlefield conditions. Using methods which may include hardware in the loop, tower, and/or flight testing, demonstrate the technology provides greater than 99 percent false alarm rejection rate and greater than 95 percent detection rate for urban and battlefield small arms and large arms settings.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This technology could support Army, Marines and Air Force airborne WFOV Motion Imagery Systems to include Constant Hawk, Gorgon Stare, Angel Fire, Night Stare, and Wide Area Airborne Surveillance systems.
Commercial Application: This capability can also have direct capability for use on police and emergency response aircraft. The sensor can provide geopostional data for high-heat source fires, and urban gun battles.

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Bandpass Near the Potassium D1/D2 Doublet by Karl K. Klett, Jr. ARL-RP-0292 June 2010. A reprint from SPIE Proceedings, Vol. 7697.

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3. L. Zhang; F. P. Pantuso; G. Jin; A. Mazurenko; M. Erdtmann; S. Radhakrishnan; J. Salerno High-speed uncooled MWIR hostile fire indication sensor, SPIE Proceedings Vol. 8012 Infrared Technology and Applications XXXVII, Bjørn F. Andresen; Gabor F. Fulop; Paul R. Norton, Editors, 801219, 20 May 2011.

4. S. A. Moroz et.al, Airborne Deployment of and Recent Improvements to the Viper Counter Sniper System, www.urf.com/madl/papers/Psc06ce3.pdf.

5. S. Snarski, et. al., Autonomous UAV-Based Mapping of Large-Scale Urban Firefights, SPIE Defense and Security Symposium Proceedings Vol. 6209, Airborne Intelligence, Surveillance, Reconnaissance (ISR) Systems and Applications III, Orlando, FL, 5 May 2006.

KEYWORDS: sensors, hostile fire detection, Remotely Piloted Aircraft, RPA, Muzzle Flashes, detection and location, InfraRed, IR, Sniper location

AF121-103 TITLE: Remotely Operated Sensor, Beacon, and Navigation Aid for Deep Battlespace (Remote Sensing)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research the feasibility of developing an expendable, precision deployable, remotely-operated sensor to detect meteorological conditions, vehicle/personnel mobility, and CBRN threats in denied territory.

DESCRIPTION: AFSOC dismounted operators need to clandestinely gather information/intelligence in denied territory to facilitate enroute mission planning, rehearsal, execution, and post mission debriefing. Operators lack modern sensors that can be inserted into denied territory with minimal human risk and be remotely operated to gather/transmit information back to mission planners or operators enroute to the objective. Sensors must be able to pass ground-oriented real-time information (i.e., meteorological data; chemical, biological, and radiological/nuclear [CBRN] threat; and freeze frame imagery) to collection platforms for immediate use. Many unattended ground sensor efforts have been recently conducted but most are too large and heavy for precision deployment from a small UAS platform.

As the operating environment hostility and inaccessibility increases, accomplishing the task of precision placement and removal of sensors, beacons, and navigational aids becomes more difficult; therefore, this SBIR should leverage small unmanned aerial systems for device placement. Previous generation sensors were air dropped, but without precision emplacement. Newer sensors have been parachute dropped, but precision emplacement is lacking. What is needed is precise location emplacement of sensors to within 3 meters of a specific monitoring point. The device also should be camouflaged, expendable, and have a minimal operating “signature” to avoid detection by adversaries. Methodologies within the current defense communication infrastructure for autonomous or polled electronic exfiltration of data and/or remote physical exfiltration of data should be addressed in this design concept. The device should have capabilities for signaling with EO/IR/RF precision location for use in GPS degraded environments.

Communication protocols consistent with Air Force Special Operations Network formats must be included, i.e., multicast UDP/uni-cast TCP and interoperability with the QNT radios. The device should have low energy consumption and be capable of autonomous operation and remote configuration for at least four weeks, but preferably longer, in various operating environments, e.g., high elevation, high heat and humidity, freezing temperatures, rain, etc.

PHASE I: In Phase I, the contractor will address system and sensor level concepts along with validating concepts for data storage and infiltration. Methods of carriage, ejection, safe landing, and auto-righting will be shown by analysis and demonstration. Power requirements and methods will be addressed for up to 4 weeks or longer operation.

PHASE II: The contractor will develop and test prototype sensors with self location and heading data, imagery, acoustic, weather, CBRNE and other data. Successful laboratory and field demonstration will be conducted showing precision emplacement of the sensor probe as launched from small and large UAS platforms. Data and physical exfiltration methods developed will also be demonstrated along with signature management and camouflage techniques.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A wide variety of missions in remote and/or denied areas, performed not only by Air Force special operations forces, but also by other services. Potential applications exist in homeland defense monitoring.
Commercial Application: Particular utility in search and rescue missions in remote areas; border patrol; and counter-drug operations. Natural disaster (nuclear/chemical) monitoring in denied areas.

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KEYWORDS: Unattended Ground Sensors, Beacon, Precision Air-Dropped, Sensors, Air Delivered Seismic Intrusion Detector, Acoustic and Seismic Intrusion Detector

AF121-104 TITLE: Feature Representations for Enhanced Multi-Agent Navigation Strategies

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design, implement, and test novel feature representations in multi-agent autonomous mapping systems for enhanced navigation accuracy/reliability.

DESCRIPTION: Current environmental mapping techniques provide reasonable quality for navigating in traditional battlespace scenarios. However, given the increasing frequency of today's military operations being conducted in asymmetric hostile environments, the need for more robust mapping methods has become apparent. Techniques capable of obtaining maps with enough fidelity as to aid current navigation methods, without reliance on a priori information, will serve to broaden the operational envelope that currently exists. Future systems will almost surely be required to have the capability to negotiate complex scenarios that are characteristic of the modern battlefield. A few of the more prominent characteristics include, but certainly not limited to, rapid environmental transitions (i.e., moving from indoors to outdoors), feature starved environments, densely cluttered environments, dynamic environments, and atypical feature shapes. The current explosion in multi-agent systems research has demonstrated the promise of such technology in addressing the mapping challenge. Multi-agent Simultaneous Localization and Mapping (MA-SLAM), in particular seems well suited for such a task. However, given that the available sensor suite will most likely be comprised of low-cost sensors, there will be some significant operating constraints that cannot be dismissed. Examples of the type of operating constraints mat include limited processing capabilities and constrained bandwidth requirements to name two. One way to negotiate these operational constraints is through the use of novel compact feature representations. Compact representation provide the benefit of requiring less bandwidth than full valued descriptions, and will require less memory for storage. Needless to say, mapping and feature descriptions will play a vital role in the ability to operate anywhere at any time. Multiagent systems, as defined here, are comprised of two or more sensor platforms capable of communicating and receiving environmental map data from other sensor platforms. The realized solution combining multiple agents, with innovative SLAM feature representation techniques will provide attractive capabilities in both military and civilian applications. Although the physical operating parameters of any prototype design such as, size, weight, and power requirements are of interest, they should not be the primary focus. Clearly, the smaller and more efficient any prototypes design is, the more attractive it may become. However, the technical thrust, and hence the primary source of innovation

should reside in the compact feature representation and map sharing methodologies. NOTE: Any proposals submitted must be unclassified.

PHASE I: Investigate the number of agents needed and what map information they need to share. Explore feature representations and communications bandwidth requirements. Simulate the algorithms as a proof of concept. Develop a prototype plan and test plan.

PHASE II: Design the system architecture and build the required number of prototype agents. Procure the required hardware to test the agents. Demonstrate the capabilities of the agents in a realistic scenario e.g., in an indoor environment. The required number and type of sensors/agents should be a result of the research conducted in Phase I.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Potential applications include counter IED, CSAR, and alternative navigation, particularly in asymmetric environments.
Commercial Application: Potential applications include search and rescue, mapping, mining, robotics, in addition to applications mentioned for the military.

REFERENCES:
1. Adluru,N.; Latecki, L.J.; Sobel, M.; Lakaemper, R. “Merging Maps of Multiple Robots”. IEEE International Conference on Pattern Recognition, 1–4. Tampa, FL, 8-11 December 2008.

2. Agostino Martinelli, Viet Nguyen, Nicola Tomatis, Roland Siegwart. “A relative map approach to SLAM based on shift and rotation invariants”. Robotics and Autonomous Systems, 55:50–61, June 2007.

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KEYWORDS: Multi-Agent Simultaneous Localization and Mapping (MA-SLAM), Cooperative Localization and Mapping (CLAM), Multi-Robot Simultaneous Localization and Mapping (MR-SLAM), feature descriptors, map management, submap joining, Cooperative Navigation (CN)

AF121-105 TITLE: Infrared Panoramic Projection for Wide Field of Sensor Testing

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a panoramic scene projector based on emissive infrared panels for multi-aperture sensor testing.

DESCRIPTION: Multi-aperture wide-field-of-view sensors enable high situational awareness, agile autonomous operation in complex environments, and ego-motion estimation based on visual sensing of the relative motion of the surrounding inertial environment. Infrared sensing offers the additional advantage of nighttime operation and operation in dark obscured environments. Testing this class of sensor requires representation of the dynamic in-band environment around the vehicle over the sensors full field of regard. While visible dome projectors currently exist, infrared equivalents do not. In addition, dome projectors based on reflective dome surfaces and conventional LCD or DMD projection technology suffer from poor contrast due to the self illumination of the dome surface. In

addition, projector timing artifacts, which may be unobservable by the human eye, may be unnacceptable for many sensor configurations. Flexible programmible LED panels exist in rectangular formats in the visible having a sparse resolution of approximately 1 cm. The waveband is incompatible with infrared test requirements, the resolution is inadequate, and the rectangular format is not compatible with building a spherical surface. Technology is required to build flexible emissive panels that can be digitally driven to display dynamic infrared scene content in a shape format that is compatible with constructing a panoramic test environment. The objective is to have calibrated output independent of the sensor attitude. Absorptive surface characteristics are desired to minimize reflection from other panels. While the current experience is with spherical environments, concepts based on cubic or alternative shapes are also of interest if advantage can be demonstrated by reducing cost and operational complexity, and the hurdles associated with spatial mapping and source uniformity can be overcome.

PHASE I: Investigate concepts for application of emissive infrared technology for panoramic scene projection. Perform detailed prototype design for concept demonstration and concept definition for full panoramic projector implementation.

PHASE II: Implement, integrate and demonstrate hardware and software solution(s) developed in Phase I. Execute an experimental program using the prototype hardware to demonstrate performance capabilities and limitations. Document the design concept and prototype experimental results. Design and document a final concept based on lessons learned during the Phase II activity.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Hardware-in-the-loop testing of future generation weapons using wide field of view sensors for situational awareness, obstruction avoidance and ego-motion estimations. Testing of night vision equipment.
Commercial Application: Concept development and testing of robotic systems designed for night time operation that employ wide field-of-view or multi-aperture sensors. Testing of emergency response and law enforcement night vision equipment.

REFERENCES:
1. C. Ewing, "The Advanced Guided Weapon Testbed (AGWT) at the Air Force Research Laboratory Munitions Directorate," AIAA Modeling and Simulation Technologies Conference,12 Aug 2009, AIAA-2009-6129.

2. Joseph Giuliani, Daniel Hershey, David McKeown, Jr., Carla Willis and Tan Van, "Generation of large scale urban environments to support advanced sensor and seeker simulation", Proc. SPIE 7348, 734805 (2009); doi:10.1117/12.820254.

3. http://www.immersivedisplayinc.com/Gallery.html, example of visible panoramic display technology.

4. http://www.digiled.com/digiFLEX/, example of visible flexible LED panel technology.

KEYWORDS: Infrared, Projector, hardware-in-the-loop, dome, emissive, LED, panel, night-vision

AF121-106 TITLE: Autonomous Situational Awareness for Munitions

TECHNOLOGY AREAS: Sensors, Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop enabling technologies for compact multi-functional ordnance that can adapt its lethal mechanisms on-the-fly to a diverse target set and diverse engagement scenarios.

DESCRIPTION: Future munitions must be precise, small, efficient, smart, and mission flexible. Their situational awareness in the terminal phase should be able to adapt to the target type, engagement, scenario, or mission constraints. For example, the terminal sense may want to command the ordnance to adjust its output from a high impulse blast for structures to a high temperature, low pressure blast for chem-bio targets, or change its fragmentation distribution from isotropic to directionally-biased to meet collateral damage constraints. This topic is emphasizing the munition sensors that are used for terminal burst point control. The Ordnance Division seeks cross-cutting technologies that advance rapid target detection, classification, and identification (potentially) by active on-board sensors that can determine range, range rate and target centroid for programming the required output. These munition sensors must function on platforms that may or may not have an active terminal seeker in the guidance loop.

Although not limited to this description, we are interested in the technologies that will enable high fidelity simulations of forward looking active imaging fuze sensor algorithms to be realized. These algorithms will be hosted on advanced active imaging fuze sensors for the purpose of terminal burst point control and weapon mode decisions.

The main need is for synthetic scene modeling & simulation tools that support active imaging fuze sensors with multiple coherent receivers and whose production run time is fast enough at sub-millimeter wave frequencies to support iterative munition sensor design. Scene models should support both non-metallic terrain (concrete, asphalt, short grass, dirt, etc.) and metallic targets that have rough surface scattering and cavities. The simulation environment should support a distributed architecture compatible with multiple independent processors while maintaining the phase information needed for multiple coherent receivers. This simulation architecture should support development of innovative synthetic aperture radar (SAR), inverse synthetic Aperture Radar (ISAR), Joint Time-Frequency Analysis (JTFA), or other signal processing techniques that could be synergistically combined to actively image and classify a target of interest that is < 5 degrees off boresight of the weapon's velocity vector.

PHASE I: The contractor will develop the concept(s) through modeling, simulation and analysis. A small-scale demonstration or computer simulation to show proof-of-principle is highly desirable. Merit and feasibility must be clearly demonstrated during this phase.

PHASE II: Develop, demonstrate, and verify the concept technology using embedded algorithms or a high fidelity simulation environment. Deliverables consist of component demonstration hardware, experimental data, and high fidelity simulations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Apply technology to terminal burst point control of ordnance suitable for military operations in urban terrain (MOUT) and other low collateral damage scenarios. Enable technology for emerging directional ordnance concepts.
Commercial Application: Short-range, high-resolution, night/day sensors for Homeland Security operations and law enforcement operations.

REFERENCES:
1. Mehrdad Soumekh, "Synthetic Aperture Radar Signal Processing," New York: John Wiley & Sons, Inc. 1999.

2. Donald R. Wehner, "High Resolution Radar," 2nd Edition Boston: Artech House 1995.

3. Lazarov, A.; Minchev, C.; , "Spectral 2-D image reconstruction in ISAR with linear frequency modulated signals," Digital Avionics Systems, 2001. DASC. The 20th Conference , vol.1, no., pp.4E2/1-4E2/10 vol.1, 14-18 Oct 2001.

4. Seybold, J.S.; Bishop, S.J.; , "Three-dimensional ISAR imaging using a conventional high-range resolution radar," Radar Conference, 1996., Proceedings of the 1996 IEEE National , vol., no., pp.309-314, 13-16 May 1996.

5. Fawwaz T. Ulaby and M. Craig Dobson, “Radar Scattering Statistics for Terrain,” Artech House, 1989.

KEYWORDS: ordnance, selectable effects, active imaging, fuze sensor, radar scene generator, SAR, ISAR, JTFA, PEC target modeling

AF121-107 TITLE: Kinetic Energy Control Technologies for Explosively-dispersed Fragments

TECHNOLOGY AREAS: Sensors, Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop enabling technologies for small, low-collateral-damage (LCD), fragmentation warheads with high lethality yet limited fragmentation footprints.

DESCRIPTION: The Air Force needs ordnance technologies for military operations in urban terrain (MOUT), closed controlled strike (CCS), and other missions with stringent low collateral damage (LCD) requirements. There are two possible approaches: (i) focused (i.e., directional) effects, or (ii) omnidirectional effects with reduced fragment fly-out. Each of these concepts is explained below.

(i) Directional fragmentation gives both high efficiency and low collateral damage since all (or most) of the kinetic energy is focused on the intended target. Generation of directional fragmentation patterns is challenging and will require innovative and cutting edge technologies in detonation science and materials (e.g., wound graphite fiber and epoxy cases, multipoint initiation techniques, detonation wave shaping, etc.). The form fact is particularly problematic. Most small missile warheads are cylindrical, and these warheads project case wall fragments perpendicular to the missile axis, rather than parallel to the missile axis, toward the designated target.

(ii) Alternatively, collateral damage may be minimized by limiting the effective range of the kinetic energy. This requires innovative materials and techniques to effectively change the fragment energy from lethal at close range to sub-lethal at intermediate range. This might be done aerodynamically (e.g., controlled deceleration via drag), mechanically (e.g., fragment breakup via shock mechanics), or chemically (e.g., reactive/consumable fragments).

This topic is predicated on pre-formed fragment warheads but it does not preclude natural fragmentation and fragmentation control techniques. Although this list is not meant to constrain other innovative concepts, technologies of interest include:

(a) Design and control of directional effects in pre-formed fragment warheads.
(b) Deconfliction of stacked forward-firing warheads in small-diameter geometries.
(c) Consumable fragments of reactive materials [Reference 2] that are highly lethal at short distances, but, through mass loss and/or velocity loss, have a greatly reduced lethal radius relative to inert fragments.
(d) Design and control of precision effects in rod warheads [Reference 1].
(e) The marriage of multiphase blast with pre-formed fragments, with the particulate phase including macro-particles up to micro-fragments.

PHASE I: The contractor will develop the system concept or sub-system component through modeling, analysis, and breadboard development. Small-scale testing to show proof-of-concept is highly desirable. Merit and feasibility must be clearly demonstrated during this phase.

PHASE II: Develop, demonstrate, and validate the component technology in a prototype based on the modeling, concept development, and success criteria developed in Phase I. Deliverables are a prototype demonstration, experimental data, a model baselined with experimental data, and substantiating analyses.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Ordnance suitable for military operations in urban terrain (MOUT) and other low collateral damage scenarios.
Commercial Application: Homeland Security operations and law enforcement operations requiring low collateral damage.

REFERENCES:
1. Various authors, "Multifunctional Energetic Materials," Materials Research Society Symposium Proceedings, Volume 896, 2006.

2. R. M. Lloyd, Conventional Warhead Systems Physics and Engineering Design, Progress in Astronautics and Aeronautics, 179:79-192 (1998); ISBN 1-56347-255-4.

KEYWORDS: munition, ordnance, low collateral damage, warhead, explosive, energetic materials, reactive materials, fragment, fragmentation, multiphase blast

AF121-108 TITLE: Direct Detection Ladar Pulse Processing

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and implement innovative HW and SW techniques to enhance the range accuracy, range resolution, measured intensity, and discrimination capability of linear mode direct detection ladar.

DESCRIPTION: Linear mode, direct detection, imaging ladar which captures both range and intensity information has broad applications in weapon seekers and ISR systems. There are many ladar system design trades that can be made to maximize dynamic range in intensity and increase range accuracy and resolution. Approaches which focus on improving detector sensitivity and optical performance tend to be material intensive, expensive, and only suitable for low volume production. Even applying commercially available detectors and optical components, receivers using traditional pulse capture techniques are often the limiting factor in both range and intensity performance. Techniques utilizing some combination of analog and digital receiver electronics to achieve dynamic range in intensity and centimeter class range resolution while using current lasers, detectors, and optical components is highly desired. In addition, the techniques must be implemented in an embedded computing environment in real-time. The primary application for this technology is weapon seekers, so data produced in a single or small number of measurements must be high quality. In other words, the ability to take multiple measurements at a single region to improve detection statistics over time is limited.

The direct detection ladar systems of interest utilize pulsed ladar systems operating at 10-35kHz, have 5-10ns pulse widths and have detector performance commensurate with commercial-off-the-shelf (COTS) Si and InGaAs photodiodes. Application to both scanning and flash ladar systems should be considered.

Generally, multiple phenomenon exist which cause loss of scene information in ladar data. Techniques for accommodating or extracting scene information from saturated pulses, conditions of output power variability, and

small target separation distance should be considered. The approach to accurately determine start pulse timing should also be understood. Techniques which are adaptable and modular (i.e. independent of optical response) would be highly desirable. Real time fusion of other data collected by low cost/tactical grade sensors to improve the ladar performance may also be considered.

PHASE I: Phase I effort should focus on proof of concept through simulation while taking advantage of simulated and representative ladar data for proof of concept. Design for implementation in hardware is essential (analog components and FPGAs). Final report should outline techniques used, design for implementation, and performance estimates. The government will provide the representative data to the contractor upon award at the contractor's request.

PHASE II: Phase II effort should implement HW and/or SW designed in Phase I into functional ladar system and result in delivery of HW and/or SW. Integration into AFRL/RW ladar assets is possible. Algorithms should be embedded in HW and run in real time for efficient data collection.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Use in seekers, ISR systems, fire control systems, & other machine vision systems with military utility. Pulse processing has also been shown to assist in ladar seeing through obscurants and occlusions.
Commercial Application: Applicable to a broad range of civilian machine vision problems such as in manufacturing, robotics, and transportation. Direct detection Lidar systems could also benefit from improvements in pulse processing techniques.

REFERENCES:
1. McMahon, Jason R., Richard K. Martin, and Stephen C. Cain. "Three Dimensional FLASH Laser Radar Range Estimation via Blind Deconvolution". J. Appl. Remote Sens., 4(043517), 2010.

2. Jordan, S.; , "Range estimation algorithms comparison in simulated 3-D flash LADAR data," Aerospace conference, 2009 IEEE , vol., no., pp.1-7, 7-14 March 2009.

3. Sundaramurthy, P.; Neifeld, M.A.; , "Super-resolved laser ranging using the Viterbi algorithm," Quantum Electronics and Laser Science Conference, 2005. QELS "05 , vol.3, no., pp. 2000- 2002 vol. 3, 22-27 May 2005.

KEYWORDS: Ladar, Receiver, Laser Pulse, Direct Detection, Range Estimation

AF121-111 TITLE: Lightweight Electromagnetic (EM) Shielding Structural Materials

TECHNOLOGY AREAS: Materials/Processes, Nuclear Technology

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Development and demonstration of lightweight high-altitude electromagnetic pulse (HEMP) hardened composite materials.

DESCRIPTION: The US Air Force has several strategic nuclear weapon system modernization efforts in the developmental planning phase as well as periodic upgrades and modifications to existing legacy nuclear weapons systems. These systems will be required to survive and operate through a HEMP environment, which necessitates shielding of electronics from the resultant high-intensity fields with EM-protective materials. The radio frequency (RF) environment is defined by MIL-STD-464C and MIL-STD-2169B. Multilayer metallic shielding is typically

employed, but can be heavy and subject to delamitation or separation of layers, especially with age or wear and tear caused by operations and maintenance.

A lightweight composite material is desired with EM properties suitable for shielding aircraft or missile electronics from the EM environment caused by a HEMP and ionizing radiation environment caused by nearby nuclear detonations. A solution is desired in which the EM shielding and ionizing radiation protection is incorporated directly into the composite matrix in order to avoid wear-and-tear and age-induced vulnerabilities caused by delamitation or layer separation. The technology must be able to readily replace traditional material systems without major redesign and exhibit weight advantages over standard metallic enclosures. Furthermore, it must be producible with existing composite manufacturing technologies and have comparable unit cost when in mass production.

The material should provide sufficient EM attenuation to produce internal field strengths 20 dB (threshold) /32 dB (objective) below the typical electronics immunity levels and ionizing radiation fluence below circuit upset levels. These levels are defined by MIL-STD-464C and MIL-STD-2169B.

The appendix of MIL-STD-2169B is classified and only available to personnel with a Secret level clearance. Requirements for the Phase II are defined by MIL-STD-2169B and its appendix. Only contractors able to obtain a Secret level security clearance should submit proposals against this topic.

PHASE I: Establish feasibility and technical merit of proposed solution through modeling, design analysis, and laboratory experiments on coupon-level samples specifically focusing on performance against the MIL-STD 464 waveform. Assess any cost, performance, or manufacturability issues and recommend risk reduction activities to address them.

PHASE II: Manufacture and test a prototype enclosure/test article defined by the US Air Force sponsor to verify manufacturability and performance against the classified MIL-STD-2169B waveform. The hardened composite technology Technical Readiness Level (TRL) should be at 6 to 7 and the Manufacturing Readiness Level (MRL) should be at 3 to 4 by the end of Phase II. Only contractors able to obtain a Secret level security clearance should apply.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Structurally incorporated lightweight EMP protection for next generation assets that will face hostile electromagnetic environments.
Commercial Application: Lightweight protection for avionic and communication systems on board commercial aircraft from personal electronic devices and stray radar energy.

REFERENCES:
1. Department of Defense Interface Standard, “Electromagnetic Environmental Effects Requirements for Systems,” MIL-STD-464C, Retrieved from http://www.everyspec.com/MIL-STD/MIL-STD+(0300+-+0499)/MIL-STD-464C_28312/, 1 December 2010.

2. Department of Defense Military Standard, “High-Altitude Electromagnetic Pulse (HEMP) Protection for Ground-Based C4I Facilities Performing Critical, Time-Urgent Missions—Vol. 1: Fixed Facilities”, MIL-STD-188-125A, Retrieved from https://assist.daps.dla.mil/docimages/A/0000/0007/1249/000000014229_000000173722_YRNNPHFXPP.PDF?CFID=27815114&CFTOKEN=94644074&jsessionid=5c30fabe1b4251daae1a4d6e554a3e2a7722, 15 February 1994.

3. “Report of the Commission to Assess the Threat to the United States From Electromagnetic Pulse (EMP) Attack—Critical National Infrastructures,” ISBN 978-0-16-080927-9, Retrieved from http://www.empcommission.org/docs/A2473-EMP_Commission-7MB.pdf, April 2008.

KEYWORDS: conductive composite, electromagnetic (EM) pulse, EM, electromagnetic interference (EMI) enclosure, EMI, hardening, high-altitude electromagnetic pulse (HEMP), HEMP, radio frequency (RF) shielding, RF

AF121-112 TITLE: Near-Surface Residual Stress Measurements for Aerospace Structures

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop robust methods to measure near-surface residual stresses in complex aerospace structural components.

DESCRIPTION: Current design methods for aerospace structure often do not permit the explicit introduction of either bulk or localized residual stresses. Tensile residual stresses are one of many design uncertainties that are accounted for either through the use of conservative material property data or elevated margin of safety requirements. Modern, advanced design methods (e.g., finite-element analysis coupled with fatigue crack initiation and fatigue crack growth analysis) do enable lightweight, sophisticated designs with reduced safety margins; however, the uncertainty associated with residual stress limits the designer's ability to fully optimize such structures (i.e., residual stress is often treated as a known unknown). Turbine engine and airframe manufacturers are aware of the potentially significant benefits that can arise from explicit accounting for residual stresses (namely, weight reduction in residual stress-free areas and enhanced structural integrity in tensile residual stress areas) and have begun to identify approaches for including residual stress effects in design.

To understand and predict the effects of residual stress on fatigue durability or crack initiation (as contrasted with damage tolerance or long crack growth) accurate and reliable residual stress data are required in the near-surface region over depths of roughly 0.025 to 1.25 mm (0.001 to 0.050 inch). Many methods currently exist for the measurement of such near-surface residual stresses; however, few have accuracy and repeatability in the full range of aerospace materials suitable for routine use in correlating fatigue performance with residual stress. Classical x-ray diffraction with layer removal can provide useful data in certain materials and surface conditions, but it also produces noisy and inconsistent data in a number of aerospace metals (e.g., titanium, nickel, and certain aluminum alloys), especially in the presence of large and/or highly textured grains, chemical variations, or multiple phases and precipitates.

An advanced method for residual stress measurement is required to further improve reliability of analyses involving residual stress effects. An improved residual stress measurement method would demonstrate the following characteristics:

• Applicable to aerospace structural materials (e.g., IN100, Ti-6Al-4V, AA7085, etc.)
• Measurement of residual stress to a depth of 1.25 mm (0.050 inch; or greater)
• Incremental depth resolution of 0.01 mm (0.0004 inch; or smaller)
• Measurement repeatability of ± 10% of the peak stress value (expected to be approximately 10 ksi) over the entire depth range
• Measurement accuracy of ± 10% of the peak stress value (demonstrated on a specimen with a well characterized residual stress distribution) over the entire depth range

PHASE I: Demonstrate a prototype surface residual stress measurement capability in a laboratory environment using a blind study to validate the method. With assistance from the TPOC verify relevance and viability of the approach with perspective users. Particular attention should be given in the proposal to the validation protocol of the technique.

PHASE II: Develop and construct a fully functional demonstration system capable of performing surface residual stress analysis for a representative aerospace component such as a superalloy turbine disk or aluminum airframe component. With assistance from the TPOC, demonstrate the capability for at least one relevant application with at least one prospective end-user.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The technology developed will be applicable to the design of more fuel-efficient and durable gas turbine engines and lighter weight unitized airframe structure.

Commercial Application: Commercial ships, airliners, and military transports have similar engines and airframes; thus, the technology will be applicable to the design of more fuel-efficient engines and lighter weight airframe structure.

REFERENCES:
1. D. Ball et al., "Toward Understanding the Impact of Bulk Residual Stress on the Life, Weight and Cost of Primary Aircraft Structure," 2010 Residual Stress Summit, Lake Tahoe CA, Retrieved from: http://sem-proceedings.com/rss4/sem.org-4th-Residual-Stress-Summit-Ball-Toward-Understanding-Impact-Bulk-Residual-Stress-Life-Weight.pdf.

2. M.B. Prime, "Residual Stress Measurement by Successive Extension of a Slot: The Crack Compliance Method," Applied Mechanics Reviews, 52, 75-96, 1999.

3. M.J. Shepard and R. John, "Incorporating Residual Stresses in Life Management of Turbine Engine Components," 2006 Propulsion – Safety and Affordable Readiness Conference, Jacksonville FL.

4. M.J. Lee and M.R. Hill, "Intralaboratory Repeatability of Residual Stress Determined by the Slitting Method," Experimental Mechanics, 47(6), 745-752, 2007.

5. G.S. Schajer, "Hole-Drilling Residual Stress Measurements at 75: Origins, Advances, Opportunities," Experimental Mechanics, 50, 245-253, 2010.

KEYWORDS: airframe structure, fatigue properties, surface residual stress

AF121-113 TITLE: Residual Stress Engineering for Aerospace Structural Forgings

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop modeling and measurement tools to account quantitatively for the effects of bulk residual stresses on machining distortion and the fatigue life of complex aerospace structural components.

DESCRIPTION: In an industry-wide effort to reduce weight, increase durability, and reduce cost, traditional built-up aircraft structure and multipiece engine components are being replaced with monolithic structures fabricated from single-piece forgings (e.g., large bulkheads). Such forgings include a wide range of geometries (from bulkheads to integrally bladed rotors) and materials (aluminum, titanium, and nickel alloys). Due to the nature of forging processes (e.g., heat treating, quenching, and cold working), bulk residual stress fields develop during manufacture. These locked-in stress fields subsequently cause problems such as distortion during machining operations and significantly impact fatigue performance. Over the last decade, Integrated Computational Materials Engineering (ICME) methods and tools to quantify bulk residual stress fields have been developed for aerospace forgings. At the same time, new methods have emerged for the measurement of bulk residual stress fields (e.g., the contour method), and these have been successfully applied in aircraft engine and structural forgings. Consequently, for the first time, it is possible to envision a part acquisition/qualification scenario in which the bulk residual stress fields in a finished part are determined by the part vendor and delivered as a data package with each ship set. This residual stress data would become part of the data set used to determine whether or not the part meets the acquiring entity's (OEM's) qualification/acceptance criteria and would become part of the quality assurance process for forgings.

Developing a quality assurance approach for bulk residual stress management in forgings clearly depends upon the role of the quality data: whether it is used to assure a new production practice (i.e., first-article inspection), assure a group of parts prior to release (i.e., lot-release inspection), or to assure individual part characteristics (i.e., per-article inspection). A quality assurance procedure might use a baseline forging simulation to forecast the nominal residual stress field throughout the component volume. Next, a set of physical measurements would be defined consistent with the role of the quality data (i.e., first-article, lot-release, or per-article inspections). Further forging simulations using known process variabilities would then predict the expected variability of the residual stress field. These

forging simulations combined with the residual stress measurement data would become the key elements of a quality assurance program.

PHASE I: Demonstrate the proof of concept for a combined bulk residual stress modeling-measurement quality assurance procedure on a first-article forging. With assistance from the TPOC verify relevance and viability of the approach with perspective users. Particular attention should be given in the proposal to the validation protocol of the technique.

PHASE II: With assistance from the TPOC fully demonstrate the bulk residual stress quality assurance procedure using production parts. This demonstration should be conducted in a fully relevant production environment. Develop a set of procedures defining a prescribed method of quality management for residual stress in forgings and a strategy for commercialization.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The technology developed will be applicable to the design of more fuel-efficient and durable gas turbine engines and lighter weight unitized airframe structure.
Commercial Application: Airliners and military transports have similar engines and airframes; thus, the technology will be applicable to the design of more fuel-efficient engines and lighter weight structure.

REFERENCES:
1. D. Ball et al., "Toward Understanding the Impact of Bulk Residual Stress on the Life, Weight and Cost of Primary Aircraft Structure," 2010 Residual Stress Summit, Lake Tahoe CA, Retrieved from: http://sem-proceedings.com/rss4/sem.org-4th-Residual-Stress-Summit-Ball-Toward-Understanding-Impact-Bulk-Residual-Stress-Life-Weight.pdf.

2. R.A. Wallis, “Modeling of Quenching, Residual-Stress Formation, and Quench Cracking, Metals Process Simulation,” Vol. 22B, ASM Handbook, ASM International, 2009, p 547–585.

3. M.B. Prime, "Residual stress measurement by successive extension of a slot: The crack compliance method," Applied Mechanics Reviews, 52, 75-96, 1999.

4. M.J. Lee and M. R. Hill, "Intralaboratory Repeatability of Residual Stress Determined by the Slitting Method," Experimental Mechanics, 47(6), 745-752, 2007.

5. G.S. Schajer, "Hole-Drilling Residual Stress Measurements at 75: Origins, Advances, Opportunities," Experimental Mechanics, 50, 245-253, 2010.

KEYWORDS: bulk residual stress, forgings, Integrated Computational Materials Engineering (ICME), ICME

AF121-114 TITLE: Lightweight Active Anti-Icing/De-Icing for Remotely Piloted Aircraft (RPA)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a lightweight, low power, retrofittable solution for in-flight anti-icing/de-icing for RPAs.

DESCRIPTION: RPAs typically do not have any onboard anti-icing/de-icing system(s) to protect critical aircraft surfaces (i.e., wing and tail leading edges, engine inlet lip) from hazardous ice formation. Both commercial and military aircraft typically employ active anti-icing/de-icing systems such as bleed air, bladders, or other pneumatic devices to prevent the ice accumulation. These systems are bulky, heavy, and consume too much power for use on most RPAs. To ensure safety of flight, the FAA regulates flight into known icing conditions and requires an onboard anti-icing/de-icing protection system. FAA requires validation of aircraft anti-icing/de-icing system(s) for Icing Airworthiness Certification. Lacking an in-flight anti-icing/de-icing capability, the operators of unmanned vehicles rely on icing forecasts and onboard icing detectors to avoid icing conditions.

Previous research has yielded ice-phobic coatings, which reduced the forces required to remove ice from aircraft wings. However, these have not yet been validated on RPAs during actual flight. Many RPAs employ a laminar airflow design, which requires an ice-free wing in order to meet performance and stability and control requirements.

This solicitation requests the design, construction, delivery, and demonstration of a lightweight, low power consumption, reliable, maintainable, retrofittable icing solution for RPA flight critical surfaces (wing, tail, engine inlet lip). An in-flight anti-icing/de-icing capability must be demonstrated for the range of conditions up to 30,000 feet, temperatures from -22 to +32 °F, with a median droplet size of 15 to 40 microns and liquid water content 0.2 to 1.0 gram/cubic meter. This capability can be demonstrated in an icing wind tunnel in accordance with FAA guidance (Ref 1.).

PHASE I: Design a laboratory scale concept for in-flight anti-icing/de-icing. Develop a laboratory test plan and conduct screening tests to prove concept for stated droplet size, liquid water content, temperature, altitude, and speed.

PHASE II: Construct the active anti-icing/de-icing system developed in Phase I and demonstrate in an icing wind tunnel to stated requirements. During Phase II, identify and partner with an RPA manufacturer to retrofit and demonstrate the technology on a selected airfoil test article. This selected airfoil test article, no larger than 4" x 6", will be provided to the contractor by the government. The contractor will need to address cost and schedule for the icing facility testing. The tests performed in the icing facility should replicate conditions for the selected platform and be in accordance with FAA guidance. Systems requiring electrical power consumption should be designed to be compatible with selected RPA platform.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A lightweight, retrofittable icing solution would be of utility to both manned and unmanned small aircraft.
Commercial Application: This dual-use technology applies to both military and commercial aircraft concerned with icing.

REFERENCES:
1. 14CFR25, Appendix C to Part 25, “Part I—Atmospheric Icing Conditions,” and “Part II—Airframe Ice Accretions for Showing Compliance With Subpart B,” 2010, Retrieved from http://cfr.regstoday.com/14cfr25.aspx

2. FAA Safety Advisory, “Aircraft Icing,” Weather No. 1, 2008, Retrieved from http://www.aopa.org/asf/publications/sa11.pdf

3. Aircraft Icing Handbook, Civil Aviation Authority, Version 1, 2000, Retrieved from http://www.caa.govt.nz/safety_info/GAPs/Aircraft_Icing_Handbook.pdf

KEYWORDS: ice accretion, light to moderate icing conditions, remotely piloted aircraft (RPA), RPA, rime ice, runback icing

AF121-115 TITLE: Fabrication and Process Optimization of Thick Laminates (= 40 ply) From High-Temperature Polyimide/Carbon Fiber Composites

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Rapid advancement and optimization of the fabrication and processing of a dual-use polyimide/carbon fiber composite system with high-performance thermal oxidative stability (= 500 to 550°F) for use in the production of turbine engine components.

DESCRIPTION: Numerous potential turbine engine applications, such as stators, fan inlet cases, ducts, and external flaps, exist for high-temperature, polyimide matrix, carbon-fiber-reinforced composites on Department of Defense (DoD) weapon systems. For example, large-acreage, lightly-loaded components such as engine ducts are prime candidates for high-temperature polymer matrix composites as they can reduce weight by 40% over their titanium counterparts. For replacement of existing metallic components with polyimide composites, the new materials must be able to operate at elevated temperatures for thousands of hours. High-temperature polymer matrix composites can meet this objective. However, the lack of robust cure cycles and inconsistent process fabrication prevents thick steps, flanges, or pad-ups from being exploited in design concepts. In fact, in some instances, part quality, variability, and defects can result in high production scrap rates well in excess of 20% for large finished parts, which can individually cost as much as $100K. To support emerging production capability of composite engine components and enhance further implementation of high-temperature composites, improvements in manufacturing yield and cost must be demonstrated.

The program goal is to improve high-temperature polyimide processing for future realization in manufacturing. The rapid processing advancement is required for a dual-use (military and commercial) polyimide system that can be manufactured for thick sections (= 40 ply) with high-performance thermal oxidative stability (= 500 to 550°F). The polyimide system must demonstrate high-temperature performance and durability equivalent to or better than PMR-15 but without the use of carcinogenic monomers. It is desired that the polyimide/fiber system be somewhat mature (i.e., Technical Readiness Level = 3 to 4) upon award of the contract. It is preferred that the system be dual-use (military and commercial) to reduce cost to the US Air Force. Proposals utilizing optimized cure cycles for current commercially available polyimide systems will be accepted.

The cure cycle and bagging scheme of the dual-use material must be developed and successfully demonstrated to routinely result in aerospace quality (< 20% scrap rate, < 2% voids) carbon-fiber reinforced, 40-ply, 12 in. x 12 in., laminated panels (Phase I). Representative duct subelements, such as flanges, access holes, steps, and pad -ups must also be demonstrated (Phase II). The system must retain statistically equivalent mechanical properties at ambient and 550°F for at least 1,000 hours in a dry environment. In Phase I, a preliminary mechanical screening matrix, including uniaxial tension, 4-pt. flexure, compression, and glass transition temperature (Tg) testing according to American Society for Testing and Materials (ASTM) methods of 12-ply laminates, will need to be performed. Mechanical testing at ambient and elevated temperature (550°F) and Tg testing at moisture saturated (wet) conditions is also expected to demonstrate the basic material properties.

In Phase II, representative subelements, based on geometries of interest provided by the government, should be manufactured with the improved process. The part quality of the subelements should be evaluated for curved beam strength with the appropriate test specimen geometry and sampling method as defined in ASTM D 6415. Resin kinetic and viscosity material information and real-time data acquired during optimized cure cycle should be provided. In addition, a preliminary assessment of the yield and cost savings should be projected for the improved process.

PHASE I: Develop robust manufacturing process concepts via fabrication of a 40-ply, 12 in. x 12 in., polyimide/T650 35 carbon laminate with < 2% voids as evidenced by C-scan and photomicrographs. Perform mechanical screening tests to establish basic properties and demonstrate hot performance (= 500 to 550°F use for 1,000 hours) using ASTM test methods.

PHASE II: Advance effort to fabrication of larger parts and representative flange or duct subelements per ASTM D 6415 (same performance metrics as Phase I). Further characterize kinetics, viscosity, mechanical, and physical properties through in-situ monitoring and other analysis methods. Initial analytical material model development (kinetics/viscosity) is desired. Provide a preliminary assessment of the yield and cost savings for the improved process.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: Any turbine engine applications utilizing high-temperature, polyimide-matrix, carbon-fiber-reinforced composites on DoD weapon systems.
Commercial Application: Cost-competitive, dual-use polyimide/fiber system for commercial aircraft engine components, automobile engine components, etc.

REFERENCES:
1. Robert A. Gray, "Improved Manufacturing Technologies for Polymer Matrix Composite Engine Components," Maverick Corporation, AFRL-ML-WP-TR-2007-4028, Accession Nos. DF666665 and ADB326128, Department of the Air Force, April 2007.

KEYWORDS: composites, manufacturing, polyimides, processing

AF121-120 TITLE: Surface Preparation of Organic Matrix Composites (OMCs) for Structural Adhesive Bonding

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a process/method that can prepare Organic Matrix Composites (OMC) surfaces rapidly and consistently for structural adhesive bonding that can be performed at atmospheric conditions.

DESCRIPTION: OMCs are utilized extensively in military aircraft due to their tailorability and high specific modulus and strength properties, which results in significant weight reductions. These composite structures come in many forms (e.g., skins, stiffeners, frames, spars, etc.) and must be joined together by fastening, bonding, etc. to form subassemblies which are in turn joined together to form larger components and then ultimately the complete aircraft. When adhesive bonding is the joining method (necessary to achieve more significant weight reduction and cost savings over mechanically fastened structure), the faying surfaces must be properly prepared in order to ensure a durable joint for the life of the aircraft. Common methods in use today for preparing these surfaces include abrasive techniques (e.g., sanding and grit blasting) and removal of a peel ply. These techniques provide fresh surfaces for bonding that are free from contamination, but they do little to enhance the faying surfaces basic bonding attributes. Plus these techniques have their downsides: mechanical abrasion, careful control of debris, residual fiber contamination, transfer of release agents, and limited high-temperature products.

Manual surface abrasion techniques (e.g., sanding and grit blasting) and simple use of peel plies alone is not of interest to this program.

PHASE I: Demo a method to improve the repeatability of bonds in IM7/5250-4 laminates joined with 350 °F cure epoxy adhesive (AF191) while maintaining initial bond strength. Establish baseline values and perform mechanical tests to validate concepts (i.e., Double Cantilever Beam ASTM 5528) showing constituency of bonds (i.e., less dependence upon operator).

PHASE II: Broaden testing to more materials systems of interest as well as the test environment: graphite BMI to Ti, glass BMI to graphite BMI, Graphite 5320-1 to Graphite 5320-1. Demonstrate technique at lower and hotter temps characteristic of operating conditions (-65 °F, room temp, room temp moisture conditioned, hot (e.g., 270 °F), and hot moisture conditioned.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: Increased use of composite bonding in aircraft leads to reduction in weight and cost savings. Also, potential applications to ground vehicles. Can be used during OEM as well as depot/overhaul operations.
Commercial Application: The commercial aircraft industry is very interested in improved composite bonding techniques, as are other industries that use advanced composite materials.

REFERENCES:
1. L.J. Hart-Smith, G. Redmond, and M.J. Davis, "The Curse of the Nylon Peel Ply," Proceedings of 41st International SAMPE Symposium, pp. 303-317, March 24-28, 1996.

2. B. Flinn and M. Phariss, "The Effect of Peel-Ply Surface Preparation Variables on Bond Quality," DOT/FAA/AR-06/28, August 2006.

3. P. Van Voast and K. Blohowiak, "Critical Materials and Processes Bonded Joint Issues," Proceedings of FAA Bonded Structures Workshop, June 2004.

KEYWORDS: adhesives, bismaleimide (BMI), BMI, bonding, organic matrix composite (OMC), OMC

AF121-121 TITLE: Porosity-Free Molded Surfaces for Out-of-Autoclave (OoA) Composites

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate innovative mold preparation materials and/or processes for vacuum bag-only composite processing.

DESCRIPTION: Out-of-Autoclave (OoA) or vacuum bag-only composite materials offer several advantages over autoclave-cured composites such as the following:

• Improved part quality through lower pressure and/or temperature processes that can reduce rework or repair by 20 to 30%,
• Improved dimensional control and repeatability that can reduce assembly costs by 10 to 20%
• Expanded supplier base that can reduce cost of composite parts by 30 to 40%
• Shared design databases that can expedite transition from prototype to production by 30 to 40%
• Lowered capital investment required
• Reduced autoclave bottlenecks during production
• Removed part size limitations (associated with autoclave processing) for designers and/or configurators

While the current generation OoA prepreg material systems (e.g., Cytec Engineered Materials' Cycom®5320-1 or Advanced Composites Group's MTM 47 and MTM 45-1) are competitive with autoclave materials systems from a mechanical performance standpoint, there are some inherent processing challenges which have not yet been overcome. For example, the low hydrostatic resin pressure during vacuum bag-only processing does not allow the epoxy resin to fully wet-out mold released tool surfaces. The result often leads to dry and/or pitted part surfaces. The dry and/or pitted surface is eliminated when the mold-released surface is covered with Teflon-coated glass fabric or Fluorinated Ethylene Propylene (FEP); however, these products are often difficult to conform and are not viable solutions for aircraft applications with even mild contour. Nonfly-away materials like peel-plies offer a solution, but these consumable materials add cost for materials and touch labor. Finally, surfacing adhesives also provide a solution, but add raw material cost, touch labor cost, and nonstructural, parasitic weight.

Innovative mold release materials, tooling materials, and/or surface architectures may provide valuable solutions to the apparent surface energy incompatibility for OoA materials and fabrication processes. This program is interested in understanding the processing fundamentals and developing sound approaches to address these surface pitting issues. Influencing factors complicating the processing may include surface roughness and surface energy of the material in direct contact with the first ply of OoA prepreg material, the cure processing conditions (temperature, ramp rate, and pressure), tooling material or mold material type and compatibility, fiber architecture (fabric, tape, fiber type and sizing), and resin chemistry and compatibility.

PHASE I: Establish the baseline surface condition described above using an OoA carbon/epoxy fabric prepreg such as T650-35/5320-1 8HS fabric on a mold release Al tool (typical RHR 63). Identify the critical variable/mechanism(s) that create/eliminate surface pitting and develop an innovative approach to overcome this issue.

PHASE II: After establishing the underlying pitting mechanism in Phase I, further develop and scale-up a viable solution suitable for production and repair. Generate a database of surface energy measurement requirements for common tooling materials, including aluminum, Invar, carbon/epoxy, carbon/BMI, polycarbonate, Teflon, & FEP. Demonstrate/validate that the solution permits successful OoA fabrication of primary structure regardless of tooling selection.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Will reduce cost, eliminate parasitic weight, and improve quality for OoA composite systems, which have applications to military aviation and ground vehicles. Applies to OEM and depot/rework operations as well as field sustainment.
Commercial Application: Will reduce cost and improve quality for OoA composite systems, which have applications to commercial aviation, the energy industry, and others.

REFERENCES:
1. Gail L. Hahn, Gary G. Bond, and John H. Fogarty, "Non-Autoclave (Prepreg) Manufacturing Techonology: Part Scale-up with CycomR5320-1 Prepregs," Society for the Advancement of Material and Process Engineering (SAMPE) International Symposium, 56, 2011.

KEYWORDS: autoclave cured, mold release, out-of-autoclave (OoA), OoA, prepreg, vacuum bag

AF121-122 TITLE: Advanced Process Control for Laser Sintered Thermoplastics

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Improve part quality and reduce manufacturing waste associated with Direct Digital Manufacturing (DDM) methods through improved process control and modeling.

DESCRIPTION: DDM technologies have demonstrated the ability to fabricate economically geometrically complex nonstructural components such as ducts, clips, brackets, and housings for multiple weapon systems. Compared to conventional manufacturing approaches and materials, manufacturing these components from high-temperature thermoplastics using Selective Laser Sintering (SLS) provides many benefits, including cost and weight savings, little or no tooling being required, and large lead-time reductions. While sufficient for rapid prototyping applications, the laser sintering systems currently employed in DDM lack the necessary physics-based process-structure-property models, in situ sensing, and adaptive process control capabilities required to guarantee optimal part quality with minimum waste in an aerospace-relevant production environment. We seek innovative approaches to improving the process control and quality of laser sintered thermoplastic parts, including the development of novel process models, in situ monitoring of processing conditions, and real time part quality feedback.

PHASE I: Develop a proof-of-concept approach to improve the state of the art in process control and modeling for conventional SLS thermoplastics and demonstrate the technical feasibility of these approaches through engineering drawings and preliminary experiments.

PHASE II: Integrate the proposed solution in a production-relevant environment, demonstrate the fabrication of production-quality nonstructural aerospace components, and document the protocols and metrics to guarantee the performance of the solution. Compare physical properties (porosity, density, tensile and compressive strength) with improved process control and modeling versus the baseline process.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applicable to all military systems requiring quality high-tolerance, low-cost, lightweight, flight-rated, nonstructural plastic components (brackets, clips, etc.).
Commercial Application: Broad range of activities, including commercial aircraft, which require higher quality and lighter and cheaper parts. Biomedical field for use as personalized orthotics and prosthetics where cost and performance improvements are greatly needed.

REFERENCES:
1. B. Caulfield et al., "Dependence of Mechanical Properties of Polyamide Components on Build Parameters in the SLS Process," J. Materials Proc Tech, 182, 477-488, 2007.

2. D. Bourell et al., "Roadmap for Additive Manufacturing: Identifying the Future of Freeform Processing," Proceedings of the RAM Workshop, March 2009.

3. D.T. Pham et al., "Deterioration of Polyamide Powder Properties in the Laser Sintering Process," Proceedings of the Institution of Mechanical Engineers, Part C: J. of Mech Eng Sci, 222, 2163-2176, 2008.

4. K. Senthilkumaran et al., "Influence of the Building Strategies on the Accuracy of Parts in Selective Laser Sintering," Materials and Design, 30, 2946-2954, 2009.

KEYWORDS: additive manufacturing, direct digital manufacturing (DDM), DDM, in situ sensing, laser sintering, noncontact inspection, process modeling

AF121-124 TITLE: Inline Material Sensor (IMS)

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and develop a radio frequency (RF)-based, dual-polarized, broadband frequency inline material inspection sensor for real-time inspection for 100% of thin film and mat materials during material manufacturing.

DESCRIPTION: Specialty thin film and mat materials are utilized on modern-day aircraft for numerous reasons, including electromagnetic interference (EMI) protection, Electro-Static Discharge (ESD) applications, and lightning strike protection. These thin film and mat materials undergo rigorous manufacturing processes, and their EM properties must be closely evaluated to maintain specification compliance. For example, extreme temperatures and pressures are exerted on mat materials during the resin pre-impregnation (prepreg) manufacturing process, which may alter the physical and electrical properties of the material. The final performance of any specialty thin film or

mat material is dependent upon a variety of factors, including overall thickness, proper coating application (in some cases), material electrical properties, and physical integrity of the final product. Physical or electrical defects must be identified and appropriately marked during the manufacturing process to ensure that defective material is not utilized during aircraft production. Having the ability to determine real-time physical and electrical compliance of specialty thin film and mat materials during manufacturing would be advantageous by identifying defective material early in the process and allowing for corrective action to be taken. This will result in reducing the manufacturing cost through the elimination of defective material and reducing the risk that defective material could be used in aircraft production.

The objective of this effort is to develop an RF-based, dual-polarized, broadband frequency inline material inspection sensor to monitor the material electrical and physical properties during the manufacturing of the specialty thin film and mat materials. Achieving the correct electrical performance of these materials is critical to ensure proper functionality when installed in various aircraft applications. Currently, there is no capability to rapidly assess the electrical and physical properties of thin film and mat materials during manufacturing. The IMS system will deliver a common multifunctional tool capable of measuring the physical and electrical characteristics of a variety of specialty thin film and mat materials in production today. The IMS must be easy to use, quick to perform measurements and determine material compliance/identify material defects, be able to measure through-transmission properties for 100% of the material area, and be easily integrated with existing thin film and mat materials manufacturing equipment.

PHASE I: Develop an RF-based, dual-polarized, broadband frequency Inline Material Sensor (IMS) concept based on requirements listed above. Design and demonstrate a bench-top system that proves feasibility of the inspection methodology by accurately characterizing the electrical and physical properties of representative specialty thin film and mat materials and by identifying defective areas.

PHASE II: Fully develop, fabricate, and demonstrate a prototype inline material sensor system to inspect the electrical and physical properties of specialty thin film and mat materials during manufacturing. Develop a control system that automatically detects and identifies electrically defective areas, ensuring 100% material coverage.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This IMS will have application throughout the manufacture of numerous specialty material systems (including EMI, ESD, and lightning strike applications) utilized on countless military weapons systems.
Commercial Application: Tools and methods developed under this program to measure and evaluate the physical and electrical properties of thin film and mat materials are directly applicable to the private and commercial aerospace industry.

REFERENCES:
1. Richard Brown, RF/Microwave Hybrids: Basics, Materials, and Processes, Kluwer Academic Publishers, Boston MA, 2010.

2. Michel Mardiguian, EMI Troubleshooting Techniques, McGraw-Hill, 1999.

3. L.F. Chen et al., Microwave Electronics: Measurement and Materials Characterization, Wiley, 2004.

KEYWORDS: aircraft maintainability, advanced sensor, nondestructive evaluation (NDE), NDE, physical and electromagnetic material properties evaluation, point inspection tool, radio frequency (RF) material systems, RF, specialty materials

AF121-126 TITLE: Optical Filters on Thin Cover Glass

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of

foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: To develop a multi-wavelength optical filter on a thin, 1 to 3 mm, solar cell cover glass. The filter designs should reflect multiple spectral notches in-band to the solar spectrum between 400 nm to 2500 nm while maintaining excellent throughput.

DESCRIPTION: There are certain operational conditions in which it would be beneficial for solar cell components to suppress several spectral lines in the visible to short-wave infrared spectrum. Multiple optical coatings design programs are available where filter spectral performance parameters can be entered and optical filters can be designed based on various thin film layers with appropriate deposition materials. However, the thickness of the deposited thin films grows with the number of spectral bands to be rejected. Normally, this requires thicker glass to withstand the stresses of thin films. For some solar cell applications, it is desired to have very thin glass (1 to 3 mm) as the substrate for the optical coating. This requires special design and deposition techniques to balance the stress forces of the thin films on the solar cell cover glass.

The filter design should transmit visible to short-wave infrared wavelengths (400 nm to 2500 nm) across the solar spectrum, maintain excellent throughput (> 98%), and reject multiple narrow spectral bands to improve the efficiency of normal solar cell device operation. Specific rejection bands of interested will be recommended by the government team and provided to the contractor team. In addition, the optical filter should be reflective (better than 85%) beyond 2500 nm. The offeror should possess the deposition systems necessary to fabricate the individual optical coating designs.

PHASE I: Investigate deposition approaches and develop a filter design capable of both rejecting multiple spectral regions and being deposited on a thin (1 to 3 mm) solar cell cover glass. The offeror shall demonstrate proof of concept and deposition system capabilities by fabricating an optical coating on solar cell cover glass.

PHASE II: Demonstrate that the Phase I filter design can be accurately produced and meets all spectral performance parameters using the deposition process. Also, the stability and repeatability of the deposition process should be demonstrated by producing the designed filters in multiple deposition runs on thin solar cell cover glass.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Optical filters to improve the operational efficiency of military solar cell components or tailor the spectral performance of military electro-optic sensor systems.
Commercial Application: Optical filters to improve the operational efficiency of commercial solar cell components or to tailor the spectral performance of optics in commercial electro-optic systems.

REFERENCES:
1. Thomas D. Rahmlow, Jr., Jeanne E. Lazo-Wasem, and Edward J. Gratrix, “Narrow Band Infrared Filters with Broad Field of View,” Retrieved from www.rugate.com/2065%20final.pdf, Undated.

2. Bertrand G. Bovard, “Rugate Filter Theory: An Overview,” Applied Optics, Vol. 32, Issue 28, pp. 5427-5442, 1993.

3. S. Ilyasa, T. Böckinga, K. Kilianb, P.J. Reecea, J. Goodingb, K. Gausc and M. Gala, “Porous Silicon Based Narrow Line-Width Rugate Filters,” Optical Materials, Vol. 29, Issue 6, pp. 619-622, 2007.

4. Stephan Fahr, Carolin Ulbrich, Thomas Kirchartz, Uwe Rau, Carsten Rockstuhl, and Falk Lederer, “Rugate Filter for Light-Trapping in Solar Cells,” OSA, Vol. 16, No. 13, p. 9332, 2008.

KEYWORDS: light control, optical attenuator, optical element, optical filters

AF121-127 TITLE: Spatially Controlled Optical Attenuator

TECHNOLOGY AREAS: Materials/Processes, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: To develop an optical element in or on which an addressable reflective obscuration can be created of any controlled size and position.

DESCRIPTION: There are viewing conditions in which it would be beneficial if an optical system component could suppress a bright source in the Field of View (FOV) so that the dynamic range of the sensor could be devoted to the lower intensity radiation from the scene. Potential applications include suppressing the sun in the FOV of a camera or viewing in the shadows of a building illuminated by bright sunlight. These applications would require that the location of the blockage be positioned to follow the bright source in the FOV.

Spatial light modulators have been developed, but only have extinction coefficients of 100 to 500. Reflective concepts using Microelectromechanical Systems (MEMS)-based digital micromirror devices have been developed that have relatively high extinction ratios, but scattering is a potential issue. The preferred implementation would be a transmissive optical element for either a flat or spherical surface. A VxOx film matrix has often been suggested as a potential attenuator, but its extinction coefficient is not sufficiently high for this application. Schemas that attenuate the optical coupling between fiber-optic bundles have achieved 30 dB of attenuation. MEMS configurations with tiny iris-like blades have also been used to suppress coupling between optical fibers. Another concept might be MEMS rotating blades that when parallel to the light path would have a small impact on the transmission, yet when rotated to be perpendicular to the light path would block the light. Although a single optical element may not fully attain the desired 105 attenuation, a pair of cross polarizers (polarizer and analyzer) in combination with any of these concepts might attain the desired attenuation. The polarizer pair would need to be parallel for the transmission and crossed for the obscuration. The size, weight, and power also should be considered when addressing the solution.

The objective of this SBIR task is to develop an optical element in or on which an addressable reflective obscuration can be created on a transmissive optical element of any controlled size and position. The obscured area, which should be variable from 30 um to 0.1 cm, requires an extinction coefficient of 105. The rest of the unobscured area needs to have high transmission in the visible spectrum and low emission. Response times of 100 ms to 500 ms would be adequate. Extension into the infrared would be beneficial. Ideally, the optical element should be capable of functioning in a space environment, including continuous direct solar illumination.

PHASE I: Investigate materials and systems, which can achieve 105 extinction of the input light in a spatially controlled area with high throughput, high optical quality elsewhere, and low scattering and show the feasibility of achieving the required extinction in a design that is adaptable for use in space.

PHASE II: Demonstrate a breadboard of a spatially controlled optical attenuator that satisfies the Phase I requirements.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A controllable optical spatial attenuation element could be incorporated in sensors to suppress the sun in the FOV of a camera.
Commercial Application: It could be used by police to suppress unwanted bright portions of a scene to aid in detecting persons in shadows. It could also be incorporated into cameras to take pictures looking into the sun.

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KEYWORDS: controllable reflective coatings/films, light control, optical attenuator, optical element, spatial light modulator

AF121-128 TITLE: Simulation of Small-Scale Damage Evolution During Processing of Polymer Matrix Materials Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Selection, between alternatives to be developed, of a computationally effective model, including interfaces/interphases/other heterogeneities, addressing the development of damage in composites during manufacturing processes and early loading.

DESCRIPTION: Processing of advanced materials must overcome challenges presented by combinations of dissimilar materials, which in composite, hybrid and multifunctional materials systems may involve wide disparities of thermomechanical properties, geometric complexities, and associated stress and flow/curing issues as well as chemomaterial differences. Residual stresses in composite structures lead to dimensional control issues, and analyses predict that thermal stresses are significantly affected by interphases; their importance to the macrolevel response is illustrated by potential orders-of-magnitude effect on fatigue life [1]. Large residual stresses promote premature failures, including not surviving manufacturing. Prediction of stresses associated with the appearance and evolution of interphases and associated damage initiation and propagation requires three-dimensional analyses. Especially as a precursor to component-level analyses up to early post-manufacturing loadings including damage, the computational burden is severe. Molding and infusion processes involve finite deformations and mass transport affecting formation of interphases as functions of surface properties of the fibers, finish and matrix reactivity [2]; related problems of interest to the Air Force involve e.g. distributed actuation, morphing, and human systems. The present study focuses on analysis and experimental validation of damage and life prediction associated with manufacturing of complex materials systems as affected by microscale processes including interphase and heterogeneity evolution.

A model system for the analysis of these effects is offered by high-temperature composites. Much progress has been made in modeling meso- and larger-scale damage in composites, including effects of substantial numbers of discretely modeled, possibly intersecting, matrix and delamination cracks, e.g., [3]. However, present methods do not account adequately for the interface/interphase/heterogeneity developments driving failure. Thermosetting resins, for example, may experience variations of cross-link density, modulus, and strength when cured near an

interface as opposed to a resin-rich region, e.g., [4]. An additional source of heterogeneity is the sizing material coating the fibers. The present topic emphasizes modeling and experimental analyses of failure of polyimide composites, e.g., MVK-14 and PMR-15, during processing and early loading. Objectives include to (a) quantitatively assess the magnitudes and spatial distributions of chemical and mechanical property inhomogeneities due to interphase regions, (b) describe the nature of interphases and identify the mechanisms and chemical kinetics by which they form, and (c) correlate degradation and damage predictions, which in general are coupled with macrolevel observations. To efficiently model the connections between reaction chemistry and stress in a region incorporating dispersed, differing constituents, thermodynamic mixture theory or related homogenization approaches can be applied. A variety of multiscale approaches can also be envisioned that rely on the explicit modeling of constituents, including interphases and their associated locally evolving boundaries. Preferred approaches to damage modeling will include the explicit representation of cracks, e.g., [3]. Acceptable computational procedures should guarantee numerically accurate solutions and be easily interfaced with widely used commercial software appropriate to larger scale (e.g. component) problems, e.g., ABAQUS, ANSYS, LS-DYNA, NASTRAN, etc. The numerical procedure should ideally be more rapidly convergent than standard approaches and highly parallelizable and should admit a range of unknown-type singularities in the solutions, e.g., [5]. However, widespread cracking presents special difficulties in addressing the many evolving boundaries; the optimum computational solution is sought. The product of the effort is commercially marketable software compatible with a commercial code and models the local effects of chemomechanical heterogeneities to address the damage resulting from processing and subsequent service histories of structural components.

PHASE I: Curing/damage modeling with interphases emphasizing a homogenization theory should be compared to a more detailed/discrete approach for inclusion of damage, computational efficiency, error, realistic residual stresses; models should be validated where possible by available solutions. Procedures exceeding quadratic convergence are beneficial.

PHASE II: A comprehensive experimental and modeling effort will address the formation of interphases and cracks in a polyimide matrix composite material during cure and early loading and the consequences of the local evolution of state on the macrolevel response. The local procedure must be compatible with a commercial code and application demonstrated to larger scale problems involving non-simple geometries, e.g. joints, out-of-plane contours, notches.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Cycle time to put new materials on Air Force systems is measured in decades. Multifunctional and hybrid materials, manufacturing dimensional control issues, and life prediction require improved analytical tools.
Commercial Application: Composite and hybrid structures are attaining preeminent importance in improving efficiencies in commercial air transportation. Manufacturing and life prediction concerns require wider exploitation.

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KEYWORDS: chemomechanical, damage prediction, inhomogeneous, Integrated Computational Materials and Manufacturing Science and Engineering (ICMSE), interface, interphase, hybrid materials, polyimide composites, polymer matrix materials, residual stress

AF121-129 TITLE: Innovative Nondestructive Damage Characterization Methods for Complex Aircraft Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop new methods for inverting representative sensing signals to provide suitable values for the presence, location, and size of damage in representative generic complex aircraft structures.

DESCRIPTION: The use of electromagnetic methods (primarily eddy current), ultrasound, and thermal techniques to detect damage in aircraft is well established and is a key item to ensure the risk of structural failures meets the requirements of the Aircraft Structural Integrity Program of the United States Air Force. As the maintenance of the structural components of aircraft moves from time-based maintenance to condition-based maintenance, there is a need for innovative methods not just to detect, but also to characterize damage in structural components.

This topic seeks new and innovative methods to characterize damage in representative generic, yet complex aircraft structures while capitalizing on the over 25 years of research in this area. Common aerospace materials include aluminum, titanium and steel alloys, plus graphite-epoxy composites. Methods that only address canonical shapes, e.g., plates and cylinders, are not sufficient to meet the intent of this topic, but could be stepping stones to reach the end objective. Typical complex aircraft structures will have compound curvatures and/or multiple layers that are fastened together with potential damage being located in each of the multiple layers of such structures. No specific aircraft structure is being targeted by this topic and, therefore, no specific geometric configuration information will be provided.

The damage characterization process must address the use of a single or minimal number of sensing elements and should focus on how the inversion from the received signal to a metric of damage presence, location, and dimensions would be accomplished. The overall approach can use automated analysis to assist in the determination of the damage characteristics, recognizing that this type of analysis has occurred in previous applications. It is anticipated that modeling will be a key element in any approach. Approaches using multiple sensing modalities can be integrated if needed. Recent trends of comparing the condition of a structural component to a baseline are of interest ONLY if they address the stochastic variability that makes such differential methods unreliable.

Guidelines for Nondestructive Inspection (NDI) capabilities required for setting inspection intervals are provided in Ref. 5. For example, rotary bolt hole eddy current inspection of mid bore cracks in titanium should detect cracks of 0.05 inch in depth and length, with 90% probability of detection and 95% confidence. Capability requirements are

highly dependent on the inspection method and the application's geometry and material. The innovative methods targeted by this topic must improve detection capability by at least 20% in pertinent damage dimensions with respect to existing methods. In multilayer structures, for example, proposed techniques could localize and size damage within 10% of actual in all dimensions, with 95% confidence. Geometric features such as radii, thicknesses, or heights can be used as reference for establishing the required accuracy as appropriate.

While the Phase I work can target a single material and a single damage type, the proposed approach should have sufficient flexibility to address structural components made from both metallic and composite materials. The technical effort should consider the various microstructures found in representative aircraft structural materials. The approach should address multiple damage modes such as fatigue cracks, stress corrosion cracks, and corrosion in metals plus delamination and porosity in composites. However, the exact damage mode is not as critical as the integration of realistic geometric complexity described above and associated stochastic boundary conditions into the characterization process. In addition, the approach should minimize, if not eliminate, any disassembly or other mechanical processing of the component. Another factor to consider is that the end product will be used by a NAS-410 Level II or equivalently trained and certified inspector.

PHASE I: Develop an approach and demonstrate the feasibility of the approach to characterize one type of damage in a typical complex aircraft structure as defined in the above topic description. Demonstration in one type of material, e.g. a metallic alloy or composite, is acceptable.

PHASE II: Further develop the output of the feasibility product from Phase I to demonstrate the applicability of the approach to multiple damage types in multiple materials in typical complex aircraft structures defined in the above topic description.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Nondestructive damage characterization for geometrically complex structures should have extensive military applications, including aerospace, nuclear, and ground structure military applications.
Commercial Application: Aerospace, nuclear, and civil structures initiatives aiming to use current condition for maintenance scheduling decisions can use nondestructive methods to characterize damage features of interest.

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Note: This list of references, while broad, is representative of the very large volume of research in this area, and proposals are expected to demonstrate reasonable awareness of previous work in this area.

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http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA493997

KEYWORDS: damage characterization, eddy current, electromagnetic methods, inverse problem, nondestructive evaluation (NDE), NDE, nondestructive inspection (NDI), NDI, nondestructive sensing (NDS), NDS, nondestructive testing (NDT), NDT, sensing elements, thermal techniques, ultrasound

AF121-130 TITLE: Computational Process Model Development for Direct Digital Manufacturing (DDM)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop computational techniques to describe a processing model for laser or electron beam-based metal power sintering/melting Direct Digital Manufacturing (DDM) processes.

DESCRIPTION: DDM is the process of taking a digital representation of a part or component and manufacturing the resulting product using a direct, automated, three-dimensional fabrication technique. There are over 20 DDM techniques, all of which rely on an existing digital design to guide the material fabrication of the part. Selective laser sintering (SLS) uses a high-power laser that fuses metal; the unfused particles support the part. The metal powder can either be fed directly into the laser (or electron beam) path and consolidated or consolidated from a bed of powder (a.k.a. direct metal laser sintering, DMLS). Both processes are of interest in the manufacture of complex aerospace components such as turbine engine blades, aircraft structural details, and heat exchangers. The United States Air Force is interested in DDM processes due to its low sensitivity to design changes; ability to provide responsive short-run manufacturing; and the reduced startup investment, including the need for tooling and dies.

While there are several commercially available SLS and DMLS processes, computational models based upon first principle physics/thermodynamics and empirical heat transfer models are not well developed. Model development based upon integrated materials science and engineering principles is critical to the maturation of DDM processes. Robust processing models can reduce risk at every stage of engineering development and enable fast and agile technology development. They can also reduce by 50% the development cycle and application of material solutions to improve innovation, performance, maintainability, and affordability.

Computational techniques of interest must address either a commercially available SLS or DMLS process. Models and techniques under consideration should have been previously developed for similar metallurgical applications where the thermodynamics, chemistry, and/or physics of powder-based alloy processing can be applied to the DDM process of interest. The techniques developed shall consider metal/alloy composition; powder size (and size distribution); laser (or electron beam) energy, spot size, and residence time; and geometrical constraints of the process such as power feed rate, power bed conditions (if applicable), and manufactured part geometry. The computational techniques shall model the finished part microstructure, composition, and residual stresses.

The goal of this program is to describe these three components fully on a demonstration part manufactured on a commercially available DDM process and associated equipment. Systems engineering principles should be used throughout for quantitative decision making in areas such as defining critical processing parameters and type of component (structural, nonstructural, propulsion, etc.) selected for verification of the model.

PHASE I: A candidate commercial DDM process shall be identified. Critical processing parameters such as candidate alloy composition, laser power and spot size, and geometry determined. One critical processing parameter shall be selected for computational modeling. An initial model shall be developed and a sample component processed to verify the model.

PHASE II: A fully integrated computational technique shall be developed with the goal of describing a finished DDM produced part microstructure, composition, and residual stresses. Intermediate experiments shall be identified and conducted to verify the fully integrated computational technique as appropriate. An aerospace quality alloy and component shall be selected and fabricated with processing conditions determined based upon the developed model.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The key advantage of DDM processes to military application is the potential cost and time savings of directly manufacturing complex components from a digital design. The elimination of tooling, dies, and casting molds would offer large cost savings.
Commercial Application: Commercial propulsion and airframe applications would benefit from DDM. In addition, the timesavings from rapid prototyping designs for engineering development would benefit both commercial and military application.

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KEYWORDS: computational models, computational techniques, DDM, direct digital manufacturing (DDM) process, direct metal laser sintering (DMLS), DMLS, selective laser sintering (SLS), SLS

AF121-131 TITLE: Passive Microfluidic Devices as Biological Fuel Cell Platforms

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and construct devices that function as enzyme-based biological fuel cells. Final product should: use range of fuels, operate in flow through mode, exhibit minimal parasitic losses, and be amenable to scalable, conformal application spaces.

DESCRIPTION: Biological fuel cells provide means for direct conversion of chemical energy to electricity using redox catalysts from biological systems (such as enzymes, organelles, or whole microorganisms) to oxidize fuels in the anodic half-cell reaction and then reduce terminal electron acceptor (usually molecular oxygen) in cathodic half-cell process. An efficient biological fuel cell may provide sustainable, compact power sources for portable electronics and other niche applications by using alcohols, sugars, and other organic sources as chemical fuel sources. The technology will decrease logistics burden for disposable batteries and decrease weight of many war fighter systems because power can be supplied by energy dense supplies that are part of materiel supply chain and by scavenging from the operational environment. The technology may also decrease ecological impact and the energy footprint of deployed forces by eliminating disposable batteries and using sustainable devices for recharge. Example near-term application may be distributed ground sensors that hold minimal metal content and display minimal environmental signature. As the technology develops with increased power densities, the biofuel cells may power autonomous microrobots and other higher-power demand devices.

The concept and fundamental aspects of biological fuel cells have been explored for more than 20 years. Contemporary biotechnology and nanotechnology practices enable controlled modification of bio-functionalized hybrid materials. This deeper understanding of bio-electrochemistry guides selection of the best redox enzymes for catalysts and enzyme-based fuel cells, which can transition from experimental concept and emerge as a legitimate portable power technology.

The topic seeks development and demonstration of device that relies entirely on bio-derived catalysts for oxidation of wide range of organic fuels including alcohols, polyols, and carbohydrates as well as catalysis of the reductive cathodic reactions (such as oxygen reduction). It is anticipated that oxygen will serve as the terminal electron acceptor for fuel cell device. The anode catalysts should support utilization of a range of fuel sources (at least three different fuels should be demonstrated) with high coulombic yield (i.e., desire complete oxidation of fuel). The device shall not operate as bio-battery with finite reactants that are constrained in a fixed reservoir; instead, the system must operate in flow-through mode in order to enable a refillable power source for the system and sustained use of catalysts. The device shall have flexible profile or means of fabrication that allows conforming design and integration in range of design spaces and concepts. Complete balance of plant measurements shall be established and zero or minimal parasitic losses are sought during device operation (e.g., pumping mechanism or other integration and parasitic losses should not exceed 10% or the energy produced by the device). For example, the offeror may propose integrated, open-air system that would sustain passive operations in which simple biological fuels (e.g., methanol or glycerol) are utilized and can be repeatedly cycled by addition of fresh fuel. Application of fuel cell

architectures using conventional inorganic catalysts will not be considered. Application of microbial-based biofuel cells are not of interest in this topic due to limited power density of the microbial systems.

PHASE I: Design and demonstrate a passive flow mechanism to fill an enzymatic fuel cell. Both anodic and cathodic processes must be enzyme catalyzed. Device provides power density of 0.1 to 1 mW/cm2 of electrode materials, with continuous output under flow through for at least 1 hour without application of external pumps or other power-consuming devices.

PHASE II: Demonstrate design in a manufacturable prototype. The device should operate >2 hours with <10% loss of power. The balance of plant should exhibit no more than 10% parasitic losses (power for external load to total power produced). The device should use more than three fuels (e.g., alcohols, polyols, or carbohydrates), preferably in mixtures. The device volumetric power density should be >10mW/cm3. The device should have shelf life >1 month.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Portable power from conversion of nonlogistics fuel for modest power demand devices (systems that require mW to W for extended periods of time). Examples include distributed sensors, portable communication, and microscale robotics.
Commercial Application: Portable power as above. Examples include consumer electronics, implantable biomedical devices, surveillance systems, and environmental monitors.

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KEYWORDS: bioderived catalyst, bioelectrochemistry, biological fuel cells, bionano interface, cathodic process, cathodic reaction, disposable batteries, enzymatic fuel cells, functionalized nanomaterials, microfluidic, redox catalyst, refillable power source

AF121-135 TITLE: Passive multi-spectral sensor for defense against hypersonic missiles (SAMs and A-A)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and demonstrate a new, innovative threat warning sensor system capable of detecting missiles at launch and in flight in sufficient time to execute effective defensive actions.

DESCRIPTION: DoD has been investigating warning concepts for several decades to protect aircraft from hostile threats. This SBIR topic seeks to investigate new, sensor concepts beyond what is currently being developed. (2-color imaging, multi-spectral focal plane array, hyper-spectral and AAR-47 UV concepts, etc.) Innovative optical sensor designs may include operation in the infrared, visible and UV radiation bands if they can meet warning requirements. The sensor system must provide a wide field of view, detect the threat of an approaching missile at far enough ranges to employ a countermeasure with high probability of detection, and low probability of false alarm.

PHASE I: Determine feasibility of a new innovative missile warning concept different than current developmental and operational systems and produce a design that meets the following warning requirements: the sensor must cover a wide field of view, detect the threat of an approaching missile with high probability of detection and low probability of false alarm, and at far enough ranges to employ one or more countermeasures.

PHASE II: Develop a working prototype module that demonstrates the capability of the new sensor system concept to meet performance requirements and provide design of a system for possible transition. Articulate a clear pathway toward productization.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integration of sensor system with future manned and unmanned aircraft systems (EW, flight control, avionics, propulsion) for enhanced survivability during combat engagements.
Commercial Application: Potential low-cost development program for a sensor system to protect commercial airliners from possible terrorist threat of missiles.

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KEYWORDS: Passive-sensors, multi-spectral, infrared, visible, UV, missile defense, missile warning sensors

AF121-136 TITLE: Low Frequency Direction Finding Antennas for Small Unmanned Aircraft Systems (SUAS)

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop, fabricate, and test prototype receiver and conformal antennas for low frequency direction finding (DF) applications onboard Small Unmanned Aircraft Systems (SUAS) platforms. System must meet size, weight and power (SWaP) constraints of SUAS.

DESCRIPTION: Direction finding techniques on SUAS platforms at very high frequency (VHF) present a significant challenge. The small size of these platforms and the large wavelengths in the band of interest require substantial space for the implementation of an antenna. Furthermore, in many instances a vertically polarized antenna is required and protruding into the air stream of the vehicle is not an option. As a result, the design of an electrically small conformal antenna deserves special attention. In fact, the interactions with, along with the excitation of the platform itself must be carefully considered. Detailed modeling and analysis as well as prototype fabrication, test and validation are desired. This study should investigate the feasibility of using new antenna geometries and materials to achieve electrically small antenna candidates that will not impact UAS performance. Additionally, this study should evaluate the performance of such candidates on a representative platform such as the RQ-7 Shadow SUAS.

PHASE I: Perform a trade study of an electrically small VHF conformal antenna concept for a RQ-7 Shadow UAS. Perform detailed design calculations and analysis to demonstrate the feasibility. A proof of concept prototype antenna shall be fabricated and tested. A configuration utilizing multiple antennas shall be identified.

PHASE II: Fabricate multiple prototype antenna units based on the results at the conclusion of Phase I. Conduct a detailed examination of the direction finding capability of the prototype system. Characterize the antennas through comprehensive S-parameter and gain measurements. Use measured data to predict direction finding system level performance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applications include locating threats, stand in jamming, and munitions deployment.
Commercial Application: Automobiles and commercial aircraft can both benefit by moving to a more compact and conformal antenna architecture.

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KEYWORDS: direct write, conformal antennas, electrically small antennas, size reduction, small UAS, SUAS

AF121-137 TITLE: High Gain Ka-Band Data Link Antennas with Wide-Field-of-Regard (WFOR)

TECHNOLOGY AREAS: Information Systems, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a Wide-Field-of-Regard (WFOR) Ka -Band antenna with extremely high data rate receive and low data rate transmit capabilities for ground-based Wide Area Airborne Surveillance (WAAS) terminals.

DESCRIPTION: High data rates are becoming increasingly important in communication systems for both military and commercial applications. Currently, ground-based antennas for receiving wide-area airborne sensor data are only marginal in being able to consistently and persistently receive the data from the airborne platforms flying at altitudes of 10 to 30 K ft. The bane of these antennas are relatively low gain and inability to accurately track the moving platforms.

Emerging wide-area electro-optical/infrared (EO/IR) motion imagery airborne surveillance, as well as other systems, will continue to require ground-based terminals with WFOR antennas for high data rate communication links from/to airborne platforms. These sensor systems will support motion imagery-based systems for contiguous airborne wide-area coverage of urban and selected environments with sufficient resolution and revisit rate to find, fix, and track vehicles and individual dismounts within their fields of view, day and/or night. The antenna, therefore, should be able to support extremely wide-band down-link signals and narrow-band up-link signals for Telemetry, Tracking, and Command (TT&C). In addition, the antenna must have a WFOR and be able to receive/transmit CP polarized waves. Closed-loop systems with a single channel receiver are preferred, but open-loop systems with a precise Inertial Measurements Unit (IMU) or antenna systems with multi-channel receivers will be considered. Solutions must provide robust acquisition and tracking over the required scan volume.

This topic seeks innovative antenna concepts to address these challenges. Possible solutions could include electronically steerable passive/active arrays (ESA) and hybrid antennas. The contractors are encouraged to explore new and innovative cost-effective concepts based on exotic materials/ metamaterials. The basic antenna characteristics are: operating frequency is Ka-Band, scan volume 120 deg cone, receive beamwidth is 1 deg, and the data rate is greater than 1 Gbps.

Transition of this technology will include developing a WFOR antenna system. The system must be able to demonstrate the acquisition and tracking of suitable moving data link transmitters at a standoff distance at multi-GHz rates. The system must be capable of maintaining these high data rate links during the motion of the source signal.

PHASE I: Design a WFOR Ka-band ground-based antenna system according to stated requirements and quantify its expected performance. The design must outline plans to construct, test, and deliver a working prototype in Phase II, including a risk and cost assessment.

PHASE II: Refine the design developed during Phase I. Build a prototype unit and conduct comprehensive testing and analysis with attention to radiation pattern vs. steering angle, efficiency, acquisition, tracking, and data rate/bandwidth.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A WFOR antenna system will find wide use for military and commercial data link applications such as wireless internet, laser communication backup, etc.
Commercial Application: WFOR antenna systems could be useful in High Definition (HD) video links for remote medicine and mission planning and operations.

REFERENCES:
1. R. Mailloux, “Phased Array Antenna Handbook,” Artec House, 1994.

2. C.A. Balanis, “Antenna Theory Analysis & Design,” John Wiley & Sons 1982.

KEYWORDS: high data rate communication antennas, phased arrays, hybrid, beam steering, simultaneous transmit and receive antennastive beam forming

AF121-138 TITLE: Airborne Passive Radar

TECHNOLOGY AREAS: Air Platform, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design and demonstrate a passive radar air to air detection sensor system for aircraft installation that can passively detect and track other aircraft.

DESCRIPTION: Combat aircraft require an accurate air surveillance picture in order to fulfill their missions. Radar has proven an effective, all-weather solution, but the transmission of radar waveforms provides a signal which can be exploited by the adversary to determine bearing to the aircraft. The capability to achieve situational awareness without emitting any signals which could be intercepted. Passive infrared and optical systems are common, but their performance can be severely degraded in poor atmospheric conditions. By illuminating an airborne target using multiple commercial ground based transmitters and linking multiple receivers into a coordinated network, it should be possible to greatly increase the chances of detecting and tracking an airborne target in all weather conditions. No single receiver may record a strong or steady echo from any single commercial transmitter, but the network as a whole might collect enough information to detect and track a target. This topic will develop approaches for networked passive radar systems which possess characteristics of size, weight, and power commensurate with fighter and bomber class aircraft without significantly diminishing the crafts performance envelope. The detection sensor system must demonstrate the capability to operate with both low false alarm rates and relatively high probability of detection under operational conditions.

PHASE I: Perform a technology feasibility assessment and deliver a description of the conceptual solution of an airborne passive radar system, data to support the feasibility of the proposed solution, and a brief outline of a Phase II effort.

PHASE II: Construct and demonstrate technology leading to airborne passive radar detection and tracking sensor system in a laboratory environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Adapt the laboratory prototype sensor system design to be an airborne prototype with complete operational compatibility to validate these new sensor system performance characteristics.
Commercial Application: Air Traffic Control of non transponder transmitting aircraft.

REFERENCES:

1. Willis, N. J., H. D. Griffiths, and D. K. Barton, “Air Surveillance,” Chapter 6 of “Advances in Bistatic Radar,” N.J. Willis and H. D. Griffiths, eds., SciTech, 2007.
2. Radar versus Stealth, Passive Radar and the Future of U.S. Military Power, Lieutenant Colonel Arend G. Westra, USMC. Issue 55, 4th quarter 2009 / Joint Force Quarterly.

KEYWORDS: Airborne sensors, passive radar detection, aerial vehicle detection

AF121-139 TITLE: Improved Real Time Geo-Registration Techniques For Airborne Imagery

TECHNOLOGY AREAS: Sensors

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OBJECTIVE: To develop novel approaches for reducing error in the geo-location estimates in imagery from airborne remote sensors.

DESCRIPTION: An objective of the military is to provide relevant airborne imagery and sensor products to the Warfighter on a near real-time basis. For the Warfighter to act upon this intelligence, the imagery must not only be timely but location accurate (to the sub-meter level in many cases). Errors in the reported pixel location could result in the deployment of troops or marines to the wrong street location, house address, or remote terrain position.

The new field of wide area airborne electro-optical/infrared (EO/IR) surveillance has resulted in the development of sensors reporting extremely large quantity of pixels per image frame. Additionally, other sensors such as hyperspectral and synthetic aperture radar are being used in a wide area format for new missions. These wide area sensors are currently being flown on medium altitude (10-30k ft) airborne platforms. To make these sensor images useful on a near real-time basis, the users must be provided with accurate geo-location information for the entire image area. Geo-location is typically determined in one of two ways. First, ancillary information sampled during the image collect including global positioning system and inertial measurement unit (IMU) data (roll, pitch and yaw) are combined with detailed sensor models (optics, focal plane array, co-registration, etc.) and digital terrain elevation data (DTED) to geo-register the pixels within the image. Second, imagery collected can be registered against pre-existing geo-located imagery to provide the geo-location of all pixels within the image.

This SBIR seeks innovative solutions to fundamental problems or limitations exhibited by current geo-registration techniques. Example limitations include the extensive IMU to camera calibration process required before IMU-based techniques can be used, the limitations in accuracy imposed by IMU, geo-registered map, or DTED accuracy, or the effect of using possibly outdated data for comparison with current data.

PHASE I: Simulation-based demonstration of improved geo-location performance should be accomplished.

PHASE II: Using real data, real-time improvements in geo-location accuracy should be demonstrated. The Air Force will provide data for realistic demonstration scenarios.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Multiple intelligence, surveillance and reconnaisance assets currently used and in development will benefit from improved geo-location accuracy and/or lower costs required to achieve needed accuracy.
Commercial Application: Law enforcement, border patrol, and other civilian tasks requiring aerial video assets will also benefit from improved geo-location accuracy.

REFERENCES:
1. F. Mirzaei and S. Roumeliotis, “A Kalman Filter-based Algorithm for IMU-Camera Calibration: Observability Analysis and Performance Evaluation,” IEEE Transactions on Robotics, v. 24(5), October 2008.

2. E. Andersen and C. Taylor, “Improving MAV Pose Estimation Using Visual Information,” in Proceedings, IEEE International Conference on Intelligent Robots and Systems, San Diego, CA, Oct-Nov, 2007.

3. H. Durrant-Whyte and T. Bailey, "Simultaneous localisation and mapping (SLAM): Part I the essential algorithms," Robotics and Automation Magazine, 2006.

KEYWORDS: geo-registration, accuracy, data fusion

AF121-140 TITLE: Multi-Sensor Data Compression

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop, build and demonstrate standard compression hardware/software for the MQ-1 ACES HY program. Facilitate timely use of airborne Hyperspectral (HSI) sensor data by tactical users and analysts. Support compression extendibility to other sensors.

DESCRIPTION: Compression approaches applied to airborne data reduce required data bandwidth requirements while preserving features required for exploitation in operationally significant timelines. Sensors such as electro-optical, infra-red (IR), full motion video, and synthetic aperture radar (SAR) use data compression techniques approved by Department of Defense (DoD) to meet communication limitations, however DoD has not yet developed and/or approved a standardized means of compressing/decompressing HSI data. The Airborne Cross Cuing Exploitation Systems – Hyperspectral (ACES HY) is the Air Force's first operational airborne HSI sensor due to fly on DoD Remotely Piloted Aircraft (RPA) in 2012. The Air Force and DoD have been experimenting with airborne HSI sensors for the last twenty years as a means to recognize targets based upon their unique spectral signatures. However, HSI sensors are high-data output sensors that are capable of quickly overwhelming the capacity of current air to ground communications links. ACES-HY partially solves this problem through on-board processing and reporting on a limited set of spectral signatures and recording all data for later analysis post-mission. A key objective of the program is to compress HSI data and to pass it real-time over existing communications links to tactical and theater users and imagery analysts. The goal is to achieve the desired sensor data bit rate without compromising the data quality required for tactical analysis using current applications. Decompression is to be done concurrently without introducing unacceptable latency into the defined imagery processing timeline. In addition, the Air Force is looking to develop a standards-based family of compression methods for other existing airborne sensors, and those being added to the inventory over the next ten years. Data compression is the science of finding efficient representations for digital data in order to reduce:

• Bandwidth and/or the time required for their transfer across communication channels
• Memory required for their storage
• Effective data access time when reading from storage devices

National Imagery Transmission Format Standard (NITFS) is the suite of standards for formatting digital imagery and imagery-related products and exchanging them within DoD and government agencies. A program objective is to complete development and testing of the new compression algorithm/hardware and to initiate National Geospatial Agency (NGA) support to include HSI compression algorithm capabilities in their portfolio of NITFS approved compression algorithms. A desirable feature of a new compression approach is its extendibility to additional sensor data types which are supported by the NITF format.

PHASE I: Research national standards for imagery transmission and determine how these apply to HSI data transmission. Conduct systems engineering and analysis to identify the system trades and identify possible designs

and a compression implementation program for ACES HY. Indicate how the technique preserves salient features for tactical HSI analysis. ACES HY and other representative sensor data will be provided to support Phases I and II.

PHASE II: Develop, build and demonstrate prototype compression/decompression hardware/software facilitating the timely use of HSI data by tactical users and imagery analysts. Conduct operationally representative demonstration of HSI compression within the current AF IMINT architecture using ACES HY sensor data. Indicate how the compression technique can be extended to SAR, EO, IR or polarimetric sensor data.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include using these compression capabilities in support of real-time operations on-board all DoD platforms carrying spectral sensors and for reduced data storage requirements in exploitation ground stations.
Commercial Application: Commercial applications include using this compression capability to reduce storage requirements for air and space derived hyperspectral and multispectral data of agricultural crops.

REFERENCES:
1. A. Singh, "Digital change detection techniques using remotely-sensed data", International Journal of Remote Sensing, Vol. 10 (6), 1989, pp. 989-1003.

2. R. Radke, et. al., "Image change detection algorithms: A systematic survey", IEEE Trans. on Image Processing, Vol. 14 (3), 2005, pp. 294-307.

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4. Schaum, et. al., "Hyperspectral change detection in high clutter using elliptically contoured distributions", Proc. SPIE, Vol. 6565, 2007, pp. 656515-1 - 656515-12.

5. J. Meola, et. al., "A Model-based Approach to Hyperspectral Change Detection", Proc. SPIE, Vol. 7695, 2010, pp. 76951G-1 - 76951G-12.

KEYWORDS: Hyperspectral, HSI, Multispectral, MSI, compression, data link, Change Detection, ACES HY, RPA, NITFS, IMINT

AF121-142 TITLE: Unified Move Stop Move Combat Identification

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a radio frequency (RF)-based combat identification system capable of maintaining target identification (ID) through move-stop-move scenarios.

DESCRIPTION: Tracking and ID of high value targets (HVT) is critical to counter asymmetric threats. This capability is needed across a wide range of weather conditions, making radar-based solutions preferred. Significant research has been performed individually on the topics of moving-target and stationary-target ID. While there has been success in each individual endeavor, missing is the work that unifies these two fields. These two fields have

remained independent as moving-target ID typically employs the use of ultra high-range resolution (UHRR) profiles while stationary-target ID uses synthetic aperture radar (SAR) images.

A moving only or stationary only target ID system is insufficient as HVTs are equally likely to occur in either state. Thus the next step for HVT Combat Identification (CID) is the development of a system that can maintain track and ID through typical HVT maneuvers. Such a capability could be achieved by combining high-range resolution (HRR) and SAR imaging into a single classification system.

One design approach is to leverage existing feature-aided tracking (FAT) technology. The typical inputs to a FAT system are UHRR profiles. Thus SAR data would first have to be reduced into range profiles. While reducing the dimensionality of SAR data to 1D would likely result in the reduction of information, there are several potential benefits to this approach. First, the developed classifiers associated with FAT systems could be leveraged. Second, the primary weakness of FAT systems is their inability to classify stationary targets. Inclusion of ultra high-range resolution (UHRR) profiles derived from SAR maps of stationary targets would provide a potential solution to this current limitation. Third, this approach will greatly enhance the ability to fuse classifier discriminates between moving and stationary target states.

PHASE I: Identify the appropriate feature extraction and classification techniques required for a CID system of HVTs in both moving and stationary states.

PHASE II: Develop and demonstrate an automated Move-Stop-Move CID system under realistic scenarios. Deliverables include an analysis of system performance for multiple targets and scenarios, utilizing standard CID performance metrics.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This improved method is directly applicable to ongoing programs supporting military aircraft and all other weapons platforms requiring a moving target ATC/R capability.
Commercial Application: Commercialization of this approach is applicable to multiple problems currently of interest for public safety, border surveillance, and homeland security.

REFERENCES:
1. SPIE proceedings on Algorithms for Synthetic Aperture Radar Imagery V, vol. 3370, (Orlando, FL), pp. 73-84, April 1998.

2. Schumacher, R., Schiller, J. , “Non-cooperative target identification of battlefield targets - classification results based on SAR images”, Radar Conference, 2005 IEEE International, pp. 167 – 172, 9-12 May 2005.

3. Kahler, B., Blasch, E., “Robust multi-look HRR ATR investigation through decision-level fusion evaluation”, 2008 11th International Conference on Information Fusion, pp. 1-8, June 30-July 3 2008.

4. R. Williams, J. Westerkamp, D. Gross, and A. Palomino, "Automatic Target Recognition of Time Critical Moving Targets Using ID High Range Resolution (HRR) Radar", IEEE AES Systems Magazine, April 2000.

KEYWORDS: sensors, automated target recognition, high range resolution, synthetic aperture radar, combat identification, move-stop-move, ATR, HRR, SAR, CID, HVT

AF121-143 TITLE: Inverse Synthetic Aperture Radar (ISAR) For Terrestrial Targets

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only

U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Inverse Synthetic (ISAR) mode to provide enhanced resolution for selected moving targets from a WAS platform for purpose of (Non-Cooperative Target Identification (NCTI); support time critical target detection, tracking, and characterization, to provide added benefit to the warfighter.

DESCRIPTION: Inverse Synthetic Aperture Radar (ISAR) uses Doppler frequencies introduced by target non-linear motion to provide enhanced cross-range resolution. ISAR mode can be used to image vehicles as they move through a curve. Moving targets which are defocused in normal SAR imagery can now be imaged. ISAR imagery is formed using relatively short dwells which provides improved Automatic Target Recognition (ATR) capabilities without a long interruption of the Wide Area Surveillance (WAS) function.

SBIR will investigate algorithms developed for earlier applications (Navy's approach on Hairy Buffalo, MITRE's Ground Moving Target Detection and Imaging approach, etc), and will recommend and develop algorithm suitable for WAS application. Algorithm (Back projection, etc) will consider approaches for waveforms employing the stepped frequency approach. The study will address waveform issues such as integration time and resolution requirements, Signal-to-Noise Ratio (SNR) requirement, and motion compensation approaches, etc. ISAR supports moving time critical target (TCT) detection, tracking, and characterization and provides added benefit to the warfighter. In addition, SBIR will investigate using ISAR to extract features for target classification algorithms and feature level fusion.

Current ISAR and ATR challenges include 1) using radars with narrow instantaneous bandwidths, and 2) estimating target motion to the fidelity required for generating useful ISAR imagery. 3) Choosing target features that provide robust target Identification (ID)

1) Hardware issues often limit airborne radars to narrow instantaneous bandwidths. The resulting range resolution provided by these narrow bandwidth waveforms may not be adequate for effective ATR. One approach to overcome these limitations is to make use of stepped-frequency waveforms. In this approach, multiple narrow-band waveforms are transmitted, each covering a different band. A wide bandwidth result is then synthesized by correctly combining the multiple received signals. Correct signal combination must account for both the clutter and the moving target, as well as any radar hardware practicalities.

2) Air-to-ground ISAR, in its simplest form, exploits the radar signal variations as the target rotates in relation to the radar sensor. The complexities of real-world ground-vehicle motion and scattering can make the generation of "quality" ISAR images challenging. Ultimately, the metric for determining the quality of the ISAR results is whether or not the resulting features provide value for some form of target ID function.

3) To be useful, the resulting target ID function, based on ISAR features, must be robust to the expected variations in target geometry as the target is observed at different times and locations.

PHASE I: Develop modeling, simulation and analysis capability to demonstrate ISAR algorithm for air-to-ground surveillance applications. Algorithm will consider approaches for waveforms employing the stepped frequency approach and realistic target and platform motion models. Investigate methods to extract features from ISAR for use in classification algorithms. At end of Phase I effort, demonstrate working ISAR capability, and discuss detailed Phase II plan to develop an NCTI capability based on ISAR features.

PHASE II: Develop and demonstrate an effective NCTI capability based on ISAR features. By end of Phase II effort, capability must be demonstrated with actual radar data (not simulated).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Developed technologies are highly applicable for integration into current/future airborne surveillance systems.
Commercial Application: Technology is applicable for commercial imaging systems.

REFERENCES:
1. Jakowatz, Charles V. JR., et al,"Spotlight Mode Synthetic Aperture Radar: A Signal Processing Approach" Sandia National Laboratories, Albuquerque, New Mexico,1996, Kluwer Academic Publishers Group.

2. John C Curlander, Robert N. McDonough, "Synthetic Aperture Radar Systems and Signal Processing" 1991 John Wiley & Sons Inc.

3. Walter G. Carrara, Ron S. Goodman, Ronald M Majewski, "Spotlight Synthetic Aperture Radar" 1995 Artech House, Inc.

KEYWORDS: Sensors, SAR, & ISAR

AF121-144 TITLE: Wind Turbine Clutter Mitigation for Terminal Air Traffic Control (ATC) Radars

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Devise a methodology to mitigate wind turbine clutter interference for existing ATC radar systems. The proposed solutions-based concept should attempt to minimize modification of the existing ATC radar system hardware/software.

DESCRIPTION: ATC radar systems detect and track aircraft in the vicinity of homeland airspace. These radars include Air Surveillance Radars (ASRs) and Air Route Surveillance Radars (ARSRs) supporting surveillance missions in the National Airspace (NAS). Their primary mission intent is to provide situational awareness of civilian aircraft, but systems like the ARSR-4 also have the responsibility to detect threat aircraft and report their findings through military and Department of Homeland Security (DHS) channels. Thus, the quality of data from ATC radar systems is critical to every stakeholder. Wind farms are rapidly being installed in the United States and abroad to meet the need for clean, renewable energy. However, wind farms can interfere with ATC radar system performance, mainly through the introduction of non-stationary clutter [1]. For example, most air traffic control radars typically use fan beams that have limited ability to be repositioned above the wind turbines, thereby causing the wind turbines to constantly be within the line-of-sight of the radar system. Wind turbine clutter can prove misleading and has been documented by radar operators to appear as anomalous weather and/or aircraft. Wind turbine induced interference effects also results in the desensitization of the radar, reducing the probability of detection for aircraft, even those at significant altitudes above the wind farm. Suggested mitigation strategies to date have called for modifications to the ATC radar hardware/software to help restore performance to affected systems; unfortunately, many of these suggestions are system specific and have not been proven to significantly increase ATC radar detection performance. The objective of this proposal is to explore alternative, innovative approaches for wind turbine clutter mitigation that can be implemented within existing ATC radar systems architecture; these approaches are focused more on the development of adaptive, knowledge-aided, or other algorithmic solutions-based concepts that will lessen or remove the deleterious effects of clutter effects imposed by wind turbines. The ideal solutions-based concept will enable the ATC radar system to detect and track both civilian and non-cooperative threat aircraft with a high probability of detection, low false alarm rate, at all altitudes and to the ATC radar systems maximum detection range.

PHASE I: Propose, develop and validate innovative solutions-based methodology to mitigate wind turbine clutter interference & improve target detection for existing ATC radars; this may be achieved via any combination of modeling, simulation, data analysis, prototyping, or other method suitable to show the benefit of the solutions-based concept.

PHASE II: Refine and propose a test methodology to validate the Phase I innovative solutions-based concept for wind turbine clutter interference mitigation and improved target detection (low constant false alarm rate) for existing ATC radar systems. Validation must be performed via integration into a candidate ATC radar system, for real-world verification of operational utility of the proposed mitigation concept.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: Mitigation of wind turbine induced clutter effects will permit military ATC radars to provide operationally relevant data for the monitoring and defense of the national airspace by providing full situational awareness of civilian & threat aircraft.
Commercial Application: The solution will have immediate application to civilian ATC radars operating in the vicinity of wind farms, improving controller situational awareness and flight safety.

REFERENCES:
1. JASON REPORT - JSR-08-125, Wind Farms and Radar (MITRE) Jan 2008 (see http://www.fas.org/irp/agency/dod/jason/wind.pdf).

2. SAVANAH RIVER NATIONAL RESEARCH REPORT - SRNS-STI-2010-00014, 15 Jan 2010, "Improved Capabilities for Siting Wind Farms and Mitigating Impacts on Radar Observations", OSTI ID: 973589 (see http://www.osti.gov/bridge/product.biblio.jsp?osti_id=973589).

3. OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING REPORT TO CONGRESS, "The Effect of Windmill Farms on Military Readiness", Accession Number: ADA455993, (see http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA455993).

KEYWORDS: radar, clutter, mitigation, wind turbine, ASR, ARSR

AF121-145 TITLE: HF Digital Receiver

TECHNOLOGY AREAS: Sensors

OBJECTIVE: High Frequency (HF) Digital Receiver Design and Development for Next Generation Over the Horizon Radar (OTHR). The digital receiver will provide wideband HF data for multiband processing for radar detection and track performance improvements.

DESCRIPTION: Next Generation Over the Horizon Radar (OTHR) has the ability to provide wide area surveillance. The radar operates over the 6 – 28 MHz band. By refracting off the ionosphere, the radar can detect targets at ranges from 1000 to 3000 km. Current generation OTHR use linear arrays with analog receivers. A next generation system is expected to have two dimensional (2D) arrays (narrow beam in both elevation and azimuth), arbitrary waveform generator/power amplifier at every transmit element, and digital receivers at every receive element. This fully digital array will have significant capability, including the ability to function in a Multiple Input Multiple Output (MIMO) radar mode.

The objective of this effort is to design and develop a large instantaneous bandwidth receiver for the next generation fully digital beamforming HF radar. The receiver design should include an analog front-end processing, analog-to-digital conversion (ADC), digital down conversion and control interface. Each section will be isolated from each other to minimize spurs and signal interferences. A very high dynamic range is needed for a low noise figure in the signal processing path to provide the radar with the capability to resolve weak targets in the presence of clutter and interference.

The analog front end will include preamps, attenuators, band-pass filters, pre-selection filters, ADC driver amplifiers, and anti-aliasing filters. Input Voltage Standing Wave Ratio (VSWR) should be less than 2:1, with a noise figure around 7 dB typically. The pre-selection filters should be programmable. The gain of the analog section shall be sufficient that the noise of the external environment at no attenuation shall dominate the overall receiver noise level. The design will maximize the dynamic range.

The analog to digital conversion shall be sampled at a minimum of 100 MHz and synchronized to an external clock source. The design should allow the capture of raw analog-to-digital (A/D) output data, stored in onboard memory buffers, with the ability to send the information to a host computer.

Digital Down Conversion (DDC) shall allow the ability to provide both narrowband and wideband channels simultaneously. The receiver will be able to delay the sampling start relative to the sync source. The DDC internal data word size shall be greater than 24 bits for narrowband and 16 bits for wideband to meet the desired dynamic range requirements.

A control interface will be provided that allows the receiver to be commanded during normal radar operation and local tests.

PHASE I: The contractor will work with the HF technical community to define performancerequirements for their digital receiver design. The design will be suitable for incorporation into an operational testbed. High risk elements will be identified and mitigation strategies outlined.

PHASE II: The contractor will build prototype HF receiver(s). The receiver will be tested both by the contractor as well as by a government team. Conducted tests will quantify performance metrics such as dynamic range and spurious signals. The production methods and cost of the design will be quantified. Results will be documented in a final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: There is increased interest in the HF spectrum for radar and communications. HF radar and communication systems are migrating to HF digital receivers to take advantage of the improvements from enhanced signal processing.
Commercial Application: There is a broad base of commercial users in the HF spectrum, including HAM operators, environmental diagnostics, surface wave oceanic radars, etc. An affordable digital receiver would be attractive to all parties.

REFERENCES:
1. Frazer, Gordon, "Forward-based receiver Augmentation for OTHR", Radar Conference 2007, Pages 373-378.

2. Fabrizio, G.; Colone, F.; Lombardo, P.; Farina, A.; "Adaptive beamforming for High Frequency Over the Horizon Passive Radar", Radar, Sonar & Navigation, IET, Vol 3, Issue:4, 2009, Pages 384-405.

3. Pearce, T.H.; "The application of digital receiver technology to HF Radar", HF Radio Systems and Techniques, 1991, Fifth International Conference on, Pages 304-309.

4. Oscarsson, C.F.A.; "Digital HF Receiver", Radio Receivers and Associated Systems, 1995, Sixth International Conference on, 1995, Pages 47-51.

KEYWORDS: HF, Digital, Receiver, Radar

AF121-146 TITLE: Passive Optical Taggants for Laser Designated Friend or Foe Identification

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research new materials, devices, designs, and construction techniques and test innovative optical tagging devices for identification of friend from foe.

DESCRIPTION: A major factor in combat effectiveness is the potential for loss due to friendly fire. Novel devices that can provide a unique capability (such as optical tagging) to support distinguishing of friend from foe are a key element in timely combat decisions and minimizing fratricide.

Innovative, low cost, passive optical taggants are needed to support identification of friendly and non-combatant ground entities in the battlefield. The passive taggants will be for frequency conversion only. The taggants should convert excitation incident light in the wavelength range of 1 to 1.6µm to emitted light within the wavelength range of 3 to 5µm. The emission/conversion wavelength range corresponds to the atmospheric transmission band for efficient detection. Additionally, the taggants should have minimum of out-of-band emissions, especially in the visible to near-infrared (IR) wavelengths, with the goal being none.

The device (i.e. packaged or encapsulated taggants) should provide conversion efficiency of approximately 30 percent or better. The device should function efficiently in a battlefield ground environment with minor variation across the military temperature range of -20ºC to +55ºC. The device should allow for installed configurations in a variety of optical cross sections and shapes. The device should be easy to install in the field on a wide variety of objects, especially vehicles and potentially persons. It should also be mechanically durable and resistant to wear such as abrasion, shock and spills (sealed).

A key goal is low cost. A target cost of less than $100 per device at production volume (10,000 per year) is desired.

No external power will be available and it is imperative that the device is passive, i.e. not have an internal power source. The device will be part of a larger imaging-based combat identification system. This system will provide the capability of distinguishing objects via spectral signatures. The military uses will include applications for identification of friend-or-foe and dual uses such as search-and-rescue missions. It is expected that the taggant would be visible to a forward-looking infrared (FLIR).

Among additional features that would be desirable would be extremely fine spectral resolution. The conversion of individual spectral lines to correspondingly wavelength converted, high resolution, low bandwidth signals would provide added functionality to allow for easily extending the application of the device beyond its current requirement. While the desired efficiency is currently stated at ~30%, some variations are expected in practice depending of the optical cross-section of the conversion device, alignment between the interrogating source, the device and the detection mechanism, and interference due to changing atmospheric conditions.

Security features to minimize the opportunity for enemy use of the device to “spoof” the system would be desirable.

PHASE I: Research, Design and Develop innovative identification optical taggant devices for identification of friend-from-foe. Device performance meeting the above objectives should be demonstrated using computational models and/or measurements, or by some other means.

PHASE II: Rugged prototypes should be built, and performance meeting the above objectives demonstrated by measurements.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: US and allied military user equipment programs will be interested in the optical taggant devices to improve the accuracy of identification devices.
Commercial Application: Commercial optical tagging technology is a very large and growing industry. Many next-generation detection and tagging schemes will include such devices.

REFERENCES:
1. G. C. Gilbreath, T. J. Meehan, W. S. Rabinovich, M. J. Vilcheck, R. Mahon, M. Ferraro, J.A. Vasquez, I. Sokolsky, D. S. Katzer, K. Ikossi-Anastasiou, and Peter G.Goetz," for Optical Tagging for LEO Consumables", Proceedings of the IEEEAerosence Conference, Paper No.504, March, 2001.

2. Marcos C. Sola, E. Glenn Dockery, Joseph A. Penn, Paul L. Zirkle, Charles R. Kohler, Teresa A. Kipp, and Janice F. Colby, “A Proposal for an Active/Passive Signature Enhancer for Identification Friend-or-Foe” ARL-TR-1377, October 1997, Sensors and Electron Devices Directorate, Adelphi, MD.

3. “Quantum Wells, Wires and Dots (Second Edition)”, Paul Harrison, 27 Jan 2006, ISBN: 9780470010792.

KEYWORDS: Taggant, optical, infrared, detection, identification, wavelength conversion

AF121-147 TITLE: Low Size, Weight and Power Direction Antenna for Common Data Link

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a Ku Band simultaneous transmit and receive antenna for line-of-sight communications on small unmanned airborne platforms. Design a lightweight, small, with low power consumption for minimal impact to the unmanned aircraft system (UAS).

DESCRIPTION: The Air Force is interested in the development and demonstration of high data rate communications at extended ranges for small unmanned aircraft such as the Shadow or the Scan Eagle. The communication link is line-of-sight using the Ku Band Common Data Link radio. The mini Common Data Link hardware development effort provides the user with a terminal that has very low size, weight, and power (SWaP) and the abiltiy to support full duplex high data rate communications. The component that remains to be developed is a lightweight, directional antenna.

This topic seeks innovative antenna concepts to address this challenge. Currently there are omni-directional antennas that do not provide sufficient gain. There are also larger directional antennas that exceed the size and weight limitations for the platforms of interest. The objective is to develop an antenna that can be used on small airborne platforms, provide higher gain toward the horizon to support line-of-sight communications, and to operate in a full duplex mode. The challenge lies in obtaining coverage around the horizon, the ability to steer the beam, and for the antenna to have minimal height protrusion (installed typically on the underside of the fuselage) and weight. These challenges will require the designer to explore the use of hybrid antenna designs (minimize height) coupled with advanced materials (minimize weight). The contractors are also encouraged to to explore new and innovative cost-effective concepts based on exotic materials/metamaterials for increased bandwidth and size reduction.

Requirements include an operational frequency band of 14.4 GHz to 15.4 GHz. The antenna shall be right hand circularly polarized. Objective gain is 20 dB and threshold is 14 dB, with the ability to handle up to 20 watts of radiated power. The G/T objective is -4 dB/K with a threshold requirement of -10 dB/K. In general the aircraft will fly at up to 5000 ft, and should be able to close the link directly below out to the horizon. Objective weight for the antenna is less than 8 lbs, with a size constrained to 200 cubic inches. The height of the antenna must be consistent with the ability of the aircraft to be landed without damage to the antenna unit. The unit, in production quantities of 100, should cost no more than $25k each with a desired cost of $10k each. Although tracking concepts do not need to be implemented, the design must be able to accommodate a step-scan tracking methodology.

PHASE I: Design a low SWaP low profile antenna operating at Ku Band. Evaluate the cost of the design, ability of the antenna beam to be positioned (track), and the installation concept. Demonstrate feasibility of the design to meet the performance goals and analyze technical challenges of the concept.

PHASE II: Refine the design developed during Phase 1. Build a prototype unit and conduct comprehensive testing and analysis with attention to performance on an airborne platform. Provide a report and recommendations based upon these results. Deliver to AFRL a working prototype.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: There are extensive applications for unmanned aircraft. The ability to communicate with the airframe and to transfer data is critical to the platform utility. This effort will enable the UAS to support other equipment while maintaining COMM.
Commercial Application: The Commercial application is consistent with the DoD application. Air transport providers would like to provide network connectivity for their customers during flight.

REFERENCES:
1. Zi-bin Weng,: Rong Guo; Yong-Chang Jiao; "Design and Experiment on Substrate Integrated Waveguide Resonant Slot Array Antenna at Lu Band" Antennas, Propagation &EM Theory, 2006, ISAPE '06, Page 1-3.

2. Vaccaro, S.; Tiezzi, F.; Llorens, D.; Rua, M.F.; De Oro, C.D.G.; "Ku band Low Profile Antennas for Mobile SATCOM", Advanced Satellite Mobile Systems, 2008. ASMS 2008. 4th, pages 24-28.

3. Vaccaro, S.; Tiezzi, F.' Rua, M.F.; De Oro, C.D.G.; "Ku Band Low Profile Rx only and Tx-Rx antennas for mobile satellite communications", Phased Array Systems and technology (ARRAY), 2010 IEEE International Symposium on, Pages 536-542.

4. Padilla, P.; Munoz-Acevedo, A.; Sierra-castaner, M.; "Passive Microstrip Transmitarray lens for Ku band", Antennas and propagation (EuCAP), 2010 Proceedings of the Fourth European Conference on, Pages 1-3.

5. Jinghui Qiu; Wei Li; Ying Suo; "A Novel High Gain Beam Scanning Hemispherical Dielectric Lens Antenna" ITS Telecommunications proceedings, 2006 6th International Conference on, pages 419-421.

KEYWORDS: antenna, low profile, directional, hybrid

AF121-148 TITLE: Virtual Receiver/Exciter (VREX) Generalized Simulator with Selectable Waveforms to Support Radar and Software Analysis

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a generalized radar simulator with selectable waveforms to facilitate radar system software development and testing for current and future radar modernization activities.

DESCRIPTION: Military operations are executed in an information environment increasingly complicated by the electromagnetic (EM) spectrum. The electromagnetic spectrum portion of the information environment is referred to as the electromagnetic environment (EME). The military requirement for unimpeded access to the EME creates vulnerabilities and opportunities for electronic warfare (EW) in support of military operations. The mission of the Electronic Systems Command Space Command Control and Surveillance Division (ESC/HSI) is to upgrade and sustain Space Surveillance Network (SSN) dedicated ground based sensors. These sensors consist of dish radars, phased array radars and optical systems. To date, there is no capability to test software patches, configuration upgrades or waveform frequency changes without the expense of traveling to the operational site. Currently,

operational radar systems without a Virtual Receiver/Exciter (VREX) simulation capability must be brought offline causing loss of function and increased risk to United States and allied national assets. This simulator is an open-architecture virtual environment and test-bed consisting of computer(s) with interface(s) to the target radar system"s primary Site Data Processor (SDP). In essence, the goal of constructing this Virtual Receiver/Exciter (VREX) is to appear to the SDP as all the radar hardware involved. The proposed Radar Open Architecture paradigm will be component-based, and provide common, open layered radar infrastructure where most feasible and practical, with modular sub-functions and open interfaces. All VREX modules will consist of open components and interfaces. The architectural components will be independent of the computing environment, transportable from radar system to radar system, and reusable. The elements of the VREX open architecture under consideration consist of a VREX system functional decomposition based on common open components, a shared library of open components, VREX component interface standards, layered VREX infrastructure, and a VREX component implementation template. The component-based VREX open architecture model is felt to be appropriate in that it will closely follow the functional design decomposition of any given radar system. VREX will simulate operational missions to include tracking, limited data collection, and simple space surveillance network track activities. The operational user will be able to create user defined scenarios to evaluate possible system limitations and test radar configurations against current and future threats. VREX will fill a crucial capability lapse in current radar development and upgrade efforts.

PHASE I: Design and document the proposed software interface between VREX and the SDP. Demo successful interaction with SDP (in a Software Programming Agency test environment): Transmit/receive status on SDP indicating available(green) status. Deliver complete module and interface specifications for VREX.

PHASE II: Implement VREX simulation including simple Special Data Gathering Object data collection in format required for AN/FPS-129 Radar. Demo successful physical interface to SDP. Simulate radar health information to SDP. Demo limited satellite track scenario with VREX simulating radar data to the SDP with sufficient fidelity for SDP to generate a track. Provide test target generation and simulation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Advancements in waveform design from VREX simulations could further electronic warfare applications & development. Collection methods & techniques could be shared with ongoing radar research being conducted at LLNL and AFRL/RY (Sensors).
Commercial Application: Improved information collection methods & software could benefit radar systems at research institutions such as NASA & SETI (Search for Extraterrestrial Life). VREX architecture could support development and sustainment of other commercial radars.

REFERENCES:
1. Curtis, R. “DoD strategy on open systems and interoperability,” StandardView, 4 (2): 104-106, June 1996.

2. Joint Publication 3-13.1 “Electronic Warfare”. 25 January 2007.

3. Lucero, S., et al. “DoD’s Perspective on Radar Open Architectures,” June 2010.

KEYWORDS: Simulator, Hardware, SSN, SLEP, Have STARE, AN/FPS-129, Sensors, Globus II

AF121-152 TITLE: W-band Airborne SATCOM Power Amplifier

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Development of advanced W-band (81 to 86 GHz) high power amplifiers suitable for high data rate communications uplinks between unmanned aerial vehicles (UAVs) and satellites.

DESCRIPTION: Tomorrow's warfighters will require improved, affordable satellite communications electronics. The Air Force is interested in developing a new generation of power amplifiers capable of operating between 81-86 GHz to address a new frequency spectrum for uplinks for these advanced satcom concepts. W-band communications has two advantages for above-the-weather UAV-to-satellite communications links. The rarified atmosphere at 40,000 feet and above minimizes atmospheric attenuation. Further, the wide 5 GHz bandwidth at W-band provides bandwidth beyond that of traditional satcom bands (i.e. X-, Ku- and Ka- bands). Innovative, advanced power amplifier research is required to meet the challenging W-band power, bandwidth, efficiency, and linearity requirements for power amplifiers for these future systems. Potential millimeter-wave power amplifier approaches include both solid-state power amplifiers (SSPAs) and traveling wave tube amplifiers (TWTAs). At the subcomponent level, various solid-state transistor, power combiner, and traveling wave tube approaches are feasible towards the integrated SSPA or TWTA. The research conducted under this topic should address amplifier performance goals of greater than 50-watt output power, greater than 30% power-added efficiency (PAE), a minimum of 30 dB power gain and an operating temperature range of -40° to + 80° Centigrade. Additional power amplifier performance goals include the capability to support 12/4 Quadrature Amplitude Modulation (QAM) with 30 dB suppression under less than 3 dB output power back off, as well as supporting 32 QAM operation with 36 dB of suppression at 3 dB output power back off. Adjacent channel interference performance supporting quadrature amplitude modulation operation is also key to linear performance for satellite communications uplink applications.

PHASE I: Design W-band high power amplifiers consistent with the performance goals and objectives identified above. Additional validation of the designs through modeling and simulation.

PHASE II: Fabrication of the Phase I-designed subcomponents and their assembly into integrated high power modules, either solid-state power amplifier or travelling wave tube amplifier prototype(s), by the Contractor. Evaluation and characterization of the prototype(s) for all relevant performance parameters.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military power amplifier applications include space and airborne RF W-band communications electronics where high data rates are required.
Commercial Application: Commercial W-band power amplifier applications include avionics and space electronics where high frequency power sources are required.

REFERENCES:
1. M. Ruggieri, S. De Fina, A. Bosisio, "Exploitations of the W-band for High Capacity Satellite Communications", IEEE Transactions on Aerospace and Electronic System, Vol. 39, No. 1, Jan. 2003.

2. Anon., "Propagation data and prediction methods required for the design of Earth-space telecommunications systems", p. 618-7.

KEYWORDS: W-band, power amplifier, satellite communications, bandwidth efficient modulation, adjacent channel interference, AISR

AF121-153 TITLE: V-band Microwave Power Module

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle

Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a highly linear 71-76 GHz Microwave Power Module to expand Satellite Communications (SATCOM) airborne link capacity.

DESCRIPTION: In order to provide tomorrow's warfighters with the best affordable satellite communications, the Air Force is interested in developing innovative Microwave Power Modules (MPM) design approaches supporting future generations of bandwidth efficient modulation waveforms as well as allowing access to spectrum in the 71-76 GHz band. V-band MPM development would provide access to additional SATCOM spectrum to support Unmanned Aerial Vehicles (UAV) and satellite links for Beyond Line of Sight (BLOS) communications. In addition, advanced MPM's will permit new communication satellite mission capabilities for bandwidth efficient modulation waveforms. In order to realize these benefits, MPM design must balance several factors including self interference, adjacent channel interference, Effective Isotropic Radiated Power (EIPR), and output backoff. Goals for MPM research include Weight < 30 lb, Size < .5 cu. ft., the capability to support 12/4 Quadrature Amplitude Modulation (QAM) with 30dB suppression with no more than 3 dB amp backoff, and Power Added Efficiency (PAE) >30%, Operating temperature range -40°. to + 80° Centigrade, Radiation hardening goals include Total Ionizing Dose (TID) tolerance > 1 Mrad (Si), SEE immunity < 1 X 10-9 errors/bit-day, transient dose tolerance > 1 X 10e12 rads (Si)/sec.

PHASE I: Develop a MPM design consistent with goals and objectives identified above. Validate design though modeling and simulation.

PHASE II: Fabricate one or more MPM prototypes and characterize for all relevant performance parameters including frequency bandwidth, PAE, and EIRP.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military MPM applications include space and terrestrial based RF bandwidth efficient communications and point to point high speed secure data links.
Commercial Application: Commercial MPM applications include avionics, space and terrestrial RF applications where high data rates and bandwidth efficiency are needed. Satellite communications to support multiple high speed data links.

REFERENCES:
1. Kitazume, Susumu, "Advances in Millimeter-Wave Subsystems in Japan", IEEE Trans. Microwave Theory and Techniques, Vol. 39, No. 5, May 1991.

2. Ngo-Wah, et al., "A V-band Eight-Way Combined Solid-State Amplifier With 12.8 Watt Output Power", IEEE MTT-S International Microwave Symposium Digest, Vol. 3, 2005, pp. 1371-1374.

KEYWORDS: Microwave Power Module, bandwidth efficient modulation, power amplifier, adjacent channel interference, satellite communications

AF121-154 TITLE: Low Noise Amplifier with Noise-cancelling for Satellite Communications

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop a Low Noise amplifier operating from 81-86 GHz and suitable for use in satellite communications applications.

DESCRIPTION: Today's communications satellites often rely on one or more receive gimbaled antennas or phased array antennas in which several hundred antenna elements are connected to receive modules. Typically, each receive module contains a Low Noise Amplifier (LNA) and a phase shifter that has been integrated into one (or more) MMIC's (Monolithic Microwave Integrated Circuits). In order to increase receiver sensitivity and dynamic range while reducing the power dissipation of the receiver and maximize the power efficiency, there is a critical need to minimize additional noise introduced by the LNA along with high linearity are required. While the dissipation in the LNA is a small fraction of the prime power consumption, the receive antenna generally remains powered at all times, thus the power consumption in the receiver represents a critical power drain. Excessive LNA power increases heat-load, which, in turn, increases the required cooling of the receive phased array antenna. In order for military satellite communications to access bandwidth available at 81-86 GHz (W-band), a new generation of space qualifiable receiver microelectronics will be required. Because LNA's play a critical role in high data rate satellite warfighter communications, the Air Force is interested in sponsoring research to both reduce Noise Figure (NF) and power consumption with the prerequisite linearity to support bandwidth efficient modulation waveforms like 16-QAM (Quadrature Amplitude Modulation). This topic is intended to support research exploring the best approach to achieving noise cancelling with optimum linearity and demonstrate the level of performance that can be achieved in low noise amplifiers for satellite application at 81-86 GHz. The proposed LNA should evaluate for parameters such as NF, gain, and output third-order intercept point (OIP3) across the frequency of operation, 81-86 GHz. LNA parameters should also be evaluated at temperatures ranging from -40 to +80° C and across the frequency of operation.

PHASE I: Perform trade study of device technology suitable for the proposed W-Band LNA. Design and demonstrate the feasibility of fabricating W-band LNA. Conduct modeling and simulation where appropriate to validate design.

PHASE II: Fabricate one or more prototype W-band LNA devices components and characterize for operating band, small signal gain, noise figure, OIP3, power dissipation, operating temperature range and radiation characteristics.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Low power and high gain MMICs for terrestrial wireless communications, avionics and HF satellite communications, HF radar and mm-Wave imagery applications.
Commercial Application: Commercial applications may be in the area of automotive radar, wireless LAN applications, avionics and telematics.

REFERENCES:
1. S. C. Blaakmeer, E. A. M. Klumperink, D. M. W. Leenaerts and B. Nauta, "Wideband Balun-LNA with Simultaneous Output Balancing, Noise-Canceling and Distortion-Canceling," IEEE Journal of Solid-State Circuits, vol. 43, no. 06, pp. 1341 – 1350, June 2008.

2. C. W. Hung, L. Gang, B. Zdravko and A. M. Niknejad, "A Highly Linear Broadband CMOS LNA Employing Noise and Distortion Cancellation," IEEE Journal of Solid-State Circuits, vol. 43, no. 05, pp.1164 – 1176, May 2008.

3. C. F. Liao and S. I. Liu, "A Broadband Noise-Canceling CMOS LNA for 3.1–10.6-GHz UWB Receivers," IEEE Journal of Solid-State Circuits, vol. 42, no. 02, pp. 329-339, February 2007.

KEYWORDS: low noise amplifier, small signal gain, noise figure, noise cancelling, satellite communications, W-band

AF121-155 TITLE: Next Generation vacuum Nanoelectric Device

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Manufacture efficient, compact E-band vacuum nano-electric devices based on recent advances in cold cathode nanostructure material technology.

DESCRIPTION: In order to provide future generations of warfighters with the best affordable satellite communications systems, there will be a continuing need to develop innovative high performance nanoelectronic devices with the reliability and operating efficiency to operate in the vacuum. The ability to develop and manufacture next generation space hardened, temperature independent electronics derived from non-solid state/non-semiconductor approaches such as nano-vacuum emitter devices will have numerous applications in military and commercial systems. These nanoelectronic devices will replace transistors, providing electronic functions that are radiation and temperature insensitive, eliminating cooling infrastructure and significantly reducing power requirements. Electron [cold cathode] sources may include nanotubes, nanotips and edges, vertical or horizontal configurations and molecular level design material content and morphology. This SBIR topic seeks to develop the technology for the manufacture of vacuum nanoelectronic devices (VND) based on the recent advances in the areas of innovative nanostructure and low electron affinity materials. The goals are to develop the technology and scientific underpinning that is required to fabricate such vacuum nanoelectronic devices and to provide the infrastructure for their manufacture and insertion into military and commercial applications.

PHASE I: Phase I should include the performance of feasibility design/analysis and the development of the conceptual vacuum nanoelectronic devices. The targeted performance for the prototype vacuum nanoelectronic devices should reflect performance parameters for conventional electronic functions.

PHASE II: Phase II to focus on the fabrication, development and evaluation of the prototype VND. These devices should demonstrate speed and power equivalent to state of art silicon technology without temperature sensitivity; and, include characterization and analysis of performance data on the prototype devices. Address the refinement of materials, theoretical models, and designs to improve/enhance the efficiency, reliability and performance of the VND.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Vacuum nanoelectronic devices offer numerous opportunities for enhancement in military applications where a temperature or radiation insensitive electronic function is needed with better speed-power product than present solid state technology.
Commercial Application: Advantageous in mobile communications (laptops, cell phones) applications, vastly increasing battery life and collapsing weight and volume limitations.

REFERENCES:
1. J.J. Hren, Proceedings of the 11th International Vacuum Microelectronics Conference, Piscataway, NJ, IEEE, Inc. 1998.

2. W. I. Milne, “Gated Arrays of Carbon Nanotubes/Fibres for Field Emission Applications”, 13th European Conference on Diamond, Diamond-like Materials, Carbon Nanotubes, Nitrides and Silicon Carbide, Granada, Spain, Sept. 2002.

KEYWORDS: cold cathode, vacuum field effect transistors, nanostructures, field emission, field emitters, nano-vacuum emitter

AF121-156 TITLE: Power Efficient Software Defined Radio (SDR) Mobile Architecture Technology for Handheld Devices

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Investigation of software defined radio based hardware architecture for the military handheld devices.

DESCRIPTION: Software-defined radio (SDR) is an evolving technology that potentially provides for flexibility and allows for longer lifecycles for military navigation and communication equipment. With SDR, military GPS user equipment (MGUE) can have the capability to be upgraded via software rather than with new hardware; thereby, resulting in greater cost savings. With this software based approach, the core GPS module (CGM) handheld for MGUE Increment 2, for example, can be quickly and efficiently updated to add new global positioning system (GPS) waveforms as they come online thereby extending the hardware lifecycle to 10 years or more.

Field programmable gate array (FPGA) technology is one possibility that provides for reconfigurable, cheap, fast and parallel processing hardware platform for SDR implementation. As an example, FPGAs containing Digital Signal Processor (DSP) blocks can be re-configured to work as parallel multiplier/adder or multiply accumulate unit (MAC). They also contain block/distributed memories, phased lock loops (PLLs) and programmable routing capabilities among the blocks that can be utilized for advanced processing to implement complex transceiver functions. Current FPGA devices run at nearly 500 Mhz, have extensive number of multipliers for digital down conversion (DDC) and embedded processors for control and interface. Major FPGA vendors have extensive SDR design tools support that helps in developing application rapidly and reducing the time to market.

As a price for their flexibility, FPGA devices generally suffer from higher power consumption and larger die size. By contrast, application-specific integrated circuits (ASICs) are used in today's smartphones and other handheld devices to minimize power consumption. The problem is that these devices do not provide the required flexibility. Alternatives need to be investigated.

The objective of this research is to develop an advanced SDR architecture that can be utilized for handheld devices such as the core GPS module (CGM). This architecture must both minimize power consumption and allow flexibility such that it can be upgraded for future GPS and/or global Navigation satellite system (GNSS) waveforms. Power can be further reduced by utilizing smart modes that shut down sections of the processing chain when not in use.

Document potential methods and chipsets that can be employed. Describe power optimization routines that can be used to increase battery life of the device. Quantify power consumption based on today's chipsets and next-generation devices.

This effort is not intended for the development of FPGA-based SDR.

PHASE I: Develop SDR hardware architecture for a military handheld. Describe the chipsets and estimate power consumption. Estimate performance in operational scenarios and describe trade-offs. Compare system performance to commercial GPS handheld devices/chipsets as baseline. Architectures selected must support flexibility for future algorithm hosting.

PHASE II: Build hardware architecture into an integrated device for demonstration purposes. This device must be able to receive and process L1, L2 and other signals at a minimum.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Re-design the breadboard prototype demonstrated in Phase II into a form factor that is ready for mass production. Extensive applications are anticipated.
Commercial Application: Abundant commercial applications anticipated efficient, flexible navigation.

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1. S. Kilts, Advanced FPGA Design: Architecture, Implementation, and Optimization, Wiley-IEEE Press, 2007.

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KEYWORDS: SDR, FPGA, handheld, GPS, navigation, mobile

AF121-157 TITLE: Quantitative assessments leveraging effects based analysis for degraded PNT

TECHNOLOGY AREAS: Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: To develop a hardware and software in the loop research asset to quantify the outcome of degraded Positioning, Navigation, and Timing (PNT) system's information on its host or integrated platform/network/infrastructure.

DESCRIPTION: A complex challenge facing the Department of Defense (DOD) and civil/commercial PNT users is the understanding of how integrated systems are impacted by degradation of key information. PNT information is a cornerstone technology that supports increased operational efficiency, productivity, precision, and safety. Because Global Positioning System (GPS) provides such a low cost and accurate method for determining PNT information, our reliance on GPS systems has been recognized. While some users may understand the need for a backup system, there is no clear method to determine requirements for a backup system to achieve graceful degradation when PNT information is attacked. The problem is confounded by the multiplicity of applications and use of PNT information in each system that is reliant upon GPS. A clear understanding of how the integrated system (host and PNT) uses this data and the resulting effects from degraded situation requires an in-depth investigation to fully comprehend potential impacts. Currently there is no tool or standardized methodology to evaluate or accomplish these types of assessments.

This SBIR will leverage expertise gathered over the years on PNT subsystems, their vulnerabilities, and integrated system uses of PNT information. The resulting asset will allow users to understand complex integrated systems impacts from degraded PNT information from the subsystem/component level through the integrated architecture level. The primary purpose of this SBIR is to create such an asset and to develop the algorithms to parametrically perform autonomous hardware-in-the-loop (HITL) and modeling analysis for both DOD and civil/commercial PNT integrated systems. The system will also be developed with the flexibility and responsiveness to provide timely and accurate analysis as the PNT architectures mature and new integration types are conceptualized. The ability to create the test scenarios, perform the analysis autonomously, simplify post test analysis while developing a comprehensive effects-based simulation is the result of this SBIR.

PHASE I: Design the HITL test asset, algorithms for parametric setup and autonomous analysis across numerous degradation types affecting PNT systems. This system will include design trades on secondary navigation and timing systems and how they will be modeled, driven and integrated. This will determine the technical feasibility of developing a test asset to analyze different integrated test systems and different degradation types for both DOD and commercial PNT systems.

PHASE II: Building from the Phase I design, Phase II will develop the integrated research system prototype that will demonstrate an existing PNT architecture and integrated platforms/systems/architectures. The initial focus will be on timing and critical infrastructures. The outputs of the system will clearly link degraded PNT effect to system level outcomes.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This system will establish the DOD standard for assessing military/allied systems and the Department of Homeland Security (DHS) seventeen critical commercial architectures determined to be vulnerable to PNT information disruption or loss. Demonstrations could include a communications network that relies on PNT for time, and an Integrated Air Defense System (IADS) that relies on PNT for applications and mission areas/targeting.
Commercial Application: This SBIR will also establish a standardized compliance test for commercial systems that support the United States (US) critical national infrastructure and will fill the void that exists today.

REFERENCES:
1. U.S. Air Force Chief Warns against Over-Reliance on GPS
http://www.insidegnss.com/node/1881#Baseband_Technologies_Inc_ .

2. Over Reliance on GPS Risks Safety http://www.suite101.com/content/over-reliance-on-gps-risks-safety-a76474.

3. A Policy Direction for the Global Positioning System: Balancing National Security and Commercial Interests
http://www.rand.org/pubs/research_briefs/RB1501/index1.html.

4. Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System. (29 August 2001) http://www.volpe.dot.gov/gps/gpsvuln.html.

5. Experts caution public against over-reliance on GPS devices
http://www.chinapost.com.tw/taiwan/national/national-news/2010/10/18/276550/Experts-caution.htm.

KEYWORDS: Navigation Warfare, PNT, automated research and testing, integrated systems, GPS, hardware-in-the-loop

AF121-158 TITLE: GPS Enhanced Dynamic Spectrum Access

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research, develop and evaluate algorithms and techniques to understand how GPS can enhance Dynamic Spectrum Access (DSA) based cognitive radios and also how DSA can increase the robustness of navigation.

DESCRIPTION: DSA relies on spectrum sensing techniques to provide opportunistic channel access to secondary users. Spectrum sensing techniques are designed not only to enable opportunistic channel sharing but also to provide interference protection to primary users. Existing spectrum sensing algorithms use various factors to realize opportunistic channels. Some of these factors are: energy content of primary signal (carrier sensing), geographical location, and time-of-day the spectrum being used. In tactical systems, location and time-of-day of spectrum being accessed define a protection contour. DSA will allow spectrum sharing only within the protection contour where minimal or no interference is incurred on primary users. Outside the protection contour, the DSA system will deny spectrum access to mitigate interference on primary users. However, existing sensing techniques do not incorporate location or timing information which would limit sensing only within the protection contour. One of the primary objectives of this research is to design algorithms that will combine output from GPS and spectrum sensing via a fusion process to provide enhanced opportunistic spectrum access. The algorithms will use a dynamic approach to fusion by combining location and timing information obtained from GPS and spectrum sensors. The algorithms will be dynamic in the sense that it uses past sensing history to predict expected outcome of the fusion process. Furthermore, accurate location for all nodes across the Cognitive Network (CN) will aid in sensing primary users that may be hidden due to low Signal to Noise Ratio (SNR) or physical barriers (Hidden Node Problem). Location information obtained from GPS can also enhance routing capability of cognitive sensor networks that rely on position to route information across the network.

The Global Positioning System (GPS) is part of a critical infrastructure of the US Military in a number of systems. Not only does GPS support many weapons, sensing, and positioning related systems, but is increasing in its use for the timing for synchronization of networks and a host of other telecommunication services. For example, there is such reliance on GPS today in many military systems that loss of GPS signal due to interference, jamming or physical barriers would have disastrous effect on these systems. Robustness of GPS can be improved via DSA in distributed navigational systems where personal inertial measurements units (IMUs) will provide navigation information in environments where GPS is denied. The IMUs can have DSA capability to enhance their spectrum efficiency thereby enhancing their navigational capabilities. The fact that a regionally diverse DSA CN is integrated with GPS can allow nodes or other unrelated systems access the CN for GPS data what otherwise is not available to them.

The objective of this research and development effort is two-fold: (1) enhance performance of Dynamic Spectrum Access (DSA) with the integration of navigational information obtained from GPS into existing DSA techniques; (2) enhance the robustness of GPS through the use of DSA. The final outcome of the research is to conceptualize and develop algorithms that accomplish the above objectives. Furthermore, conduct feasibility study of the algorithms; examine attainable performance improvements as well as describing the incurred tradeoff.

PHASE I: Design algorithm and develop system architecture. Develop models and simulation techniques to show achievable performance of the proposed algorithm. Provide an assessment of the complexity of the proposed R&D approach and recommendations for practical implementation.

PHASE II: Implement and demonstrate the architecture/algorithms from Phase I in a SDR platform. The demonstrations must be performed under practical communications environment taking into account intentional/unintentional interference and channel impairments, etc.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: DARPA DSA radios such as XG DSA2100, PRC153 may readily benefit from such architecture. Future military handheld devices can utilize this technology.
Commercial Application: Abundant commercial applications anticipated for robust communication and navigation.

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1. Ed Butterline and Sally L. Frodge, “GPS Synchronizing Our Telecommunications Network”, Proceedings of the 12th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GPS 1999).

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3. http:www.ieee802.org/22/.

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5. National Telecommunications and Information Administration (NTIA) Technical Report, Interference and Dynamic Spectrum Access Subcommittee, November 8, 2010.
http://www.ntia.doc.gov/advisory/spectrum/reports/CSMAC_InterferenceCommitteeReport_01102011.pdf.

KEYWORDS: Cognitive radio networks, GPS, handheld, dynamic spectrum access, cooperative communication

AF121-159 TITLE: Monolithic S-band Multichannel Transmit/Receive Module for Communication Phased Array Antennas

TECHNOLOGY AREAS: Information Systems, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Design, develop, and test very low-cost advanced Monolithic Microwave Integrated Circuit (MMIC) S-band transmit/receive (T/R) modules for large communication phased array antennas.

DESCRIPTION: Phased array antennas have demonstrated the high performance and operability required for Air Force (AF) communication and surveillance applications. However the acquisition cost of active phased array antennas is the single most significant factor hindering their wide application in both military and commercial fields. The cost of the transmit/receive (T/R) modules with the associated array panels and control electronics may constitute over half of the total antenna cost [1, 2]. MMIC technology matured sufficiently over the last few years to significantly simplify the construction of T/R modules and array panels for large phased array antennas [3]. The objective of this solicitation is to design, develop, and test an advanced MMIC technology-based full-duplex, S-band T/R module and the associated panel array implementation to large phased array antennas [1] to achieve a cost target below $100 per T/R module in high volume production.

The contractor will demonstrate their T/R modules on a 4 x 4 element or larger subarray. Each module should have one transmit channel, 1-2 W radiated power, RHCP, and two independent receive channels, switchable RHCP/LHCP. The contractors are encouraged to explore emerging technologies and innovative architectures that will increase efficiency and minimize interference between the transmit and receive channels.

As an example, one may consider a single subarray of the recently successfully completed Advanced Technology Demonstration (ATD) antenna described in [4]. The hexagonal subarray consists of 37 elements and T/R modules supporting simultaneously multiple transmit and receive beams. Current T/R module state of the art technology [4] is based on COTS components and surface- mount processes resulting in low-cost, but not yet affordable, extremely large arrays (over 60,000 elements). This topic will consider an alternative design using MMIC technology, where, from an extremely large array perspective, the rate of the cost decrease vs. array size is faster in comparison to conventional COTS technology. The design and implementation of the MMIC T/R module must be not only affordable but must also provide full-duplex multiple simultaneous communication links which has never been done before, and thus presents significant fabrication and technical challenges as well as risk.

A preliminary MMIC layout, a detailed plan to implement the design and fully automated testing strategy, and a detailed cost analysis for large quantity production of this T/R module are required deliverables.

PHASE I: Assess the feasibility and demonstrate a complete MMIC-based design of the S-band, full-duplex T/R module and the associated subarray panel. The T/R module design will be evaluated with both large and small signal simulations to characterize its overall performance.

PHASE II: Refine the design of Phase I and demonstrate the proof of concept with the fabrication and test of the fully functional scalable subarray . Performance validation and detailed cost analysis will be conducted. Provide a detailed plan and roadmap to incrementally increase the technology readiness level and risk reduction for eventual transition to an acquisition program.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The products can be used to reduce the cost of large phased array antennas for satellite communication and space operations control.
Commercial Application: The products can be used to facilitate the use of phased array antennas for air traffic control and mobile communication applications.

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2. Nicholas Fourikis, Phased Array-Based Systems and Applications, John Wiley & Sons, Inc. 1997.

3. Gabriel M. Robeiz, Kwang Jin Koh, Tiku Yu, Dongwoo Kang, Choul Yound Kim, Yusrf Atesal, Berke Cetinoeri, Sang Young Kim, and Donghyup Shin, "Highly Dense Microwave and Millimeter Wave Phased Array Modules an Butler Matrices Using CMOS and SiGe RFICs", IEEE 2010 International Symposium on Phased Array Systems and Technology, 14-18 October 2010.

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KEYWORDS: Monolithic microwave integrated circuit (MMIC), phased array antenna, transmit/receive (T/R) module, panel array

AF121-160 TITLE: Laser Instrumentation for Development of Sensors Aboard Hypersonic Air Vehicles

TECHNOLOGY AREAS: Air Platform, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop innovative laser instrumentation for hypersonic air vehicles to characterize the hypersonic flow environment thereby enabling the development of sensor systems aboard hypersonic vehicles.

DESCRIPTION: Air vehicles flying at hypersonic speeds are expected to take on a growing role in future air operations. These vehicles will need reliable sensor systems to perform telemetry, communication, navigation, reconnaissance, targeting, and terminal guidance. High temperature flow (and its resulting heating of the airframe) creates an environment that can adversely affect the performance of on-board sensor systems. It can alter the phase and amplitude of signals transmitted and received by the vehicles and often blacks them out altogether. Blackout

affects all military and civilian reentry vehicles, including the Space Shuttle, and prevents them from receiving communication and Global Positioning System (GPS) signals. Even in a case that the signals are not entirely blacked out, the sheath remains a lossy, dispersive, inhomogeneous, and fluctuating medium. These characteristics pose a significant challenge for wideband systems using conformal arrays for communication, radar, or GPS reception. Such a system must contend with spatially and temporally varying antenna matching characteristics. Several hypersonic flight test opportunities are planned in the near future, leading to operational hypersonic air vehicles. Modern instrumentation must be developed to fly on these vehicles, not only to diagnose the environment but also to develop sensor systems for hypersonic vehicles. Traditional diagnostic instruments such as Langmuir probes and Radio Frequency (RF) probes have limitations on the details of the flow that they can acquire. Laser probes have the potential to obtain finer details of the hypersonic flow.

It is known that the hypersonic flow can affect the laser beam in several different ways: (1) it can alter the direction, phase and polarization of the beam; (2) plasma instabilities in the flow can significantly distort signals passing through it; (3) there may be charged micro-particles (due to ablation) in the flow which can scatter and significantly alter the signals; (4) a high intensity laser beam can induce nonlinear processes whose characteristics are not well understood; and (5) the laser sensor is adversely affected by emissions from the hot flow and heated windows.

The laser instrumentation must be able to sense and quantify these phenomena. The proposed work is important in achieving the following capabilities: (1) Future Long-Range Standoff Weapon —ensure that datalink is uninterrupted because of environment; (2) Improved Terminal Seeker in High-Speed Environment—the laser propagation study is vital for terminal seeker development (EO/IR, ladar); (3) Plasma Mitigation—diagnostic instrumentation developed here is critical for designing plasma mitigation strategies; and (4) In-Flight Update Instrumentation—important in the development of appropriate sensors for robust communication through hypersonic flow.

PHASE I: Develop laser instrumentation concept to study scattering and propagation in plasma flow of reentry vehicles. Study characteristics of laser scattering from instabilities caused by shear flow, the impact of micro-particles in the flow, and instabilities caused by high intensity laser beams.

PHASE II: Develop a compact, lightweight prototype of the measuring system conceptualized in Phase I. In Phase II, test the prototype in a terrestrial plasma chamber to establish performance characteristics and deliver an instrument that can be qualified for flight test.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The technology demonstrated in this effort will be applied directly to communication, navigation, and targeting systems for future Air Force hypersonic air vehicles.
Commercial Application: The technology will apply to civil space transport and commercial launch and reentry vehicles.

REFERENCES:
1 Grantham, W. L., “Reentry Plasma Measurements Using a Four-Frequency Reflectometer,” The Entry Plasma Sheath and Its Effects on Space Vehicle Electromagnetic Systems – Vol. I, NASA SP-252, National Aeronautics and Space Administration, 1970, pp. 65 - 108.

2. Swift, C. T., F. B. Beck, J. Thomson, and S. L. Castellow, Jr., “RAM C-III S-Band Diagnostic Experiment,” The Entry Plasma Sheath and Its Effects on Space Vehicle Electromagnetic Systems – Vol. I, NASA SP-252, National Aeronautics and Space Administration, 1970, pp. 137 - 156.

3. Hayes, D. T., S. B. Herskovitz, J.F. Lennon, and J. L. Poirier, An Ablation Technique for Enhancing Reentry Antenna Performance: Flight Test Results, AFCRL-TR-74-0572, Air Force Cambridge Research Laboratories, Hanscom AFB, MA, November 1974. DTIC: ADA012250.

KEYWORDS: hypersonic environment, turbulent flow, interaction of EM signals, maneuverable reentry vehicles, laser instrument

AF121-163 TITLE: Performance Prediction for Airborne Multistatic Radar

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: This effort will develop a unique modeling and performance prediction capability for airborne bistatic and multistatic radar, to include passive radar.

DESCRIPTION: Interest in bistatic radar, where the transmitter and receiver are not collocated, has historically waxed and waned, and is once again enjoying a resurgence. A multistatic system is one where multiple transmit sites or multiple receive sites, or both, are used to construct the radar picture. A passive radar system is one where the radar designer and user do not control the radio frequency (RF) transmissions. This effort will develop a capability to model and predict the performance of bistatic and multistatic radar systems using one or more airborne receivers and one or more airborne or ground-based transmitters. Radar modes to be analyzed include Air Moving Target Indication (AMTI), Ground Moving Target Indication (GMTI), and Synthetic Aperture Radar (SAR).

A capability to model and predict the performance of these systems is critical to future development and deployment. Analysis of airborne multistatic systems is significantly more complex than that of ground-based systems. The problem also becomes more difficult when the goal is passive operation; however, being passive provides added survivability since there are no transmitted waveforms to be detected. Passive radar systems have traditionally been developed to exploit a particular emitter. The vision of future systems is to adapt to the local RF emitters, dynamically developing a passive radar strategy which is suitable to the local RF environment. The algorithm which does this may be referred to as an Illuminator Selection Manager, and passive radar performance prediction is a critical component. A performance prediction model will also allow an assessment of the military utility of such systems by providing inputs to higher level simulations.

The models developed under this effort should include the effects of items such as apertures and receivers, transmitted waveforms, signal processing algorithms, clutter, and relative motion of the transmitter, receiver, and target. The models should allow parameters describing the various aspects of the system performance to be easily varied. With this construct the models should easily accommodate different instantiations of multistatic radar systems past, present, and future.

In Phase I, an AMTI performance model will be developed, and an approach identified to add GMTI/SAR capability to the model. Analysis will demonstrate how the performance models support development of an Illuminator Selection Manager and military utility analysis.

The bistatic/multistatic radar model developed under this effort may use as a starting point existing AFRL capabilities, including but not limited to RLSTAP and SMS.

PHASE I: Design/develop multistatic radar model to be used to predict AMTI performance of systems employing both cooperative (non-passive) and non-cooperative (passive) illuminators. Validate by comparing predictions to measured results provided Government Furnished Information (GFI).

PHASE II: Add GMTI and SAR capability to the multistatic radar model. Enhance the models for AMTI, GMTI, and SAR as required to accommodate real-world effects such as denser electromagnetic environments and more challenging clutter. Validate the models by comparison to measured results provided as GFI. Support the integration of the performance models into an Illuminator Selection Manager or a military utility analysis simulation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Multistatic radar may enable surveillance capability--allowing high-value transmitters to maintain stand-off range. Airborne passive radar allows penetrating platform to perform surveillance without transmitting RF energy that could reveal presence.
Commercial Application: Commercial applications could include reduced cost close-in surveillance around air fields which may not have the budget for a full radar system.

REFERENCES:
1. Griffiths, H. and Baker, C., "The Signal and Interference Environment in Passive Bistatic Radar," Proc. of Information, Decision, and Control Conference (IEEE Cat. No. 07EX1647C), Adelaide, 2007.

2. Pugh, M.L. and Zulch, P.A., "RLSTAP Algorithm Development Tool for Analysis of Advanced Signal Processing Techniques," Record of 29th Asilomar Conference on Signals, Systems, and Computers, 1178-1182, 1995.

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KEYWORDS: Bistatic radar, multistatic radar, passive radar, AMTI, GMTI, SAR, modeling, performance prediction

AF121-164 TITLE: Conformal Coherent Optical Sensor

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a novel coherent sensor which will enable conformal apertures at optical wavelengths. Multiple systems should have the ability to be used together to create high resolution imagery.

DESCRIPTION: In most active imaging systems a light source is used to illuminate a desired scene and the backscattered light is collected across a single, large aperture and focused to a detector array. A single aperture provides resolution up to the diffraction limit but requires large optics with correspondingly large volumes to achieve high spatial resolution at long distances. These large lenses quickly begin to suffer from cost, weight, and practicality issues as their area and volume increase. Distributed, coherent apertures offer a solution where optical field values captured at smaller sub-apertures can be coherently combined to synthesize a large area aperture.

In distributed aperture systems, individual coherent imaging systems are used to sample a large area of an optical wavefront. A computer is then used to correct the captured fields, combine the fields through software, and phase the resultant field into a single high-resolution image. When taken to the limit the result is a large array of very small apertures each with a single detector element which would sample the field across a large plane by using a very thin interferometric system. These smaller sub-apertures drive the ladar imaging system towards conformal apertures

which would drastically reduce sensor volume by limiting the thickness of any conformal imaging system. Conformal systems could more easily serve a wide range of aircraft platforms by utilizing a much lower system volume.

The proposed system will utilize coherent imaging ladar to make interferometric measurements of the field backscattered from an object. The proposed system will capture field amplitude and phase at optical wavelengths while multiple systems may work together so that a large effective aperture can be synthesized from the individual system measurements. The proposed system should be designed with the intent of limiting the volume of the proposed sensor including any collection or local oscillator insertion optics.

The ultimate goal is to have a conformal aperture to minimize SWaP of the sensor therefore this should drive any solution. The device will be required to have a clear aperture with low loss so that the light returning from the target can be efficiently captured.

PHASE I: The effectiveness of various candidate concepts will be evaluated. Preliminary designs will be modeled and fabrication feasibility shown. Shortcomings in fabrication and critical technology that would require additional development during Phase II will also be identified.

PHASE II: A prototype system which utilizes the sensor array will be developed and tested. A demonstration of the concept to measure complex fields and provide imaging products will be designed and carried out. A path toward a conformal sensor along with improvements to increase device efficiency and phase stability of outputs will be identified.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Conformal apertures would allow laser radar imaging systems to be installed on a wide range of aircraft. As a result, high-resolution imagery could be easily obtained.
Commercial Application: Conformal apertures have use in fields such as law-enforcement, homeland security, astronomy, and in each of these fields users may benefit from smaller, active imaging systems.

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KEYWORDS: lasers, optics, imaging, laser radar, sensor, focal plane array

AF121-165 TITLE: Uncertainty-Preserving 3D Reconstruction from Passive Motion Imagery

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop robust automated algorithms to create and update a cohesive, georegistered, uncertainty-preserving, efficient 3D site + terrain model using wide-field-of-view, narrow-field-of-view, visible-light, and infrared motion imagery streams.

DESCRIPTION: Analysts seeking to form a cohesive picture using information obtained from diverse sources need a common frame of reference. In military applications, geographic positions and timestamps are typically available for each data type (e.g., imagery, motion cues, verbal reports), which aids comprehension although sheer data volume (e.g., motion imagery) and redundancies among the sources (e.g., multiple platforms observing a single region and yielding concurrent and intermittently overlapping data) must be handled properly. Consequently a four-dimensional reference frame comprised of latitude, longitude, altitude, and time may prove useful in unifying the

various sources, depicting the information obtained from each source, and resolving any discrepancies that arise. An especially useful reference frame may be a site model encompassing the ground area of interest, including terrain, buildings, stationary objects, and even moving objects.

Site models, whether up-to-date or outdated, may not be immediately available once a region has attracted analyst interest and in such cases must be built quickly. Although lidar sensors may yield data suitable for 3D model construction, the abundance of sensors providing motion imagery and the literal nature of that imagery makes motion imagery favorable for 3D model construction. Robust automated methods are desired for rapidly constructing and refining a 3D site model as motion imagery sources become available. Each motion imagery source of interest to this effort produces data that falls into one of two general groups: 1) wide-field-of-view (WFOV) frames with pixel counts in the tens of megapixels, with ground sample distances (GSDs) and revisit rates supporting wide-area awareness, and with frame rates less than 10 Hz, and 2) narrow-field-of-view (NFOV) frames with pixel counts comparable to those of high-definition video, with GSDs and revisit cycles supporting scrutiny of geographically disparate objects, and with frame rates greater than 10 Hz. A given analyst may need data from one or both groups to contribute to a 3D model.

Motion imagery may be collected by different platforms at different times, and distinct streams may contain observations of distinct subsets of the overall region of interest – nonetheless they must be integrated into a cohesive whole. The motion imagery sensors themselves may be panchromatic or they may be sensitive to daylight, short-wave infrared, or mid-wave infrared wavelengths. The sensor and platform metadata accompanying a motion imagery stream may contain position errors and pointing-angle errors. Variations in resolution, variations in frame rate, motion blur, and optical distortion further complicate matters, with the overall mixture creating uncertainties which lead to geolocation errors and errors in the 3D structure itself.

The uncertainties associated with military motion imagery hinder point correspondences and disrupt traditional deterministic structure-from-motion approaches. In response, probabilistic volumetric reconstruction approaches have been developed which explicitly accommodate uncertainty, automatically refining the 3D reconstruction as additional observations are received. To date this work has emphasized a single stream of WFOV data arising from a (panchromatic) daylight sensor, with the initial frame-to-frame registration bootstrapped through user intervention.

The desired algorithms are fully automated and produce a 3D model of the area of interest, rigorously accommodating multiple asynchronous motion imagery streams, diverse sensor phenomenologies, uncertainties within metadata, and the resulting 3D model uncertainties. Because analysts may need to “make do” with whatever data is available, NFOV data must be valid system input despite its increased registration difficulty (compared to the larger geographic overlaps observed in WFOV imagery). Similarly, mixtures of NFOV and WFOV and/or mixtures of daylight and infrared motion imagery must constitute valid input as well.

PHASE I: The expected product of Phase I is a probabilistic 3D reconstruction algorithm that takes as input a single stream of mid-wave infrared motion imagery and builds an uncertainty-preserving 3D site model corresponding to the input data, documented in a final report and implemented in a proof-of-concept software deliverable.

PHASE II: The expected product of Phase II is a prototype implementation of the Phase I proof of concept, enhanced to integrate multiple geographically-overlapping, phenomenologically-diverse motion imagery streams into a cohesive whole 3D site model.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Visualization, training, combat search and rescue.
Commercial Application: Mapping and navigation, city planning, emergency response.

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KEYWORDS: 3D reconstruction, photogrammetry, implicit representations, surface reconstruction, Bayesian methods, volumetric appearance modeling

AF121-166 TITLE: Low Cost Universal Reliability System On-A-Chip for Multi-Channel Characterization

TECHNOLOGY AREAS: Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Goal is to invent, design and demonstrate a universal reliability system-on-a-chip (URel_SOC) to enable less costly and more efficient methods to assess end of life next generation Radio Frequency (RF) devices, components, and front-end microsystems.

DESCRIPTION: Future Air Force RF sensor, electronic warfare, and communication systems require the increased performance of next generation electronics. Transistor scaling and new materials drive the electronics performance increases. Technology scaling lowers breakdown voltages which impacts the device power handling capability. New materials introduce significant uncertainty in operating limits and overall component lifetime. As a result, potential system failure may occur due to active devices driven into unsafe operating regimes and unknown material degradation. Hence, a major need for system insertion is high quality and timely assessment of electronics reliability to trade performance specifications against useful life. Current reliability studies are costly and lengthy primarily due to existing modular systems where a single reliability test channel is needed with multiple expensive power supplies and meters. A more comprehensive system would include commercial test equipment to capture alternating current (AC)/RF signals ranging from KHz to GHz. These reliability systems trend are even more costly and require large overhead in staff and space to provide a limited number of channels for technology assessment. Current reliability channel cost is in the order of tens of thousand dollars.

Recent advancements in silicon technology have enabled the development of close-in sensors and stimulus components ranging from direct current (DC) to RF signals. This technology has potential to revolutionize assessing complex electronics for military use. One can envision a universal reliability system on-a-chip (URel-SOC) for RF characterization where DC and AC sensors/stimulus may be implemented monolithically to realize a low cost system. Integration of voltage regulation to supply the necessary voltages and waveforms to multiple channels; on-chip RF sources for input stimuli; and digital controllers and monitors to coordinate testing activities such as supplying power to the Device Under Test (DUT) and capturing device performance simultaneously as the stressors are being applied should be possible. Successful invention, design and demonstration of a URel-SOC construct can

be used to gain statistically valid detailed life studies of RF devices, components, and systems by determining all failure mechanisms due to real world environment and operational stresses to develop the required reliability models to further enhance current models and permit a realization of a fail-safe system at high performance.

PHASE I: The Phase I effort is to invent the universal reliability system-on-a-chip concept and the corresponding architecture capable of assessing low power/high power devices, RF components, and RF microsystems. The URel-SOC should permit multi-channel characterization, extending up to the evaluation of 50-DUT simultaneously. Furthermore, a methodology for extracting reliability-based device models should be developed for inclusion into performance-based models.

PHASE II: In Phase II, the effort will focus on the design and demonstration of the URel-SOC. This system should include but not limited to sensory components, input stimulus components, and an algorithm to control the suite of sensors, input stimulus (actuators), and data capturing of measured parameters. In addition, reliability-enhanced device models will be developed and demonstrated for inclusion with device performance models.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integrate Device Under Test (DUT) into the URel-SOC for a demonstration of reliability enhanced models and the URel-SOC system.
Commercial Application: Commercial RF devices, components, and RF systems would benefit from a low cost URel_SOC test setup.

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2. Roland Shaw, David Sanderlin and Jansen DeJulio, “Performance Characterization, Repeatability, and Consistency of X-Band GaN HEMTs Prior to High Temperature RF Reliability Testing”, 2006 JEDEC.

3. Lavon B. Page and Jo Ellen Perry, “A Model for System Reliability with Common-Cause Failures”, IEEE TRANSACTIONS ON RELIABILITY, VOL. 38, NO. 4, 1989 OCTOBER.

KEYWORDS: Life test systems, RF devices, RF MMICs, transceiver ICs

AF121-169 TITLE: Bearings for High-Speed Cruise Missile Engine

TECHNOLOGY AREAS: Weapons

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop bearing technology for demonstration in an engine capable of sustained supersonic performance for flights longer than one hour at altitudes above 50K. Engine must be suitable for use on 5,000-lb. class stand-off weapons.

DESCRIPTION: Turbine engine bearings usually rely on conventional liquid lubricants and engine buffer air to maintain safe operating temperature limits. The conventional lube system consists of a lubricant tank, oil-to-fuel heat exchanger, pumps and oil deaerator. In a 1,000 lbs. thrust class engine, these subsystems add as much as 25% to engine cost and weight. Fuel lubricated bearings, vapor lubricated bearings, and air foil bearing are viable methods to eliminate the conventional liquid lubricant system and hence most of this cost and weight. However,

thermal management of all of these approaches is critical to achieve successful bearing operation. In this effort the small business is encouraged to work with an engine manufacturer to define bearing concepts suitable for supersonic engines. The bearing concepts should be able to support bearing thrust loads and rotating dynamic loads typical for a 1,000 lbs thrust class engine. The end product of this effort is a fully viable and validated bearing concept for a Mach 3+ turbine engine. The effort will require bench top testing, analytical modeling, and full-scale bearing demonstration at engine conditions. The small business is encouraged to demonstrate a clear transition path with an engine manufacturer involved in high speed propulsion.

PHASE I: Perform detailed numerical analyses and subscale testing of the proposed concept. Demonstrate a design concept that will adequately meet operating conditions of the engine for demonstration in Phase II.

PHASE II: Fabricate and fully develop a prototype hardware or process to verify improvements in Phase I. Fabricate and evaluate prototype device, hardware or process to confirm predictions at engine operating conditions. The goal is to demonstrate technology to a technical readiness level (TRL) of 5.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Supersonic propulsion systems and technologies are applicable toward various time-critical weapons systems and small strike/reconnaissance vehicles.
Commercial Application: Enhancing higher temperature operation and/or reducing manufacturing costs both apply to small uninhabited aircraft vehicles and uninhabited aircraft to increase reliability and reduce costs.

REFERENCES:
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Keywords: Turbine engine, supersonic, missile propulsion, high temperature, cost reduction

KEYWORDS: Turbine engine, supersonic, missile propulsion, high temperature, cost reduction

AF121-170 TITLE: Prognostics Approaches for Remote Piloted Aircraft (RPA) Propulsion and Vehicle Systems in Harsh Environments

TECHNOLOGY AREAS: Air Platform

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate a Propulsion Health Management (PHM) approach that applies advanced diagnostic and prognostic algorithms to legacy RPA propulsion systems, controls, and vehicles operated under harsh or off-design conditions.

DESCRIPTION: The use and production of RPAs has increased over time. They are assuming greater operational roles in the field. Increased or expanded usage has led to designs with increased capability, but with potential reliability issues. Current designs are characterized by the use of state of the art and legacy components, often developed for more benign environments. High RPA loss rates or Not Mission Capable are a deficiency and contributor to concerns about expanding RPA deployment, employment strategies and the projected cost effectiveness of future fleets.

Development of an appropriate PHM strategy for RPAs is one way to provide a capability that can considerably reduce engine/vehicle loss rates due to in-flight and impending (developing) faults. Development of a PHM capability can enhance mission capability and damage tolerance in specific applications. Reduction in maintenance workload by increasing troubleshooting effectiveness and accuracy (reducing false positives), also offers significant benefits and is a goal of the PHM research program. Planning maintenance events during vehicle down time using the PHM system provides a cost effective solution to increased mission effectiveness rather than experiencing failures during missions and trying to schedule repairs and find parts to fix the discrepancy during busy flying schedules. Studies conducted by the Army and Navy on ground and shipboard turbine engines show that multiple engine and vehicle sub-systems critical to mission success and with potential reliability issues can benefit by incorporating advanced PHM technology, especially in propulsion systems, using existing sensors. These subsystems include fuel pumps, bearings, rotating components, gear sets, controls, actuators, and sensors. Critical electrical components can include power generation, motors, wiring harnesses, interconnections, and batteries. The target results from implementing PHM can be discerned and prioritized based upon costs and impact upon operational capabilities. Higher levels of capability can be achieved by integrating failure mode and effects and criticality analysis (FMECA) models as well as engine and vehicle performance and control heuristics and models.

Development of cost effective diagnostics and prognostics concepts and documenting expected mission effectiveness and applicability for an RPA engine/vehicle is the aim of this SBIR effort. Focus should be placed on application to a fielded turbo-shaft engine systems in the 700 to 1000 horsepower class with Full Authority Digital Engine Control (FADEC) technology, but potentially limited sensing and PHM installed. This effort should consider suitable aerospace RPA vehicle classes up to 10,000 pounds with future potential to 20,000 pound vehicles. Development work should evaluate the potential efficacy of applying advanced algorithms and approaches to provide useful prognostic indicators for the top critical, recurring, and high maintenance cost engine system faults based on baseline data created from models or historical engine/flight data. Suitable advanced algorithms that are able to accommodate discreet and continuous data are recommended. The use of hybrid approaches (include both physics based and heuristic models) are and must be capable of implementation in real time. Analysis of the proposed concept should show the applicability of the concept to address real-time failures as well as predict trends or remaining useful life of critical components.

PHASE I: Develop a PHM approach that will provide high cost/benefit metrics and accommodate installation/retrofit issues on a legacy RPA engine/vehicle systems. Evaluate the potential to identify real-time faults on legacy and future systems. Document the criteria and parameters used to evaluate and demonstrate PHM effectiveness and show the relationships and impacts the PHM system has upon cost and operational capability. Recommend working with an engine OEM company in developing metrics and installation concepts.

PHASE II: Develop and refine the Phase I concept from the knowledge gained in Phase I in a software or a model based prototype. Demonstrate the PHM system capability by conducting real-time tests on a ground engine, engine simulator, or test rig and show how real benefits are achieved through quantitative measurements and architecture design tradeoffs. Develop a plan to show how the PHM technology can be implemented on a specific engine or platform and provide a transition path for legacy and future engines or platforms.

PHASE III DUAL USE APPLICATIONS:
Military Applications: Small and Large RPA Engines / Aircraft Applications
Commercial Applications: Applicable to Ground and on-line Commercial Aircraft PHM Systems

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KEYWORDS: Diagnostics, Airframe, Engine, Propulsion Health Management, Algorithms

AF121-171 TITLE: Optimizing Coating Processes and Chemistries for Enhanced Hot Section, Low Cycle Fatigue (LCF) Life

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop coating processes and chemistries to minimize adverse effects on the low cycle fatigue (LCF) life of hot section flow path components and support sustainment of current and future generation aircraft propulsion systems.

DESCRIPTION: In response to rising engine cycle temperatures, high temperature, nickel-based, single-crystal alloys are being designed to increase thermomechanical fatigue resistance. However, the same compositional changes that have increased material strength have also decreased their corrosion resistance. To achieve the intended lifetimes for these alloys will require a coating that possesses the necessary oxidation and corrosion resistance. The challenge is to produce a coating system that is both chemically and physically compatible with the base material and inherently long lived.

The coating must therefore be well matched with the base material in terms of chemical activity of key constituents to minimize coating/substrate inter-diffusion and, hence, maintain surface protection and greatly reduce the extent of secondary reaction zone (SRZ) formation; microstructure (e.g., a columnar single-crystal bond coat on an epitaxial growth single crystal substrate), given that nickel has high crystal (E) anisotropy, incompatibility stresses in thermal cycling can lead to premature cracking; mechanical properties currently used high-temperature coatings generally impart a mechanical-properties debit to the base material, but tractable solutions should exist for the coated systems to actually have improved mechanical properties compared to the uncoated base material; and coefficient of thermal expansion to minimize the thermal fight between the coating and the base material.

Coating attributes that are generally associated with long coating lives include oxidation resistance, which is the ability to form a continuous, intact and adherent protective oxide that can exhibit sustained growth for an extended service; hot-corrosion resistance, the ability to provide extended resistance against sulfate-deposit induced attack at temperatures in the range of about 600 to 950 °C; phase stability, which is the ability of the coating to maintain its phase constitution over the entire range of service temperatures and for an extended period; surface stability, which is the ability of a coating to maintain a planar surface during thermal exposure; and high strength and toughness, which imparts to a coating mechanical properties at least comparable to the base material, while at the same time the coating should not be prone to brittle cracking.

In order to reach these targets, advances will be needed in both the processing and the chemistries of high-temperature coatings. It is anticipated that the resultant engine durability improvement will support sustainment efforts for a wide range of propulsion and power generation systems. Since this program involves the application of a coating process to engine components, it is highly recommended that the development team include an engine original equipment manufacturer (OEM) and a coating manufacturer as active participants.

PHASE I: Determine the feasibility of utilizing available coating chemistries and deposition methods to achieve properties critical to turbine engine applications. Develop a detailed test plan for characterizing the developed coatings, establish a set of criteria for selecting the most promising coatings for further testing, and develop a feasible approach for modeling coated structure's performance and life.

PHASE II: Produce a set of coated coupons utilizing the most promising coating chemistries and deposition methods from Phase I. Use the test procedure developed in Phase I to characterize the developed coatings and determine the best candidates for application to a representative turbine engine component or a sub-element thereof. Evaluate the

coatings' performance and durability. Develop and validate analytical modeling approach into useful predictive tool.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A successfully developed coating system would have a wide range of applicability to many military turbine engines, especially to alleviate themomechanical fatigue failures.
Commercial Application: A successfully developed coating system would have a wide range of applicability to many commercial turbine engines, especially to alleviate themomechanical fatigue failures.

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KEYWORDS: Turbine engine, coating, single crystal nickel alloys, coating durability, coating properties, coating interface adhesion/bonding, coating process, low cycle fatigue, coating chemistry, inter-diffusion, coefficient of thermal expansion, chemical activity, mechanical properties, oxidation resistance, corrosion resistance

AF121-172 TITLE: <u>In Situ, Real-time Monitoring of the Properties of Engine Part Coatings</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Improve coating process efficiency and reliability by developing an in-process method for monitoring the coating progress and properties on an engine part.

DESCRIPTION: Thermal spray coatings have long been used to protect critical aircraft structural and engine parts from such things as fretting, wear, and hot, reactive gases. Since the fabrication process plays a major role in determining the coatings' ability to perform those functions, a great deal of effort has been put into developing a better understanding of the basic coating process science. To that end, robust sensing systems have been developed to monitor the process conditions in real time (e.g., the distribution of the coating particles relative to the plasma spray plume position). The insights provided by these measurements have supported the development of detailed process maps that can be used to link the process control settings with specific spray characteristics at the very point where the molten spray particles strike the intended target. Extending this map to predict the coating properties of interest (thermal conductivity, modulus, etc.) has been much harder to do. This difficulty stems in part from the highly interactive nature of the thermal spray process, so that each control setting can potentially produce multiple changes in the spray conditions which can in turn affect the coating micro-structure. Another barrier, the lack of real-time data for the evolving coating, has been addressed by the development of an instrumented witness coupon to track the evolving coating properties, such as thickness and elastic modulus, in real time, but with the caveat that the shape and the properties of the engine part can also influence the evolving coating structure. The witness coupon

data may be sufficient for populating process maps, but, in determining whether the process is going satisfactorily and more importantly, when to stop, the operator will need to track coating progress on the actual part. At present there are no reliable in situ methods for tracking that progress. For instance, coating thickness is usually measured by mechanical means (micrometer, calipers, etc.) or by using an instrument such as an eddy current sensor. Both mechanical and eddy current measurement methods require an interruption of the coating process, which introduces both inconsistencies in the coating process and reduces the economic efficiency of a thermal spray booth.

It is anticipated that the potential coating process improvements will support sustainment efforts for a wide range of propulsion and power generation systems. Since this program involves the coating manufacturing equipment, it is highly recommended that the development team include a coating and/or coating equipment manufacturer, to provide crucial insights into the types (coating thickness, porosity, etc.) and quality (rate of data acquisition, the quality of the data, etc.) of information needed to support current production processes, and to facilitate the integration of the monitoring system into a commercial spray booth. The inclusion of an engine original equipment manufacturer is also recommended, to guide the development of a process monitoring system that will enable existing spray booths to better meet engine requirements and to assist in transitioning the technology into a commercial system.

PHASE I: Determine the technical feasibility of monitoring the evolving coating properties on the engine part as it is being coated, and utilizing the resultant coating properties data to develop a process control model. Develop a protocol for evaluating the capability of potential monitoring systems to meet current production needs.

PHASE II: Produce a prototype production process for monitoring the evolving coating properties on an engine part or a representative sub-element thereof. Use the protocol developed in Phase I to evaluate the impact of the monitoring system on the operator's ability to predict the coating process outcome. Develop a process by which the resultant coating properties data may be incorporated into a process control model, and test this process on an engine part.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The potential military applications for this technology include both the original equipment manufacturing and depot maintenance refurbishment of thermal barrier coated components for military engines.
Commercial Application: The potential commercial applications include manufacturing and end-user refurbishment of thermal-barrier-coated components in commercial aircraft and ground-based power generators.

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KEYWORDS: Coating process, coating properties, coating thickness, in situ monitoring systems, engine component, coating structures, mechanical properties, process control

AF121-173 TITLE: Engine Health Management of Mechanical Systems for High Performance Turbine Engines

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop a mechanical systems health monitoring platform for early detection of bearing distress in aviation gas turbine engines. This program addresses a critical need to reduce cost and risk associated with turbine engine bearing failure.

DESCRIPTION: A recent safety investigation found that engine bearings are a significant contributor to engine related mishaps for the DoD and the Air Force. The total cost incurred to the DoD during a five-year period was $350M. Of the $350M, the cost to the Air Force was $180M. Most of the cost is associated with secondary engine and aircraft damage after the bearing has reached a critical failure. An improved health management approach is needed to provide early warning of bearing distress. Early warning of impending failure can significantly reduce cost and risk to military aircraft.

Today, most aviation turbine engines rely on the magnetic chip detector and oil analysis for health management of the engine mechanical system. The mechanical system consists of rolling element bearings, gears, seals, and lubrication system hardware. In the past, visual inspection of the magnetic chip detector by flight line personnel was sufficient to catch most bearing failures prior to complete engine failure. However, as bearing loads and speeds have increased, the time from initiation to complete bearing failure has dramatically decreased, in some cases reaching the period of a single mission. Such a short duration time to failure requires real-time on board monitoring. Visual inspection of the magnetic chip detector is no longer sufficient. To improve early detection, on board sensors such as the oil debris monitor (ODM) and quantitative debris monitor (QDM) have been developed. These sensors have proven to be very effective at detecting bearing distress before critical failure is reached. However, a limitation of the ODM and QDM is that they cannot provide fault isolation. Fault isolation would help to determine the severity of the situation and help predict the remaining time to failure. Vibration monitoring is a technique that has the potential for fault isolation but cannot reliably detect early failures. Ultimately, fusing oil debris detection with vibration analysis may provide an effective health management approach for aviation gas turbine engines. This approach can provide early detection with fault isolation. The potential of fusing oil debris data with vibration analysis is being demonstrated in laboratory testing. However, to transition this technology to actual engines requires additional development. Specifically, full-scale engine ball and roller bearings need to be evaluated in seeded fault failure testing; robust flight weight sensors and data processing hardware need to be developed and demonstrated; and improved software algorithms fusing the oil debris and vibration data need to be developed. Working with a major engine company is highly encouraged to complete these steps and increase opportunity for technology transition in Phase III.

PHASE I: Design of flight weight sensors and data processing hardware will be completed. Basic demonstration of sensor approach and software will be conducted in full-scale or bench-top testing. Evidence will be provided that Phase II goals can be met.

PHASE II: Fully develop the innovative system proposed in Phase I. Conduct seeded fault testing with full-scale engine ball and roller bearings. Bearing testing will be conducted at conditions for a high performance turbine engine. The contractor will demonstrate flight weight sensors and data processing as part of the seeded fault testing and will develop algorithms combining oil debris and vibration analysis.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military application: High potential exists to incorporate a successful health monitoring platform in existing and development military engines.
Commercial Application: Commercial applications: Bearing health management is used on civilian aircraft, industrial gas turbines, wind turbines for power generation, marine engines, paper mills and other manufacturing industries.

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3. P.J. Dempsey, D.G. Lewicki and H.J. Decker, 'Investigation of Gear and Bearing Fatigue Using Debris Particle Distribution', NASA/TM-2004-212883, 2004.

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KEYWORDS: bearings, fault isolation, gas turbine engine, engine health monitoring, prognostics, bearing failure

AF121-174 TITLE: Adaptive Heat Rejection for Two-Phase-Enabled Aircraft Thermal Management Systems (TMS)

TECHNOLOGY AREAS: Air Platform

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and demonstrate an adaptive condenser configuration, applicable to tactical aircraft, for an advanced vapor compression system (VCS) capable of selective rejection of heat to two time-variant heat sinks.

DESCRIPTION: High performance aircraft are experiencing increasing thermal challenges due to heat generation from avionics and propulsion systems, as well as requirements to lift this heat to temperatures high enough for rejection from the platform. Current TMS, including pumped PAO loops and closed air cycles, are reaching limits in total heat transfer, availability of appropriate thermal sinks, and impact on the engine and other subsystems. To meet emerging requirements, next-generation TMS must utilize all available sinks, including fuel, ram air, and aircraft engine/cooling turbine air flows to effectively manage aircraft thermal loads. Temperature, flow rate, and pressure of each heat sink varies throughout a mission, meaning that the ability of the TMS to adapt by selecting the most appropriate heat sink will be of critical importance.

As part of the Air Force Research Laboratory's Integrated Vehicle Energy Technology (INVENT) Program, advanced TMS are being developed which emphasize not only improvements to the efficiency of heat transfer, also the ability of the system to respond to changes in aircraft heat sink availability. One potential portion of this solution is to explore expanded use of VCS as the primary heat acquisition and temperature lifting subsystem for management of lower temperature heat loads such as avionics and other electronics. However, there remain significant unknowns associated with responsive TMS control, adaptive components, and system hermeticity.

The intent of this solicitation is to explore novel hardware and architectural/control concepts for the high-temperature (condenser-side) portion of a VCS. These concepts must enable responsive heat rejection to two time-variant sinks (air and fuel). Under some circumstances, there may even be some benefits gained by providing cooling to the fuel utilizing excess cooling capacity available in the air stream. For novel condensers, designs which are highly integrated are favored, and offerors are encouraged to explore internal configurations and heat transfer surfaces which are optimized for each of the different flow streams (refrigerant, fuel, and air). To increase opportunities for successful transition and commercialization, offerors are encouraged to collaborate with air framers or second-tier suppliers to develop designs that are consistent with aircraft subsystem requirements. For the

purposes of this effort, offerors can assume a 50kW-class VCS, utilizing R-236fa, with a COP of 2.0 (total heat rejection of 75kW). The following representative fuel and air data should be considered as design points for heat rejection. There are other mission points to consider for aircraft design, but these points should be sufficient for developing conceptual solutions.

Case 1: Fuel Inlet: Temp=75°C; Flow Rate=0.28 kg/s; Air Inlet: Temp=30.9°C; Flow Rate=21.3 kg/s.
Case 2: Fuel Inlet: Temp=75°C; Flow Rate=3.38 kg/s; Air Inlet: Temp=118.2°C; Flow Rate=52.6 kg/s.
Case 3: Fuel Inlet: Temp=75°C; Flow Rate=0.37 kg/s; Air Inlet: Temp=22.6°C; Flow Rate=10.5 kg/s.
Case 4: Fuel Inlet: Temp=75°C; Flow Rate=1.31 kg/s; Air Inlet: Temp=63.9°C; Flow Rate=18.0 kg/s.
Case 5: Fuel Inlet: Temp=75°C; Flow Rate=0.83 kg/s; Air Inlet: Temp=60.7°C; Flow Rate=23.0 kg/s.
Case 6: Fuel Inlet: Temp=75°C; Flow Rate=2.91 kg/s; Air Inlet: Temp=98.4°C; Flow Rate=14.4 kg/s.
Case 7: Fuel Inlet: Temp=75°C; Flow Rate=2.45 kg/s; Air Inlet: Temp=117.9°C; Flow Rate=47.1 kg/s.
Case 8: Fuel Inlet: Temp=75°C; Flow Rate=0.40 kg/s; Air Inlet: Temp=34.2°C; Flow Rate=21.4 kg/s.

The outlet temperature of both heat sink streams cannot exceed 89.9 °C. Any heat rejection concepts should be designed to minimize weight/volume as well as pressure drops experienced by all of the fluid streams.

PHASE I: Demonstrate technical feasibility of the conceptual solution and hardware. The Phase I effort should develop the proposed innovative solution and provide data to demonstrate the feasibility of the proposed system in addition to the necessary hardware component.

PHASE II: Design, fabricate, and demonstrate the prototype component technology, as well as any novel heat rejection architecture, that helps enable adaptive thermal management for aircraft. This initial demonstration should be tailored to occur in a laboratory environment. It is desired that the prototype system be delivered to the government at the end of the Phase II effort for additional testing and evaluation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The hardware developed under this effort can be adapted to help enable adaptive multi-sink heat rejection for advanced military airborne thermal management systems.
Commercial Application: Future commercial aircraft may have similar thermal management limitations.

REFERENCES:
1. Future Aircraft Power Systems- Integration Challenges, Kamiar J. Karimi, PhD, Senior Technical Fellow, Carnegie Mellon University Press, 2007.

2. Aircraft Avionics Cooling, Present And Future, Swain, E.F., Aerospace and Electronics Conference, 1998. NAECON 1998. Proceedings of the IEEE 1998 National Aerospace and Electronics Conference.

KEYWORDS: adaptive thermal management, heat exchanger, thermal management, vapor cycle system, condenser, adaptive heat rejection

AF121-175 TITLE: Hydration Tolerant, low Thermal Conductivity (K) Thermal Barrier Coatings

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a low-k thermal barrier coating (TBC) that can withstand repeated exposure to water vapor and water droplets in the engine environment.

DESCRIPTION: With the increasing reliance on TBC to protect engine components from the damaging effects of high cycle temperatures comes the potential for significant structural damage if those coatings should ever fail. A great deal of effort has been put into increasing coating durability and reliability in the engine environment, with most of the attention being paid to the coating system's response to complex thermo mechanical loading in a hot, chemically reactive environment. As a result, significant improvements have been made in the structural and chemical stability of current-generation coating systems.

In recent years, another problem has cropped up, involving premature coating failure due to exposure to high levels of moisture. Both electron beam/physical vapor deposited (EB/PVD) and thermal-sprayed coatings have been affected. Unlike most other failure mechanisms, this one apparently occurs after the engine has cooled down. The TBC usually spalls off very soon (within minutes) after being wetted. Studies have shown that this type of failure is more likely to occur in coated structures that have been operated in a thermal gradient, e.g., backside cooling on the wall of a combustion chamber. The root cause appears to be a chemical reaction between the water molecules and one or more constituents, most likely gamma-aluminum, of the bond coat. The volume change that accompanies this reaction is what causes the coating to spall. The accumulation of the hydrogen gas that is generated as one of the byproducts may help to speed up the failure process, which may explain why this type of failure is more likely to occur under ambient conditions. At higher temperatures, off gassing of the hydrogen is usually sufficient to keep it from accumulating in the TBC.

This goal of this topic is to develop a coating system that can better withstand the effects of ambient moisture. It is highly recommended that the development team include a coatings expert as well as an engine original equipment manufacturer (OEM) and a coating manufacturer.

PHASE I: Determine the feasibility of developing a hydration-tolerant, low-K TBC. Develop an analytical model to describe the moisture effect on the coating system and predict coating life. Develop a protocol for evaluating candidate coating systems and validating the analytical model. Select the top three coating systems for further testing in Phase II.

PHASE II: Evaluate candidate coating systems using the protocol developed in Phase I. Select one of the coating systems for further testing under more engine-like conditions. Conduct pre- and post-test evaluations of the coating properties and microstructural changes. Update the analytical model to reflect the test results. Perform a final proof test of the coating system under near-engine conditions, and validate the analytical model.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Improvements in TBC durability will support meeting engine life requirements for a wide range of military applications, including aircraft, marine, ground-based propulsion and power generating systems.
Commercial Application: Improvements in TBC durability will support meeting engine life requirements for a wide range of commercial applications, including aircraft, marine, ground-based propulsion and power generating systems.

REFERENCES:
1. Rudolphi, M.; Renusch, D.; Schütze, M. “Verification of moisture-induced delayed failure of thermal barrier coatings”, Scripta Materialia, Vol. 59 (2008) 255-257, 2008.

2. Smialek, James L.; Zhu, Dongming; Cuy, Michael D. “Moisture-induced delamination video of an oxidized thermal barrier coating”, Scripta Materialia, Vol. 59 (2008) 67-70, 2008.

3. Yanar, N.M.; Stiger, M.J.; Maris-Sida, M.; Pettit, F.S.; Meier, G.H., “Effects of high temperature exposure on the durability of thermal barrier coatings”, Key Engineering Materials, Vol. 197 (2001) 145-163, 2001.

4. Rudolphi, M.; Renusch, D.; Zschau, H.-E.; Schütze, M., “The effect of moisture on the delayed spallation of thermal barrier coatings: VPS NiCoCrAlY bond coat + APS YSZ top coat, Vol. 26 (3) 325-329 (2009).

KEYWORDS: thermal barrier coating, moisture effects, bond coat, spallation, spinel formation, phase changes, thermally grown oxide layer, hydration, TBC, coating life prediction, microstructure

AF121-181 TITLE: Low-Temperature Sintering Processes for Ceramic-Coated Heat Exchangers

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To examine alternative post-forming thermal processing methods for sintering ceramic coatings over metallic substrates at low temperatures (<1000 oC).

DESCRIPTION: The Air Force has rapidly growing demands for more electrical power for soldiers, vehicles, and facilities. As a result of these demands, there are significant thermal-management challenges that may quickly become a limiting design factor for future military applications. Of these challenges are high-temperature (>500 oC) heat exchangers that play a crucial role in thermal management and energy recovery subsystems. Current technology is based upon metal-supported heat exchangers that are prone to corrosion, such as scaling and embrittlement, and eventual failure in the operating environments. Recent advances in heat exchanger coatings have focused on the use of ceramics due to their stability at high temperatures and resistance to corrosion in hostile environments. The environmental coating overlays the metal which has the effect of a protective barrier layer. Ceramic coatings are typically formed using powders and subsequently sintered to form a solid body. Ceramic forming methods include slip casting, tape casting, colloidal spray deposition, and dry pressing. The use of vacuum methods for coating formation are not attractive options given the cost and throughput constraints. However, post-forming thermal processing of coatings using nonvacuum deposition methods over a metallic surface are quite challenging since the ceramic requires high sintering temperatures. The high processing temperatures may subsequently lead to unwanted interfacial reactions, film delamination due to oxidation of the metallic surface, and/or strain induced defects in the film due to the large differences in coefficients of thermal expansion (CTE) of the materials. When dissimilar materials are interfaced, differential thermal expansion or contraction can have a pathological impact on the long term durability of the heat exchangers. The emphasis of this topic shall be on the development of the technology appropriate to provide control over porosity, CTE mismatch, and strain to fracture. The sintering process shall result in a dense ceramic coating directly on the metallic substrate surface over various thicknesses of between 1 and 100 microns. Control over the sintering atmosphere is preferred.

The objective of Phase I shall be to demonstate the feasibility to process a ceramic film over metallic substrate while maintaining control of microstructure (i.e., achieve high (>98 percent theoretical) density of ceramic film, minimize grain growth/coarsening), minimal strain (objective of <1 percent over ceramic body), and temperature uniformity (<3 percent variance across sample). Phase II shall seek to scale process to demonstrate larger volumes of coated substrates and project cost savings of high throughput approach compared to traditional high temperature thermal processes.

PHASE I: The offeror shall demonstrate the feasibility of the proposed low temperature sintering process on an approved model ceramic coating (e.g., 8YSZ) deposited onto a metallic substrate over areas of up to 160cm2 and thicknesses between 1 and 100 microns. Appropriate characterization methods (e.g., SEM, XRD) shall be performed to validate results.

PHASE II: Demonstrate feasibility of full-scale production and show cost competitiveness with conventional approaches. Evidence that temperature variability is minimized to <1 percent across sintering chamber while maintaining dense strain-free ceramic coating (>98 percent theoretical) shall be demonstrated over large samples >160 cm2. A bench level system employing the proposed process shall be delivered at conclusion of effort to TPOC for analysis.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Anticipated military applications include processing of high-temperature heat exchangers/recuperators, high-temp electronics packaging, and fuel cells; for use in aircraft auxiliary power units and air condition/energy recovery systems.
Commercial Application: Anticipated commercial applications include processing of high-temperature heat exchangers/recuperators for use in corrosive waste heat recovery systems, coal and fuel cell power systems, stationary power generation, and remote site power needs.

REFERENCES:
1. A. Sommers, et al., "Ceramic and ceramic matrix composites for heat exchangers in advanced thermal systems-a review," Applied Thermal Engineering, Vol. 30, 2010, pp. 1277-1291, (2010).

2. W.R. Laws and, G.R. Reed, "Compact Ceramic Heat Exchangers for Corrosive Waste Gas Applications," Heat Recovery Systems, Vol. 2, No. 5/6, 1982, pp. 475-486, (1982).

3. M.N. Rahaman, Ceramic Processing and Sintering: Second Edition, CRC Press, Boca Raton, FL, 2003, pp. 470-537, (2003).

4. R.K. Shah, et al., "Opportunities for Heat Exchanger Applications in Environmental Systems," Applied Thermal Engineering, Vol. 20, 2000, pp. 631-650, (2000).

KEYWORDS: low temperature sintering, ceramic processing, thick film processing, thermal processing

AF121-182 TITLE: Miniature Infrared Camera for High Temperature and High Pressure Applications

TECHNOLOGY AREAS: Air Platform, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: The proposed work is to develop a miniature infrared (IR) camera capable of providing quantitative measurements in the high temperature and high pressure operating environment of gas turbine engines.

DESCRIPTION: Diagnostic tools for gas turbine engines can offer insights into pollutant formation, mixing processes, and interactions between flows and surfaces. Size limitations and the high temperature and high pressure environment of gas turbine engines have limited the suite of tools which have been used, particularly in the combustor. Advanced diagnostic tools capable of surviving the harsh environment of a combustor can facilitate characterizing the stability, performance, and limitations of engines. This information is critical in designing the next generation of engines and in maintaining legacy aircraft.

IR images and radiation intensity measurements provide guidance for determining surface temperatures and the characteristics of reacting and non-reacting flows. Radiation emitted from soot, hot surfaces, water vapor, and carbon dioxide can be calculated using the same camera by spectrally filtering the measurements. Water vapor concentrations [1], temperature distributions in spark kernels [2], mean properties of exhaust plumes [3], and film cooling effectiveness of gas turbine components [4] have been obtained using infrared cameras. This solicitation is seeking to extend these types of measurements to the environment within gas turbine engines.

Proposals are solicited for developing a miniature IR camera sensitive between 1.5 to 5 microns and capable of being fitted with neutral density or narrowband filters. The anticipated size will be comparable to a lipstick camera used for visible imaging. The camera must be able to survive hot temperatures downstream of a combustor (with cooling) and operate at pressures up to 10 atmospheres. The cooling and housing system can be developed in conjunction with researchers at the Air Force Research Laboratory (AFRL). Data (photon counts) will be transferred from the camera to a computer located outside the engine for processing and analysis. The camera must provide quantitative measurements and allow users to independently calibrate the instrument.

It is expected that this work will result in a diagnostics tool for infrared visualization within combustors, turbines, and compressors. This instrument will facilitate troubleshooting difficulties in engines, saving time and money.

In order to successfully perform the work described in this topic area, offerors may request to utilize unique facilities/equipment in the possession of the U.S. Government located onsite at Wright-Patterson Air Force Base. Accordingly, the following items of Base Support may be provided, on a no-charge-for-use basis, to the successful

offeror, subject to availability. The facilities/equipment includes the High-Pressure Combustion Research Facility (HPCRF).

PHASE I: During Phase I it is anticipated that the feasibility of the innovative camera system to meet the topic requirements will be demonstrated. It is anticipated that the system will be designed and subsystem testing be started.

PHASE II: For the Phase II of the project, the IR camera will be built, and water cooled housing for the camera will be built in collaboration with AFRL. Demonstration of the instrument system will be performed in combustor test facilities at Wright-Patterson Air Force Base. The final product will be delivered to the Air Force at the conclusion of the project.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This tool can be used to understand the physical processes within the compressor, combustor, turbine, and afterburner sections of new and legacy engines. The measurements acquired will validate computational fluid dynamics models to the hardware.
Commercial Application: This product can be marketed as a diagnostics tool for high temperature and high pressure environments. This is applicable to applications including power plants, land based gas turbine units, industrial boilers, and reciprocating engines.

REFERENCES:
1. D. Blunck, S. Basu, Y. Zheng, V. Katta, J. Gore, "Simultaneous Water Vapor and Temperature Measurements in Unsteady Hydrogen Flames," Proceedings of the Combustion Institute, Vol. 32, pp. 2527-2534, (2009).

2. D. Blunck, B. Kiel, "Trajectory, Development, and Temperature of Spark Kernels Exiting into Quiescent Air", 49th AIAA Aerospace Sciences Meeting, Orlando, FL, 2011-716, (2011).

3. D. Blunck, J. Gore, "A Study of Narrowband Radiation Intensity Measurements from Subsonic Exhaust Plumes," Journal of Propulsion and Power, Vol. 27, No. 1, pp. 227-235, (2011).

4. Schulz, A., "Infrared Thermography as Applied to Film Cooling of Gas Turbine Components," Measurement Science and Technology, Vol. 11, No. 7 pp. 948-956, (2000).

KEYWORDS: infrared camera, diagnostics, radiation, combustor, gas turbine engine

AF121-183 TITLE: Novel Silicon Carbide Epitaxy Process for Dramatic Improvements to Material Characteristics, Cost, and Throughput

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Demonstrate the feasibility of a novel approach to SiC epi growth that could dramatically improve SiC epitaxy quality, cost, and throughput thus advancing the commercialization of SiC power devices.

DESCRIPTION: The DoD has long realized the merits of SiC power semiconductor devices for military applications. DoD funding has helped to realize the commercialization of wide temperature, highly efficient SiC power devices such as ultrafast Schottky barrier diodes and more recently power transistors. While world record performance is being achieved with such devices in certain applications, widespread insertion of SiC technology into military, automotive, and renewable energy applications is being hindered due to material and processing cost and, to some extent, material quality. Improvements to carrier lifetime and basal plane dislocation density would have a dramatic effect on the development and reliability of bipolar devices. Unipolar devices (e.g., MOSFETs, JFETs) are more mature and have been demonstrated in a wide range of applications where high efficiency and/or high temperature operation is crucial. However, the cost of material (bulk and epi) and device processing still hinder SiC from meeting the full demands of the power electronics market – both civilian and military. One of the reasons for the high cost of SiC is the temperatures used to grow and process the material. For instance, ion implantation is

typically performed at temperatures above 500 °C and implant activation anneals at above 1600 °C. This creates an incompatibility with processing toolsets designed for silicon device processing which requires much lower temperatures. Additionally, while Si epitaxy is grown at temperatures below 1100 °C, SiC epitaxy growth is typically performed at temperatures in the 1500 to 1600 °C range. Growth at these temperatures creates a great demand on tool design, tool life, energy consumption, and throughput. The objective of this topic is to pursue technologies in SiC epitaxy growth that would have a dramatic effect on the cost and quality of SiC device production. Technologies that relax tool demands, increase throughput, and improve yield are of interest. Also of interest are novel technologies that might enable the production of device designs that are impractical or impossible with current SiC technology.

PHASE I: Demonstrate the feasibility of the proposed process to improve quality, decrease cost, or provide novel new capabilities through either modeling & simulation or (preferably) through actual epi growth samples.

PHASE II: Fully develop the advanced process and produce at least ten test samples to characterize the results. A detailed cost-benefit analysis will be provided to document expected benefits in utilization of the process. State-of-the-art current and voltage ratings for commercially available SiC devices should be used as a minimum basis for cost benefit projections.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Power control and distribution of more-electric aircraft, hybrid electric ground vehicles, and directed- energy weapons.
Commercial Application: Renewable energy harvesting, hybrid electric vehicles, commercial more electric aircraft, etc.

REFERENCES:
1. Treu, M., Rupp, R., and Solkner, G., “Reliability of SiC power devices and its influence on their commercialization - review, status, and remaining issues,” Reliability Physics Symposium (IRPS), 2010 IEEE International, 2-6 May 2010, pp.156-161.

2. Zhang, Q., Callanan, R., Das, M.K., Sei-Hyung Ryu; Agarwal, A.K., and Palmour, J.W., “SiC Power Devices for Microgrids,” Power Electronics, IEEE Transactions on Power Electronics, Vol. 25, No.12, December 2010, pp. 2889-2896.

3. Leone, S., Beyer, F.C., Pedersen, H., Andersson, S., Kordina, O., Henry, A., and Janzén, E., “Chlorinated precursor study in low temperature chemical vapor deposition of 4H-SiC,” Thin Solid Films, Vol. 519, pp. 3074–3080, 2011.

KEYWORDS: silicon carbide, epitaxy, power semiconductors

AF121-184 TITLE: Thermal Management for Military Aircraft High Performance Electrical Actuation System

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a passive thermal management system (TPS) for next-generation, high performance electrical actuation system.

DESCRIPTION: Conventional aircraft actuation systems operate using hydraulic fluid as the primary working fluid. This type of actuation system has several drawbacks such as low energy efficiency, corrosion, leaks, higher logistics cost, etc. High performance electric actuation systems (HPEAS) offer great benefits over conventional hydraulic actuation systems, including reduced power consumption, heat load, and peak power, among others. Due to the distributed and modular nature of HPEAS, its thermal management poses a unique challenge. The hydraulic fluid, acting as a heat sink in hydraulic actuation systems, is no longer available. This research topic seeks innovative passive cooling technologies and integrated, light weight, and compact thermal management system for

HPEAS, mainly the electromechanical actuator (EMA) integrated with motor drive electronics. The definition of passive here means it does not interface with the aircraft's environmental control system (ECS) or power and thermal management system (PTMAS). The aircraft operates at altitudes up to 40k ft at up to supersonic speeds, and body force of -3 to +9 g. The expected ambient temperature range in wing and fuselage bays is expected to vary from -58 to 71 °C continuous, -65 to 87 °C for 30 minutes, and -78 to 107 °C for 1 minute. For engine bays the temperature is expected to range from -58 to 200 °C continuous, -65 to 300 °C for 10 seconds, and -78 to 400 °C for 3 seconds. The structural temperature limits are 250 °F for graphite composite and 275 °F for aluminum. The power of a single actuator could be as high as 100 kW and the actuator should be able to hold 75% of the stall load indefinitely. Due to the dynamic nature of aircraft, the heat generation of EMAS is highly transient. The electric peak power could be as high as ten times of the average over less than one second.

PHASE I: Demonstrate the technical feasibility of the proposed innovation, including analysis, design, and experimental approach for demonstration of the concept.

PHASE II: Perform detailed analysis, design, fabrication, and testing of the proposed passive thermal management system demonstrator for a fighter-type military aircraft flight control actuation system. Validate models for the design using the test data. Assess performance of the design in simulated or actual application environments.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military application includes flight control, utility control, and propulsion system actuation of a manned or unmanned military aircraft. Perform integration and packaging of the passive cooling system with an EMA for one of the applications.
Commercial Application: Commercial application includes both flight control surfaces and engine actuation systems. Perform integration and packaging of the passive cooling system with an EMA for one of the applications.

REFERENCES:
1. INVENT Spiral II BAA at
https://www.fbo.gov/index?s=opportunity&mode=form&id=c3a61f77d94ca51f0fdc9687036362f4&tab=core&_cview=1.

2. K. McCarthy, A Heltzel, E. Walters, J. Roach, S. Iden, and P. Lamm, "A Reduced-Order Enclosure Radiation Modeling Technique for Aircraft Actuators," paper number 10PSC-0093, SAE Power System Conference, Fort Worth, TX, Nov. 2-4, 2010.

KEYWORDS: EMA, HPEAS, INVENT, thermal management, electromechanical actuator, heat transfer

AF121-185 TITLE: Prognostic Health Management (PHM) of Electromechanical Actuation (EMA) Systems for Next-Generation Military Aircraft

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop and demonstrate electrical and mechanical PHM technology that is integrated with an aircraft EMA system.

DESCRIPTION: High performance electric actuation system, one of the integrated vehicle energy technologies for energy optimized aircraft, offers great benefits over the conventional hydraulic actuation systems including reduced power consumption, heat load, peak power, and weight, among others. The major challenge in implementing EMA to aircraft flight critical control surfaces is its reliability. Prognostics and diagnostics health management (PHM) technology would greatly improve EMA's reliability, safety, and maintainability by predicting and detecting EMA failure modes and parts remaining useful life. Overall mission readiness can be maximized and lifecycle costs can be minimized through the development of accurate PHM systems that provide accurate real-time fault detection and effectively predict remaining useful life. Much research has been done on prognostic and diagnostic theory and algorithms. The goal of this research topic is to develop an innovative PHM technology and product, based on the

state of the art theory and algorithm, to accurately detect, real time, any electrical and mechanical faults of an EMA and predict failure modes.

The innovative PHM technology and product developed under this topic should be applicable to a wide set of actuators, control systems, and operational scenarios. It also must be computationally efficient so that on-board data can be processed in real time. Specifically, the innovative PHM technology and product should enable the EMA to reach a goal of probability of loss of control (PLOC) not exceed 10e-7 per flight hour and probability of loss of function (PLOF) for a single actuator system less than 1.5x10e-5 per flight hour.

Proposals should include: 1) offerer's innovative PHM theory and capability, 2) prior success in fault identification and prediction through either a lab-based test or real-data correlation, and 3) hardware and operation conditions planned for a real-time integrated demonstration under realistic operation conditions.

PHASE I: Prove, in small-scale demonstration, that the proposed PHM technology and product are capable of real-time prediction of faults, failures, and anomalies. The faults or anomalies can be a combination of software simulated and hardware-induced.

PHASE II: Demonstrate the PHM technology in real-time on an embedded EMA controller and actuator under realistic operation condition. The size of the EMA and operation condition should be compatible with sixth-generation energy optimized aircraft. Faults or anomalies should be introduced as realistically as possible. Performance assessment includes false alarm rate, missed faults, diagnostic and prognostic accuracy, and computational performance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military application includes EMAs for flight control surface, landing gear, weapon bay door, or engine and nozzle actuation of manned or unmanned military aircraft. Integrate the PHM technology and product with an EMA for one of the applications.
Commercial Application: Commercial application includes EMAs for flight surface or engine actuation in a passenger or cargo plane. Perform integration and packaging of the PHM product with an EMA for one of the applications.

REFERENCES:
1. Hvass, Paul Brian; and Delbert Tesart, "Condition Based Maintenance For Intelligent Electromechanical Actuators", pp. 27-80. Robotics Research Group, Mechanical Engineering Department, The University of Texas at Austin, Austin, TX 78712, June, 2004.

2. Dixon, R., Pike, A.W., "Applications of Condition Monitoring for an Electromechanical Actuator - A Parameter Estimation Based Approach," Computing and Control Engineering Journal, IEEE Xplor, pp. 71-81, April, 2002.

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4. Integrated vehicle energy technology BAA;
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KEYWORDS: EMA, flight control actuation, fault prediction, PHM, health monitoring, condition-based maintenance

AF121-187 TITLE: Reconstruction Algorithms for High-Energy Computed Tomography Images of Rocket Motors

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop algorithms and computer platform for reconstructing high-energy CT images to produce superior quality images in less than one minute.

DESCRIPTION: X-ray computed tomography (CT) is the nondestructive inspection (NDI) technique used to evaluate the integrity and monitor the aging of large solid rocket motors (SRMs). CT is the only method available to look inside the SRMs to verify structural integrity. The ability to detect changes and defects in bondlines and other components of the SRM over time is limited by the inherent resolution of the CT instrumentation, the noise from many sources, and the contrast of bondlines and defects. Due to the limitations of conventional filtered back projection CT algorithms, there are situations where it is sometimes unclear if a defect is present or has developed over time. Such ambiguities occur when the apparent defect size is on the edge of the resolution limit or has a contrast that is comparable to noise, distortions, or artifacts. Iterative algorithms for CT reconstruction have shown promise for reducing or eliminating many of these problems in medical CT; however, there are practical problems that have not been solved in medical CT with these approaches. These algorithms suffer from noise enhancement in certain situations, and they still require hours to execute the reconstruction of one 4096 x 4096 pixel slice on a single computer. The reconstruction time is affected by both the size and quantity of the raw CT data as well as the computer hardware. The typical solid rocket motor has between 150 and 400 CT slices, so the image-processing time is unacceptably long. The ideal solution would work on a single workstation, but a small cluster would be acceptable. The use of supercomputers is unacceptable due to facility and funding constraints. Creative solutions that address the whole topic and demonstrate a strong backing in modern computer science techniques, engineering principles, previous research and development, and scientific literature are highly sought after.

The successful proposed Phase I development shall build upon and demonstrate significant enhancements over all existing technologies to improve both CT image quality and image reconstruction processing time, as well as investigate the technical challenges involved in the implementation of the new algorithms into the ICT 1500 and ICT 2500 CT systems. The proposed solution shall demonstrate its affordability and usability. Usability shall minimally take into account operability, sustainability, supportability, interoperability, modularity, and reliability of the proposed solution. The proposed solution shall leverage standards-based communication, open-source software, and standard file formats wherever possible, otherwise state why there are deviations. Also, identify technical issues that are likely to arise in prototype development and present a resolution plan. The developed prototype should have a robust design allowing it to readily be transitioned onto existing and future CT and computer operating systems; however, it is paramount that the prototype functions successfully with the current CT systems (ICT 1500 and 2500).

PHASE I: Develop one or more proof-of-concept technologies, demonstrate feasibility, and provide a prototyping plan of viable technologies to support ICBM Aging and Surveillance programs. Candidate computer architectures shall specify computer models, components and supporting software environments along with an analysis predicting the computation time.

PHASE II: Demonstrate prototype on actual CT images acquired on SRMs at Hill AFB, UT. This demonstration shall quantify improvement in both image quality and computer reconstruction time, ideally reducing the single image reconstruction time to one minute or less. Deliver a working prototype of both software and hardware by the end of year one, and a final polished prototype with user's manual and programmer's guide.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The focus of this development is ICBM sized solid rocket motors. However, this technology could also be applied to tactical and space motors as well as the inspection of some aircraft structures.
Commercial Application: This technology could be used on any industrial CT system with the same results. It could support the commercial space launch and aircraft industries.

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KEYWORDS: Computed Tomography (CT) images, nondestructive inspection (NDI), artifacts and noise, solid rocket motors (SRMs), aging and surveillance, nondestructive evaluation (NDE)

AF121-188 TITLE: Techniques to Suppress Cavitation in Liquid Rocket Engines

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop improved physics-based techniques to suppress or reduce cavitation in rocket engine turbopumps.

DESCRIPTION: Cavitation in liquid rocket engine turbopumps can result in critical damage to both the turbopump as well as components downstream of the turbopump. Failures of this component due to cavitation surge and rotating cavitation can cause key failures resulting in the loss of key assets, or the delay in deploying those assets. This topic seeks to examine innovative techniques to suppress or reduce cavitation in liquid rocket engine systems. This will enable pumps to have higher suction capacity which will potentially reduce the number of stages required to pump fluid to the required pressure. Reducing the number of components should reduce the weight and increase the reliability of pumps. Potential approaches can include, but are not limited to: optimization of flow paths to reduce low-pressure regions or placing potential cavitation regions in known areas to attempt to reduce damage.

As far as cavitation is concerned, the most challenging situation is for liquid hydrogen fueled rocket engines. The low density of hydrogen combined with the extreme cryogenic conditions make cavitation more likely in these situations. However, cavitation can occur with other propellant combinations.

The proposals should identify both the damage mechanism that will be addressed by the novel suppression technique as well as an explanation of the physical mechanisms which suppress cavitation. Specific areas which could be addressed include:
a) cavitation bubble formation and blockage;
b) cavitation damage to blades;
c) head fall-off due to cavitation;
d) cavitation induced instabilities;

e) other cavitation phenomena to be described by the proposer.

It is recognized that there are limited opportunities to test these techniques in full-scale liquid rocket engines. As part of this effort, the offeror should identify key simulative experiments and computational validation cases that can be used to validate the reduction of the cavitation within a rocket engine or the reduction in damage from cavitation.

PHASE I: Identify the suppression techniques and potential validation cases and methods applicable to rocket turbomachinery conditions.

PHASE II: Utilize computational tools or simulative experiments to demonstrate the impact on rocket engine turbomachinery.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Utilize the models and diagnostics to create design tools or processes for the development of rocket engine turbomachinery.
Commercial Application: Turbomachinery provides high energy density power generation or flow driving force in many applications, from power generation to aircraft engines. New designs and optimized tools could significantly improve the efficiency and life of these devices.

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KEYWORDS: Turbomachinery, Cavitation, Modeling and Simulation, Verification and Validation, cavitation bubble damage, Bubble Formation

AF121-189 TITLE: Novel Engine Cycles for Upper Stage Liquid Rocket Engines

TECHNOLOGY AREAS: Materials/Processes

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop advanced upper stage liquid rocket engine cycle technologies to improve performance over current systems.

DESCRIPTION: Upper stage rocket engines have used traditional cycles, such as pressure-fed, expander, and gas generator cycles for the past 50 years. However, over that time period, other concepts that could result in increased reliability, operability, or reduced cost have been identified. The purpose of this effort is to identify and develop novel cycles which will have great benefit to the overall launch vehicle system, but have not been fully developed.

Modern, state of the art, upper stage engines can be restarted multiple times, have specific impulses that exceed 465 seconds with a Liquid Oxygen/Liquid Hydrogen propellant combination, have reliabilities that exceed 0.999, and can be throttled to at least 60% of full thrust. Minimizing the size and weight of the engine is also an important consideration. It is expected that any system proposed will, at minimum, meet these overall requirements.

Any cycle proposed under this topic will have to be shown to be competitive with existing systems in capability over the range of system applicability. An engine balance should be performed to show that the cycle closes and that component pressures, temperatures, and estimated masses are reasonable for an upper stage application. Due to the harsh environments in liquid rocket engines, where necessary, testing may be performed in conditions which are not fully representative of the engine. In order to demonstrate feasibility, modeling and simulation of the appropriate fidelity can be used to augment the test data, provided the simulations are appropriately validated.

The result of this effort will be a potential high performance, highly operable, reduced cost upper stage liquid rocket engine concepts. These concepts will need to be further developed for commercialization in phase III efforts.

PHASE I: Specify the proposed innovative liquid upper stage vision concept. Compare engine/vehicle performance using this new concept with the performance of existing launch vehicle systems and identify the benefits over current state of the art cycles. Perform thermodynamic engine balance and demonstrate initial feasibility of the cycle through experimentation and/or modeling.

PHASE II: Perform critical risk reduction efforts that will demonstrate the viability of the concept. Testing of hardware performed at subscale and on components which are not fully representative of all operating conditions shall be augmented with modeling and simulation to demonstrate applicability to the representative environments. Perform functional demonstration to show viability of new innovative engine cycle.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High performance upper stage engines are required in order to launch payloads of military utility into the appropriate orbit.
Commercial Application: As the growth in commercial spacelift systems continue, low-cost, high performance engines will enhance capability to deliver payloads to orbit.

REFERENCES:
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KEYWORDS: Upper stage rocket engines, Verification and Validation, Assured Space Access, Liquid Hydrogen Propellant, low-cost rocket concepts

AF121-191 TITLE: High-Frequency Sensors and Actuators for Scamjet Engine Controls

TECHNOLOGY AREAS: Air Platform, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of

foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop and apply high-frequency sensors and actuators to improve scramjet engine operability and performance with closed-loop control. Some aspects of control will require sensing and actuation on the order of 10 milliseconds.

DESCRIPTION: Hydrocarbon-fueled supersonic combustion ramjets (scramjets) are expected to operate from Mach 3.5 (or marginally lower) up to Mach 7 or 8. Scramjet engines are categorized into three general sizes: small-scale (nominal air flow of 10 lbm/s), mid-scale (nominal air flow of 100 lbm/s), and large-scale (nominal air flow of 1000 lbm/s). Recent efforts focus on mid-scale scramjets that need to operate over a broad Mach number range, use minimal or no variable geometry, integrate with other propulsion cycles, and maintain thermal balance using only on board fuel as a heat sink without significant losses to integrated system performance.

Currently, scramjet engine control schemes are limited and unstart margin is built into the system through conservative isolator lengths and non-aggressive fuel scheduling. An active control system with appropriate sensors and responsive actuators is needed to increase engine performance, while simultaneously enabling system weight reductions.

An effective control system is dependent on the quality and quantity of inputs it receives from sensors in order to make appropriate decisions. In order to implement an engine control system, it will be necessary to make reliable measurements of pressure, temperature, heat flux, and skin friction in a harsh environment. The thermal operating environment within a scramjet combustor is characterized by temperatures on the order of 3000 °F. In addition, some transient events (e.g., ignition, flame blowout, and engine unstart) within a scramjet combustor occur on the order of 1 kHz. Therefore it would also be desirable for sensor technology to have a frequency response of that order or higher. Another area of consideration is the durability of the sensor. In the near term, scramjet engines are expected to operate for 10 to 15 minutes, but longer term goals include reusable combined-cycle vehicles that will operate in similar fashion to the jet aircraft of today.

Actuator performance in a scramjet environment is also crucial to a successful control system. The actuator must also withstand the severe thermal environment of the scramjet engine and have a response time on the order of 10 milliseconds for certain engine transients. Most likely, the use of nontraditional actuators (e.g., plasmas, pizeo, etc.) will be required. Proposals in response to this topic should be experimentally focused and address functionality in high-temperature environments (associated with reacting flows of hydrocarbon/air chemistry).

PHASE I: Demonstrate the feasibility of an innovative, high frequency sensor and actuator system for use in the combustion environment described. Identify a path, including TRL levels, for development and application of the technology. Feasibility can be demonstrated via numerical analysis or testing.

PHASE II: Fully develop the sensor/actuator system proposed during Phase I and fabricate necessary test rigs or hardware necessary to confirm Phase I predictions within a laboratory environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High-speed propulsion systems and technologies are applicable toward various time-critical weapon systems, strike/reconnaissance vehicles, and space launch applications.
Commercial Application: Enhancing current scramjet system designs is needed to enable access to space applications to compete with existing rocket platforms.

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KEYWORDS: hypersonic, scramjet, propulsion, sensors, actuators, control system

AF121-192 TITLE: Wireless Power for Battlefield Airmen Operation

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a safe, compact, reliable, efficient wireless power transmission technology for integration into the Battlefield Renewable Integrated Tactical Energy System (BRITES).

DESCRIPTION: Battlefield Renewable Integrated Tactical Energy System (BRITES), a portable power system, was designed to provide the dismounted airman with a lightweight and flexible energy solution for deployed operations. This system was developed to reduce the quantity of batteries carried by airmen through hybridization of a high energy power source, such as fuel cells, air-batteries, or other high energy sources with a high power battery. A power manager regulates power from each of these sources and delivers it to meet the user’s power and energy needs. BRITES, through the Power Generation and Management (PG&M), has been evolving and its transformation is providing a series of enhanced capabilities, while reducing weight and size. One drawback of this approach is the additional cabling required to regulate power within the various power sources and sinks. Also, the added risk of damage, like corrosion, and the risk of physical connection points are limiting factors to overall reliability. Thus, cable management issues need to be mitigated. This topic seeks innovative approaches which eliminates the direct connection electronics utilized by the airmen. Acceptable solutions should seek to work to ensure that the system is charging when it is in range, but can easily be decoupled and used autonomously on battery power. A technology solution which permits power transfer to vest-worn electronic devices is envisioned, this will also provide reduced weight and volume compared to conventional hardwired approaches. At the conclusion of this effort, the accepted solution must demonstrate that it can lead to meeting military environmental requirements, as applicable methods established in MIL-STD-810G and 461F. The design and type of architecture used should not impact the host of electronic devices, with emphasis on human/equipment safety and cost. “Plug and play” and “add on” type architectures, are preferred to facilitate efficiencies in operability and maintenance.

PHASE I: Design and fabricate a breadboard prototype to demonstrate the feasibility of the approach to incorporate wireless power transfer technology to power candidate vest-wearable devices (e.g., radios, computers). Perform risk/safety assessment of system. Emphasis should be placed on reducing weight and volume for soldier use.

PHASE II: Fully develop the Phase I system and fabricate a prototype to be integrated into a practical vest-worn, power system capable of meeting the power needs of typical vest-worn electronic gear. The offeror must demonstrate that the concept is readily manufactureable. Maximum power transfer level shall be 100W; volume and weight should be minimized.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Soldier-portable power transfer to recharge and/or power battlefield computers, hand held radios, GPS’s, thermal imaging devices, and laser designators and range finders. The offeror must demonstrate that the concept is qualified against military methods established in MIL-STD-810G and 461F .
Commercial Application: Wireless battery chargers, power electronic devices carried by border patrol, homeland security, and search and rescue personnel.

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KEYWORDS: Wireless power transfer, wireless battery recharger, wireless power distribution

AF121-193 TITLE: Mapping Liquid Mass Fractions in Optically Dense Rocket Combustion Chambers

TECHNOLOGY AREAS: Air Platform

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop capability to image liquid mass fractions at high-pressure, high-soot laden rocket combustion conditions.

DESCRIPTION: Fuel-air mixture preparation and acoustic coupling with heat release within a combustion chamber has a controlling impact on the development of combustion instabilities. Such instabilities can lead to premature engine wear and ultimately to catastrophic device failure. These conditions have led to failures in rocket engines and augmenters in the past. Unfortunately, the conditions in rocket combustion chambers, particularly the high-pressure combustion environment and high soot loading, are often beyond the reach of conventional optical diagnostics. As a result, liquid rocket injection is one of the most important unresolved diagnostic challenges in rocket propulsion field. And these challenges, while at their height in rocket engines, are not confined to the rocket propulsion but also apply to air-breathing propulsion, power generation and transportation. The continued lack of understanding limits the ability of engine designers to optimize performance over the full range of engine operation and complicates the transition to advanced fuels. A method is sought for gaining access to this harsh environment to allow the mapping of liquid structures and fuel mass fractions. These data should ideally be quantitative to allow comparisons with Computational Fluid Dynamics and other analytical models. Measurements of additional quantities, such as mixing efficiency, which would further aid model comparisons is also sought but not required. Recently, techniques such as X-ray radiography and ballistic imaging have been used for studying liquid injection under non-reacting conditions for a variety of optical densities which would not be within the reach of conventional diagnostics. Through further development, these and other techniques may allow detection of liquid mass fractions under conditions that are nearly opaque to visible wavelengths. Proposed techniques should be able to operate in rocket test cell facilities or engine test stands for measurements under realistic (hot-fire) operating conditions. Since there are a number of applications, such as gas-turbine combustors, augmenters, rocket engines, scram-jets, furnaces, pool files, diesel engines and fluidized beds in which particle loading is significant, the development of technology for performing diagnostics under these conditions would represent a significant breakthrough in measurement capability.

PHASE I: Demonstrate an innovative system to measure liquid mass fractions in combustion chambers with high particle loading. Address the effects of pressure up to 50 bar, optical density, line-broadening, beam steering, and optical access on quantitative accuracy.

PHASE II: Fully develop the innovative system designed in Phase I. Conduct fundamental theoretical and experimental studies of the approach. Develop and optimize comprehensive data interpretation algorithms with appropriate validation techniques. Develop a prototype and demonstrate high-speed measurement capability in a combustion chamber with high particle loading similar to that of a rocket combustion environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The diagnostic will be useful in making measurements in rocket & turbine engines, scram-jets and augmenters. These measurements will help improve liquid injection in propulsion devices lowering design risks & costs and enabling improved performance.
Commercial Application: The system will enable quantitative measurements in a variety of applications including propulsion devices, power generation, furnaces and fluidized beds. The improved understanding of sprays will lead to better performing designs and models.

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KEYWORDS: liquid mass fraction, particle-laden flows, combustion devices, propulsion devices

AF121-194 TITLE: Spatiotemporal Dynamical System Analysis Tools for Very Large Data Sets

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop analysis techniques for very large high-bandwidth spatiotemporal experimental and numerical data sets.

DESCRIPTION: Computational fluid dynamics (CFD) tools such as Reynolds Averaged Navier Stokes (RANS), Large and detached eddy simulation (LES/DES), and direct numerical simulation (DNS) have greatly benefitted from advances in computing power. With improvements in CPU/GPU throughput and parallel architecture, memory and storage for these analysis tools have increased 100 fold – full annulus turbomachinery simulations produce thousands of solutions per revolution; in combustion advanced kinetics models result in more variables for each species modeled. As a consequence, these models produce large sets of data that must be stored and analyzed by the CFD user. A single set of unsteady data can routinely be hundreds of millions of points and on the order of tens of terabytes.

The advent of new laser technologies is enabling high-bandwidth point, planar, and volumetric velocity and two-phase measurements in simple and complex experimental rigs. Further, advances in laser technology have also enabled point, planar, and 3-D measurement of flame position, temperature, and species concentrations in chemically reacting flows that were unimaginable just a few years ago. These new technologies also enable temporal acquisition rates up to 50,000 Hz and beyond. Examples of these techniques include: particle-image velocimetry, planar laser-induced fluorescence, diode laser-based thermometry and species techniques, and femtosecond laser-

based point or line coherent anti-Stokes Raman scattering (CARS) spectroscopy techniques. New laser techniques also produce terabyte-size sets of data for storage and analysis.

State of the art post-processing for such datasets is research codes with a specialized method or commercial tools which are not amenable to rapid, scalable analysis of terabyte-size sets. Desired is a toolbox for linear and nonlinear analysis of large sets of computational (from CFD) and experimental data derived from the aforementioned computational and experimental techniques. In general, tools are desired that can reduce large data sets read from standard CFD and camera formats into useful scientific and engineering information and reduce sets of data for storage. Techniques involving mean, rms, and spectral analysis are desired. Also desired are techniques such as proper orthogonal decomposition (POD), singular value decomposition (SVD), stochastic estimation, and wavelets. Chaos theory techniques to extract useful nonlinear coupling information are also desirable. Methods should be assembled in a toolbox for improved understanding of the data generated. These tools could produce a comparison of the mean, spectral, or modal information from experiments and computations over a wide spatial and temporal space of the data. Such capabilities are typically implemented piecewise in visualizers or research codes that are not amenable to operating on terabyte-size datasets or in batch environments. Sporadic implementation of the various methods in a number of different tools makes utilization of multiple methods impractical with the current state-of-the-art software.

PHASE I: Develop a framework for the large data set mathematical analysis toolbox. Demonstrate the feasibility of scalability aspects of the proposed framework on a simple, 1 terabyte dataset of analytically derived, existing CFD, or existing experimental data. The dataset should comprise 1 second of data acquired at 10 kHz or greater (each dataset should be composed of at least 10000 frames). The maximum operation time should be on the order of a day rather than a week.

PHASE II: Develop a software toolbox capable of analyzing large sets of computational and/or experimental data on multiple platforms and environments. The datasets should be loaded from standard CFD and camera formats. Demonstrate the utility of the software package by applying it to multiple terabyte-size sets of spatiotemporal data either analytically developed, from the CFD methods above, or experimentally acquired. Each dataset should be composed of at least 10000 frames. Several analysis methods conceptualized in Phase I should be demonstrated, i.e. POD, wavelet, chaos, and Fourier analysis. Timelines for operation of the methods on each dataset should be meaningful to the experimental and computational process, meaning basic analyses should be able to be performed on the order of days whereas the most complex analyses should take no more than a week.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The developed toolbox and associated technologies can be used in development and procurement programs for comparison of large data sets, both computational and experimental, and for validation of design system practice and robustness.
Commercial Application: A nonlinear analysis toolbox will have a broad range of applications, making this technology applicable to power plants, internal combustion engines, turbine engines, and commercial experimental test facilities.

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KEYWORDS: large dataset analysis, nonlinear analysis, dynamical system, high-bandwidth measurements, high-fidelity computational fluid dynamics

AF121-197 TITLE: Fire Suppressant Transport Model

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop an engineering model to evaluate the transport of high-boiling-point fire suppressants in cluttered aircraft environments.

DESCRIPTION: Dry bay and engine nacelle fires are the damage mechanisms contributing the most to military and commercial aircraft vulnerability. Consequently, dry bay and engine nacelle fire extinguishing capabilities are at the forefront of concern for the aircraft survivability community. However, dry bay and engine nacelle vulnerability-reduction measures are typically overlooked by the design community because of associated weight, cost, and maintenance penalties. Historically, fire extinguishing systems using halon as suppressant have been very effective, but due to ozone depletion concerns halon use is no longer permitted in new designs. Alternative suppressants shown limited effectiveness and/or have not often been considered due to violation of acquisition, platform, and/or environmental requirements, including those mentioned above. Furthermore, halon alternatives have high boiling points and must be dispersed in the liquid state.

A valid and credible suppressant transport model is needed to optimize fire extinguishing system designs to reduce weight, cost, and maintenance penalties. Such a model must be capable of simulating fire suppressant dispersion through high-risk fire zones (e.g. dry bays and engine nacelles). The model must account for confined spaces and clutter within high-risk fire zones. The model must handle complex geometries/designs and related airflow conditions. The model must output the protection level offered by the suppressant and system design of interest,

danger zones, and optimal suppressant injection locations. The model must be capable of simulating common halon alternatives (i.e. water, carbon dioxide, potassium carbonate, potassium bicarbonate, sodium bicarbonate, potassium iodide, potassium chloride, and ammonium phosphate) in a cluttered dry bay environment. Simulations must be verified and validated to replicate lab-scale tests at a minimum 90% accuracy and full-scale dry bay and engine nacelle tests at a minimum 80% accuracy.

PHASE I: Design and develop a beta version of the model. Demonstrate the model's performance via lab-scale demonstrations. Demonstrate ability to simulate all halon alternatives of interest, and handle complex geometries and airflows. Identify steps to integrate into complex fire models.

PHASE II: Develop the final model version. Demonstrate model's performance compared to test data from full-scale demonstrations. Produce results within 80% accuracy compared to full-scale dry bay and engine nacelle test data. Produce results within 90% accuracy compared to lab-scale tests.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The program offices will integrate the fire extinguishing system to new and legacy platforms if effectiveness, weight penalties, and costs are met.
Commercial Application: The system will be applicable to dry bays and confined and cluttered spaces in commercial systems.

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KEYWORDS: Fire protection, fire extinguishing, low-cost, light-weight, aircraft dry bay, engine nacelle, fire suppression, suppressants, extinguishing model, suppressant model, clutter, airflow, complex geometries

AF121-199 TITLE: Aircraft Tire Thermal Measurment Device

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop device(s) for real-time thermal measurement of aircraft tire tread crown temperature (finding max temp) and generate temperature profiles (tread surface to inner liner) of an aircraft "radial" tire operating under dynamic loading conditions.

DESCRIPTION:
1. It is imperative to have a full understanding of all the capabilities of military aircraft tires in order to ensure safety during takeoff, landing and ground maneuvering operations. The ability to accurately measure temperature distributions across the tire tread crown as well as the internal temperature profiles (i.e., from the tread surface to the inner liner) is instrumental in development, design, qualification testing of aircraft tires and safe operational limits.

2. Understanding thermal affects on military aircraft tires will aid in determining tire tread degradation limits and permit a comprehensive wear study for new and improved tire designs, developments, and qualification tests. An additional, thermal measurement allows critical performance areas to be located within a tire and correlate these

areas to field performance. This can be useful in the prevention of pre-mature failures during aircraft flight operations.

3. The 46th Test Group's Landing Gear Test Facilities dynamometer will utilize this technology on it's 168 inch internal drum dynamometer. This dynamometer can reach a maximum speed of 350 mph with a maximum acceleration of 16 ft/sec². The maximum load that can be applied is 50,000 lbs. In addition, a maximum yaw of ±20 degrees as well as a maximum camber of ±10 degrees can be applied to the test tire. The desired dynamometer operating speed range for the temperature sensing device is from 0 to 250 mph. The device will need to be capable of operating in a wide range of ambient temperatures (< 32°F to above 100°F); although normal lab ambient ranges from 60°F-90°F. Assuming the device measures internal temperatures of the tire (causing exposure to the contained air or nitrogen gas), the device will need to withstand temperatures above 200°F. During testing, tires may be operated under variable yaw and camber with vertical load defections, as well as with or without braking. The testing surfaces that the tire runs on are variable and range from a smooth steel to rough concrete to aircraft carrier non-skid. Testing will also deal with environmental contamination (rubber particles, dust, water, snow, spray, etc.) and this should not adversely impact the device's operation. Thus, the thermal measurement device needs to be durable to work under these adverse conditions.

4. Currently there is no device that can measure both external and internal measurements of a rotating tire. Some desired capabilities of the temperature measurement device include determining the optimal tire crown surface operating temperature as well as the internal temperature of the inner lining. The device must work for re-tread tires. Temperature measurements can be achieved through non-contact as well as contact procedures.

Having this temperature device capability would also benefit the commercial industry in tire design, manufacturing and development. It may have practical safety applications in both the automotive and airline industries as well allowing predictive tire integrity safety measurements.

PHASE I: Demonstrate feasibility to actively measure aircraft tire tread crown temperature (finding max temperature) and generate through thickness temperature profiles (from tread surface to inner liner) under dynamic vertical load/camber/yaw defections from an aircraft radial tire running on an internal drum or variable inertia dynamometer.

PHASE II: Develop full-scale prototype measurement device, device shall be integrated with an existing internal drum dynamometer (i.e., 46th Test Group Landing Gear Test Facilities 168i internal drum). Demonstrate real-time data acquisition capabilities while producing the desired temperature profile diagrams (temperature versus radial position through the thickness of the tire).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Improve safety-of-flight predictions and pre or post-flight evaluations for aircraft tire performance and integrity for any mission/sortie operational condition(s) (i.e., elevated time-temperature limits, tread chucking and/or blown tire avoidance).
Commercial Application: Provide a commercial thermal test system capability for automotive, trucking, and aircraft industries to aid in quality manufacturing and design improvements; resulting in increased tire wear and safety.

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4. McClain, J. G., Vogel, M., Pryor, D. R., Heyns, H.E. The United States Air Force's Landing Gear Systems Center of Excellence – A Unique Capability, AIAA, 2007-1638.

KEYWORDS: F-35, Joint Strike Fighter, Quick-Turn Sortie, C-130 Sustainment, Hercules Cargo Aircraft, Tire Temperature Limits, Pre-Flight, Maintenance Checks, Cost Reduction, Aircraft Tire, Flight Line Inspection, Thermal Measurement, Temperature Profiles, Thermal Sensor, Safety of Flight, Fighter aircraft, Cargo Aircraft, Tanker and Bomber Aircraft, Tire Integrity, Reduced Maintenance, Automotive, Truck or Heavy Equipment Tire Testing

AF121-201 TITLE: Massive Parallel SAR Scene Simulator

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop an innovative technique for computing the synthetic aperture radar (SAR) signatures in real-time for utilization within a SAR radar Hardware-In-The-Loop (HITL) test environment.

DESCRIPTION: HITL is a simulation technique which utilizes custom test hardware, software and digital models running in real-time to stimulate and evaluate the SAR radar Unit-Under-Test (UUT). The objective is to create a simulated environment where airborne SAR radars can be tested and evaluated under realistic dynamic conditions. The simulated environment must contain sufficient target and clutter (terrain) fidelity in order to effectively test the image detection algorithms within the SAR UUT.

SAR target signatures must be generated as a real-time response to engagement geometry parameters by transformation of appropriate scatterer characteristics into radar space, computing the antenna pattern-weighted amplitude response and the geometry and frequency-dependent phase for each scatterer that are then coherently summed as scatterer returns. The resultant waveform modulation signals are then sent to radar signal processing algorithms for hardware command generation and RF radiation through free space transmission within a HITL anechoic chamber.

Millimeter Wave (MMW) background (clutter) models must also generate signals in response to changing engagement geometry and radar waveforms. These models are designed to represent the significant energy scattered from terrain illuminated by the transmitter and subsequently received by the SAR radar. A high resolution class-map describing the features and height of the individual resolution cells represents the ground clutter or terrain. The terrain Radar Cross Section (RCS) is computed from a combination of scattering coefficients and resolution cell size. The terrain clutter data base can be quite large (>100 MB) and must be accessed by each of the compute elements at real-time rates within the simulator.

Efficiently computing the target and clutter models with large numbers of scatterers, applying class maps, determining the kinematic properties of dynamic entities and controlling the HITL custom test hardware at real-time rates has proven to be a daunting task that limits the fidelity of the environmental signatures. With the advent of large Field-Programmable Gate Arrays (FPGAs) or similar technologies, it is theoretically possible to economically develop a large parallel processing architecture that can compute and process the SAR scene coefficients at real-time rates. This parallel processing architecture will avoid the limitations of serial computations of scene coefficients found in modern CPUs which utilize only a few digital signal processing compute elements. Computational performance increases on the order of 10 to 100 times current speeds may be possible with this massively parallel approach.

PHASE I: To develop a parallel processing architecture that will address SAR radar computational processing requirements for calculating a dynamic synthetic scene. Phase I will research technologies, develop design concepts and model elements for a feasible approach for HITL SAR radar test environment.

PHASE II: To develop and demonstrate a working prototype of a large FPGA-based SAR scene simulator, based on Phase 1 approach, that can be tested within a SAR HITL test environment. This prototype should include a generic target and clutter model to compute the synthetic scene coefficients for the dynamic engagement. In addition, phase II will validate performance predicted in Phase I has been achieved.

PHASE III DUAL USE COMMERCIALIZATION:

Military Application: Systems requiring near real-time processing of scene coefficients, such as SAR scene generation for testing of RF weapon sensors in HITL, phased array radars, radar ground mapping and clutter data.
Commercial Application: Commercial applications for this technology such as Satellite Image Processing, Airport Screening, Phased Array Radars, Ultrasound Image Processing, SIGINT, Radar Ground Mapping and Clutter Data.

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KEYWORDS: SAR, simulation, FPGA, HIL, HITL, radar, mmw

AF121-202 TITLE: High-Speed, Multispecies Sensing in Gas Turbine Engines and Augmentors

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

OBJECTIVE: Development of a multispectral measurement capability for high-speed and high-accuracy temperature and species concentrations of gas turbine combustors and augmentors in turbine engine test facilities.

DESCRIPTION: Measurements of combustion and gas dynamic properties inside gas turbine engines and augmentors are needed to aid in engine development, performance testing and evaluation, and for verification and validation of combustion modeling codes. Current probe based measurement systems (Ref. 1) are limited to slow temporal response due to sample transport times and relatively slow analysis methods. State-of-the-art non-intrusive optical measurement techniques are capable of obtaining transient thermodynamic properties and species information, but have heretofore required optical access to the measurement point of interest, and/or have been limited to single species measurements or laboratory bench configurations that are unsuitable for ground test facility applications (Refs. 2-4). Advanced instrumentation and flow-field diagnostics that combine the advantages of both intrusive and non-intrusive measurement systems are needed to fill the technology gap by adequately defining the transient gas chemical species characteristics and thermodynamic behavior in the combustion environments. The goal is to eventually incorporate the prototype system with optical probes similar to those discussed in Ref. (1) and Ref (5). The Phase I should demonstrate the feasibility of measurement technologies for simultaneous multispecies concentrations in a laboratory kerosene-air flame. The Phase I effort should target at least three specie types. The Phase II should develop a high-speed sensor prototype that can simultaneously measure multiple combustion products, free radicals and temperature at a minimum rate of 1 kHz. The exhaust temperature will range up to 2200 K and pressure to 2 atm. The flow-field diameter will be about 0.5 meter. The government can help coordinate access to an augmented turbine engine mounted in a static test stand for the prototype demonstration. High consideration will be given to companies who will be able to work on and transition to an ITAR restricted asset.

PHASE I: Demonstrate a proof of concept for measuring three or more species concentrations in a laboratory burner flame.

PHASE II: The Phase II should develop a high-speed sensor prototype that can simultaneously measure multiple combustion products, free radicals and temperature at a minimum rate of 1 kHz. The exhaust temperature will range up to 2200 K and pressure to 2 atm. The flow-field diameter will be about 0.5 meter.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This capability could be used for the development of military turbine and afterburner combustion processes and active control for flight systems.
Commercial Application: Passive sensors could be used for the development of commercial turbine and afterburner combustion processes, turbine engine coal-fired plants.

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2. S. Roy, A Caswell, S. Sanders, L. Ma, D. Plemmons, and J.R. Gord, "50 kHz Rate 2-D Temperature and H2O Concentration Measurements at the Exhaust Plane of a J-85 Engine using Hyperspectral Absorption-Based Tomographic Sensor," Submitted to Combustion and Flame, June, 2011.

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KEYWORDS: multispecies sensing, multispectral measurement, species concentration, augmentors

AF121-203 TITLE: Modeling and Simulation for Combined Space Environment Chambers

TECHNOLOGY AREAS: Space Platforms

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a comprehensive dynamic computational modeling capability for space chamber test facilities with multiple environment simulators.

DESCRIPTION: A three-dimensional, dynamic modeling capability is needed to design tests and interpret test data for space chamber simulation facilities. The orbital environment is a complex mixture of natural and non-natural components, including energetic particles, atomic oxygen, solar radiation, cryogenic temperatures, vacuum, magnetic fields, outgassing of condensable material, thruster contamination, and radiation from directed energy weapons such as lasers and radio frequency jamming. Testing the survivability of satellites in ground based facilities requires elaborate space chambers with multiple environment simulators. The modeling and simulation capability to predict complex interactions in such chambers does not exist. At a minimum, modeling should include: atomic oxygen, charged particles, solar radiation, visible through infrared laser radiation, and cryogenic

temperatures. Rarefied flow capabilities in Computational Fluid Dynamics packages and Direct Simulation Monte-Carlo for cryo-deposition offer minor parts of the solution, but are not models and do not include interactions between multiple sources to be investigated. An innovative solution can be developed as a standalone or integrated with existing modeling codes. Phase I should develop a framework for integrating the source models into a full capability and demonstrate an algorithm for modeling at least one environment component from the above list in a vacuum chamber. The Phase II effort should develop, integrate, demonstrate, and validate algorithms for all sources (mentioned above) in a robust computational package. The final capability should allow input of source conditions and output three dimensional, temporally varying conditions in the cryo-vacuum chamber.

PHASE I: Develop a framework for integrating the source models into a full capability and demonstrate an algorithm for modeling one environment component.

PHASE II: Develop and integrate algorithms for all sources into a robust computational package.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Enables prediction of conditions in combined effects space chambers at DoD, NASA, spacecraft design, mission planning. Organizations that have interest are AFRL, NRL, Los Alamos National Lab, DARPA, and National Security Space Institute.
Commercial Application: Enables prediction of conditions in combined effects space chambers in industry. Serve as baseline for industry satellite development, exo-atmospheric codes. Commercial satellite manufacturers for design and operations decisions for spacecraft.

REFERENCES:
1. L. Baxter, R. Simpson, J. Prebola, M. Smotherman, D. Moore, R. Goldflam, D. Battles, D. Higham, and D. Perkes, "Spiral 1 Space Threat Assessment Testbed (STAT) Development," ITEA Journal, v. 30, pp. 345-353, 2009.

2. J. Colebank, B. Stewart, N. Tracey, J. Staines, and H. Smith, "Survival in the Orbital Battlefield: Improving the Odds," AIAA 2010-1765.

3. Vincent Pisacane, "The Space Environment and its Effects on Space Systems," AIAA, 2008.

KEYWORDS: Combined sources modeling, vacuum chamber, space environment effects, rarefied flow, solar radiation, laser

AF121-204 TITLE: Fabrication Process for Small, High-precision Aerodynamic Balances

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a highly accurate fabrication process for small balances that measure aerodynamic forces and moments on wind tunnel models.

DESCRIPTION: Development of a highly accurate fabrication process is needed for small aerodynamic force and moment measuring balances that have small and complex features like flexures, bellows and internal passages. The currently preferred fabrication process for 0.2 to 0.3 in diameter balances is electrical discharge machining (EDM). EDM requires post-fabrication polishing to remove the undesirable heat-effect layers of material and is unable to create the smaller-scale features envisioned in future balance designs. An alternative method for manufacturing future balances that mitigates or eliminates the disadvantages with EDM is desired. The alternative method should have the capability to manufacture balances with internal features like channels for cooling or for wire routing. All innovative approaches will be considered. One technology with potential is Direct Metal Laser Sintering (DMLS). DMLS is fully automated and can manufacture parts as thin as 0.050 in. with extremely high tolerances. The nature of the technique may reduce the time, cost and risk of manufacturing. However, as with other methods, the DMLS process must be designed to manufacture a balance with homogeneous material properties that does not crack or warp during fabrication and has an acceptable surface finish. Phase I should demonstrate the feasibility to manufacture an existing small-diameter balance (0.3" diameter, 3" to 5" length, CAD files will be provided) with

material properties consistent with 15-5 steel. Success will be evaluated by homogeneity and similarity to the material properties of 15-5 and dimensional inspections of manufactured parts with external features representative of a state-of-the-art aerodynamic balance design. Phase II should develop and demonstrate the capability to fabricate a next generation aerodynamic force and moment balance with complex internal and external features. Internal features include multiple non-concentric, intersecting smooth-walled passages for cooling fluid or wire routing that are 2 mm in diameter. External features include thin-walled web flexures and 2 mm wide smooth-walled slots. A batch of six prototype balances of a future design should be fabricated to demonstrate an acceptable success rate; success to be determined by dimensional inspections and load testing of the manufactured aerodynamic balances.

PHASE I: Demonstrate the feasibility to manufacture an existing small-diameter balance design with material properties consistent with 15-5 steel.

PHASE II: Phase II should develop and demonstrate the capability to fabricate a next generation aerodynamic force and moment balance with the features quantified in the above description.

PHASE III / DUAL USE:
Military Applications: Hypersonic store separation wind tunnel testing.
Commercial Applications: This would extend the capability of DMLS making it more commercially viable for a wide-range of applications for small components/instruments in the aerospace, automotive, and surgical fields.

REFERENCES:
1. Richard M. Bishop, “New AEDC Wind Tunnel Capabilities”’ AIAA 2000-1062.

2. Simon K. Choi and James R. Stewart, “Force Balance Measurement Sensor in Wind Tunnel Aerodynamic Testing Environments”, AIAA 2004-6812.

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4. David M. Cahill, “Evaluation of Wind Tunnel Internal Force Balances from Multiple Vendors”, AIAA 2004-1292.

5. CAD Drawings, released on 11/15/11, 4 pages, provided by TPOC and uploaded in SITIS on 11/18/11.

6. Balance ISO View, ANSYS v12.1, 2 pages, uploaded in SITIS 11/30/11.

KEYWORDS: DMLS, aerodynamic balances, fabrication process

AF121-207 TITLE: Floral Disruptor - Directed Energy Weed Abatement and Prevention Tool

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a device that uses directed energy technology to prevent and abate unwanted plants (weeds) in areas that require control or defoliation. The purpose of this system will be the removal of unwanted plants and keep seeds from germinating.

DESCRIPTION: Every year millions of dollars are spent on weed control in and around military installations. Weed control and abatement can either be performed chemically; by applying poisonous herbicides, or mechanically; by mowing or tilling. Herbicides can be grouped by activity, use, chemical family, mode of action, or type of vegetation controlled. Herbicide use generally has negative impacts on bird populations, although the impacts are highly variable and often require extensive field studies to predict accurately. Having a cost effective device that eliminates the use of herbicides or reduces the amount of machinery could extensively save money and protect wildlife at the same time. Private industry has been actively engaged in the research, development, and deployment of various physical control technologies utilizing microwave radiation (as heat), lasers, and sound to deter, disrupt, deny, or degrade the desired objective. Thermal technologies such as foam, hot water, steam and

quenched hot gases to physically rupture cell membranes within young, vigorous green weeds to shut down the plant's capacity for photosynthesis, has been explored as a means for safe, effective weed control . The technological challenge is to develop a device that would effectively destroy weeds in various growth stages from seeds to maturity using some form of directed energy in designated areas.

The Sikes Act and Air Force Instruction (AFI) 32-7064 require the Department of Defense (DoD) to manage the natural resources of each military reservation within the United States and to provide sustained multiple uses of those resources. Edwards AFB complies with these requirements by preparation and implementation of an Integrated Natural Resources Management Plan (INRMP). The primary purpose of the INRMP is to use adaptive ecosystem management strategies to protect the properties and values of the base's natural environment in concert with the military mission. This is accomplished by defining and implementing natural resource management goals and objectives that collectively achieve habitat and species sustainability; thereby, ensuring no net loss in the capability of the installation's lands with a realistic testing and training environment.

Finally, the frequency used for this system must not interfere with any current operational aircraft or ground-based sensor systems and it must not be able to target personnel or wildlife.

PHASE I: Define the proposed concept and develop key component technological milestones. Produce a conceptual design and provide a detailed analysis of the predicted performance to include simulation of the prototype device. Determine the technical feasibility of the device and provide a plan for practical laboratory testing and eventually field deployment.

PHASE II: Develop and successfully demonstrate a working prototype system based upon the Phase I results.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military facilities have many needs to abate and control the spread and growth of unwanted plants or weeds. This device will provide a viable and cost effect alternative to traditional chemical or mechanical weed control techniques.
Commercial Application: Commercial facilities have many needs to abate and control the spread and growth of unwanted plants or weeds. This device will provide a viable and cost effect alternative to traditional chemical or mechanical weed control techniques.

REFERENCES:
1. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) C95.1-1991, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic.

2. Non-Chemical Weed Management: Principles, Concepts and Technology; Mahesh K. Upadhyaya and Robert E. Blackshaw.

3. 47 Code of Federal Regulations (CFR) 80.83 - Protection from potentially hazardous RF radiation.

4. 29 Code of Federal Regulations 1910.97 – Non-ionizing radiation.

5. Air Force Occupational Safety and Health (AFOSH) Standard 48-9, Radio Frequency Radiation (RFR) Safety Program.

KEYWORDS: Electromagnetic radiation, radiofrequency radiation, microwave radiation, weed, seed, floral, pre-emergent, sensors, wavelength

AF121-208 TITLE: System Identification and Modal Extraction from Response Data

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop a system that is robust, efficient, and simple that can identify modes shapes from flight test data without measured inputs and display and compare them to analytical modes in near real time.

DESCRIPTION: Often in the development of new aircraft and systems, the dynamics of the elastic structure interacts with the surrounding airflow. Many times this interaction becomes unstable causing excessive oscillations of the structure. These oscillations can accelerate fatigue and in the case of flutter, can cause structural failure of the aircraft. Because of the destructive nature of flutter in particular and aeroelastic instabilities in general, it is necessary to assure that new aircraft and aircraft configurations are free from these instabilities. In order to assure aeroelastic stability of new aircraft configurations, it is critical to identify and understand how the structural modes are interacting with the aerodynamics at different flight conditions. Many times the aircraft do not have systems to input a controlled excitation, and even when they do there is often a discrepancy between the intended and actual excitation and components that do not respond to inputs of the excitation system. Currently in situations where controlled inputs cannot be used, the Random Decrement method is often used but is difficult and can lead to erroneous conclusions. Modern system identification methods like Operational Deflections Shapes and some to the State Space Method can identify modes without measured inputs. In addition to identifying modes, visualizing them is also important. In order to aid flight test engineers in efficiently conducting aeroelastlc stability ("flutter") testing, this research is intended to build on modern system identification methods in order to derive a method that is robust (tolerant to noise and non-Linearities); efficient (identify system with minimal time on condition in near real time); and simple (on-line, no interaction required). In addition to identifying the system, a visualization suite also needs to be developed capable of displaying mode shapes derived from flight test data and comparing them to analytical mode shapes in near real time. At a minimum, this visualization should include options for displaying overlaid mode shapes and a difference map that highlights the areas of greatest difference between flight test and analytical mode shapes.

PHASE I: Develop technically feasible identification algorithms that will result in a robust, efficient and simple algorithm, as well as, conceptualizing a modal visualization plan.

PHASE II: Develop, demonstrate and validate a prototype system identification algorithm and visualization code.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Many military aircraft with external stores exhibit aeroelastic instabilities such as Limit Cycle Oscillation. They all require extensive flutter testing during the development phase. This technology would increase the efficiency of this testing.
Commercial Application: Aeroelastic stability is also a concern for commercial aircraft. This tool will be useful for both sectors of the aircraft industry, as well as other industries such as the automotive and rotational machinery industries.

REFERENCES:
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2. Stochastic System Identification for Operational Modal Analysis: A Review, J. Dyn. Sys. Meas., Control -- December 2001, Volume 123, Issue 4, 659.

3. Peter M. Thompson, Edward N. Bachelder, David Klvde, Chuck Harris, Martin Brenner, Wavelet¬ Based Techniques for Improved On-line Systems Identification, USAF Developmental Test and Evaluation Summit, 16-18 November, 2004, Woodland Hills, CA.

KEYWORDS: System Identification, Mode Shapes, Aeroelastic, visualization software

AF121-209 TITLE: Low Background Blackbody

TECHNOLOGY AREAS: Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a low temperature blackbody capable of performing midwave infrared sensor tests normally done at room temperature because there is no low temperature test equipment designed for this purpose.

DESCRIPTION: The sensitivity of tactical midwave imaging sensors has been shown to be extremely sensitvie to background temperature. No test equipment outside of the EO lab at Edwards AFB exists to test for sensitivity over a wide range of background temperatures. The only test device is the $1.5M scene projector developed for use in much more complex tasks. Use of this valuable and unique asset for these relatively simple sensitivity tests is not cost effective.

Measurements using this complex device clearly showed the sensitivity reduction as the background temperature was reduced. The lowest temperature used was -40°C, which is a good lower operating limit for existing fielded midwave imaging systems which typically operate between temperature extremes of -40°C. and 100°C.

Desired specific tests to be performed by the prototype blackbody are Noise Equivalent Temperature Difference (NETD) and Minimum Resolvable Temperature (MRT) to a resolution on the order of 1 mK.

The technology challenge is to develop and build a prototype device that will accommodate the performance of the tests described above at any selectable background temperature within the range of fielded midwave imaging sensors. The goal is to develop such a device with a significant cost reduction below that of the complex device currently in use.

PHASE I: Design a concept for the development of a blackbody described above. Deliver a design description document explaining how the concept will perform the desired tasks thermally, electically and mechanically as well as a description of an operator interface.

PHASE II: Develop, demonstrate and deliver a prototype device which meets the desired performance, cost and functional capabilities explained in the description.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This device will be used by government installations which use or repair EO devices. It will be required as a depot recalibration tool in case of a detector replacement in the field. The test device will also be used by development laboratories and manufacturers.
Commercial Application: The test device will also find similar uses by commercial manufacturers and maintainers. This is a large market given the widespread use of such sensors for a variety of industrial, general aviation, and commercial vehicle applications.

REFERENCES:
1. Maritime Defense and Security Research Program, Naval Postgraduate School, Monterey, CA, SITREP newsletter, Volume 49, September 2010.

2. H. Pham, F. Crawford, M. Mele, D. Hatfield, “Measured Contrast Performance of a Midwave Staring FLIR”, MSS Passive Sensors, February 2008.

3. H. Pham, F. Crawford, D. Hatfield, “Measured NE?T Performance of a Midwave Staring FLIR”, MSS Passive Sensors, February 2009.

4. Mark A. Massie, Todd R. Cicchi, Eric J. Woodbury, Huy Pham, Dean Hatfield, Paul McCarley, “Optimizing and Automating FLIRs for Low Contrast, Low Noise Operation”, MSS Passive Sensors, February 2010.

KEYWORDS: low background temperature, midwave infrared, blackbody, sensitivity testing, measured contrast

AF121-212 TITLE: Re-evaluation of Oil Analysis Program

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Improve the current Oil Analysis Program and modify processes and/or equipment as required to create more effective oil analysis.

DESCRIPTION: The Joint Oil Analysis Program (JOAP) was established by the Joint Army, Navy, and Air Force regulation as a combined effort to establish and maintain a standard program that would consolidate and coordinate the three separate service oil analysis programs. The goals of the JOAP are to improve the operational readiness and economy of military equipment by the effective use of oil analysis, and to collect and analyze technical data in order to increase the effectiveness of oil analysis in diagnosing oil condition and potential equipment failures. When the JOAP was initially established, great improvements were made in the engine life. Changes were made to equipment and engines to reflect the JOAP results. However, currently the Technical Orders (TO) require engine oil samples to be taken and analyzed on either a daily or post-flight basis depending upon the weapon system. The oil samples are submitted to field level Non-Destructive Inspection (NDI) labs for spectrographic analysis and physical property testing. Spectrometric oil analysis is used to determine if there are any unacceptable amounts of wear metals suspended in the oil. Physical property testing provides details on the quality of the oil. Data from spectrometric and/or physical property testing may be used as guidelines to assist in identifying incipient mechanical failures or in determining the quality and useful life of the oil. Lubricant physical property testing provides data on conditions that are standards of measurement for judgment of the quality of the oil. Physical property tests aid in determining degradation or contamination of the lubricant which occur from combustion blow-by, oxidation from overheating, moisture from coolant leaks, additive depletion, etc.

The presence of wear metals is an indicator of bearing failure and immediate action may be required. A spectrometric oil analysis is used to determine the type and amount of wear metals in lubricating fluid samples. Engines, transmissions, gearboxes, and hydraulic systems are the types of equipment most frequently monitored. Wear metals are generated by friction between moving metallic surfaces in mechanical systems. Wear-metal generation occurs in all engines to some degree, and the wear metals will collect in the lubrication.

The United States Air Force has invested in improvements in both the design and materials used in bearing manufacturing and production so the frequency of oil testing may need to be modified. The testing equipment could be improved for more rugged environments, quicker testing results, and more comprehensive test results. The oil analysis results could be used to pinpoint more specific problems, such as a detailed analysis of specific debris in the oil to trace back to problem part area(s), and/or trending methods to predict possible wear and future failures. The current oil analysis methods could be improved to result in significant savings as far as testing type, frequency, and saving future damage to aircraft.

PHASE I: Research and develop best approaches for more comprehensive oil analysis methods including frequency and type of sampling, and/or equipment updates to collect and analyze oil samples.

PHASE II: Further develop best approaches determined in phase I, creating prototype equipment for sampling, oil collection, or oil analysis, and develop best methods to improve oil analysis program.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applies to a multitude of Army, Navy, Coast Guard, and Air Force engines.
Commercial Application: Applies to various commercial aircraft and various large scale boat engines.

REFERENCES:
1. Joint Oil Analysis Program, Army Regulation 700-132 OPNAVINST 4731.1C CH-1, AFI 21-131(1), http://www.apd.army.mil/pdffiles/r700_132.pdf.

2. “Joint Oil Analysis Program Manual Volume 1, Introduction, Theory, Benefits, Customer Sampling, Procedures, Program and Reports.” (NAVY) NAVAIR 17-15-50.1, (ARMY) TM 38-301-1, (AIR FORCE) T.O. 33-1-37-1, (COAST GUARD) CGTO 33-1-37-1, http://www.tinker.af.mil/shared/media/document/AFD-061214-032.pdf.

KEYWORDS: JOAP, oil analysis

AF121-213 TITLE: Condition Based Maintenance: Planning and Implementation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop advanced techniques to optimize planning and implementation of a Condition Based Maintenance (CBM) operation to minimize overall flow time while maintaining a high quality process.

DESCRIPTION: The PDM (Programmed Depot Maintenance) repair processes involve three major divisions: Aircraft, Engines, and Commodities. While much of the attention is directed toward the end items for Aircraft and Engines divisions, commodities also has requirements. There are thousands of LRU’s (Line Replaceable Units) removed at depot, in the field, and in combat areas that must be returned to the depot and be refurbished. Most of these items are not available commercially. Small inventory levels force quick turnaround to prevent fleet shortages and there is limited advanced visibility of the repairs needed. The LRU’s are returned in various conditions and require intensive evaluations to determine the necessary repair processes (routes). No standard route exists since each end item is repaired based on its condition (condition based Maintenance - CBM), and no standard parts list is available since only necessary items are replaced. While condition based maintenance may save funds, it can be difficult to control and manage since every item must be treated uniquely. Critical supply needs and internal parts shortages often force mid-stream priority adjustments further complicating the process. The commodities division manages thousands of different end items (high diversity) with many different routes (high variability). The current planning and implementation processes are labor intensive and requires constant vigilance to meet delivery dates and accommodate adjustments. While much data is collected, it requires time consuming analyses to utilize it and constant communication to keep it current. The new concepts should address both planning and implementation of the plans without overburdening personnel with data collection and analysis tasks. It must also consider the experience and time constraints of the maintenance personnel and simplify the process where at all possible. The new concepts must be flexible enough to address thousands of different end items and repair operations. While research has been conducted on maintenance planning and scheduling, the focus has been on high demand, low variability operations. There are many gaps in the research associated with high variability, low demand operations and very little research available on condition based maintenance optimization and physical implementation. Any approaches to solving the issues must take into account the physical constraints, security protocols, and personnel restriction/limitations. The resulting concepts / processes / training must be demonstrated with the context of the depot repair environment and must follow the strategic, operational, and tactical framework of the Department of Defense depot repair processes.

PHASE I: Research best concepts to meet needs and resolve the constraints associated with condition based maintenance operations. Based on the results of the research performed, develop a concept demonstration for assessing the program’s feasibility for Phase II.

PHASE II: Develop a real world demonstration of the concepts/processes/training to be assessed by managers involved in the numerous production lines, shops, and support processes. The demonstration should include the integration of the concepts/processes/training in at least two different areas. The program shall also provide a plan to transition the technology to commercial development and deployment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Various applications to areas with complex, variable planning requirements.
Commercial Application: It could have a significant impact on material quality, accuracy, efficiencies, and throughput for commerical applications. The processes and/or technology selected will improve quality, reduce costs, and increase throughput.

REFERENCES:
1. Don Nyman and Joel Levitt, “Maintenance Planning, Coordinating & Scheduling”, Industrial Press, Inc, 2010.

2. Peter Brucker and Sigrid Knust, “Complex Scheduling”, Springer, 2010.

3. Bill Hale, “An alternative vision for CBM+ for the Air Force”, Thomson Gale, 2005.

KEYWORDS: condition based maintenance, job shop optimization, planning and scheduling

AF121-214 TITLE: Wireless Technology for Probes and Accessories for Nondestructive Inspection Testing Instruments

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop wireless technology for probes and instruments used in Nondestructive inspections (NDI) to increase capability, reduce cost and time, and increase inspectors’ efficiency thereby improving aircraft structure maintenance plans and practices.

DESCRIPTION: Currently aircraft structure and turbo engine parts undergo numerous repair cycles. During life cycle maintenance these parts undergo numerous NDI processes designed to identify critical flaws that could cause catastrophic failure of the aircraft or engine. Common instruments used by NDI maintenance in the AF and in the DoD are used for eddy current, ultrasonic, and radiographic inspections. Eddy current and ultrasonic instruments utilize inspection probes (and sometimes imaging systems) connected by cables. In radiographic inspections, a radiographic control unit is connected to a tube head and cooler and to an interlock safety system by cables. All of these connecting cables are expensive, non-repairable, and could be a cause of Foreign Object Damage (FOD) to aircraft and engine parts. These cables also reduce the inspection efficiency when they get in the way during actual inspections especially in tight and hazardous aircraft spaces common for inspections to take place.

The total number of eddy current, ultrasonic, and radiographic nondestructive testing inspections being performed by the AF and the DoD both in the field and at each Air Logistics Center (ALC) and depot is vast. The total number of connecting cables in use for these inspections is also quite large. Quality of these cables is not always consistent and some of them become unserviceable after only a few uses.

It is possible to design wireless NDI instruments that could be used in the nondestructive testing inspections described above. This will eliminate the cost expended in procurement of these connecting cables, eliminate the FOD hazard caused by these cables when performing NDI, and increase the efficiency of technicians when performing the inspections.

PHASE I: Research and design the type and kind of NDI instruments where wireless probe and accessories technology could be applied. Identify savings that could be generated when using wireless technology.

PHASE II: Further develop wireless instruments, equipment, and probes proposed in Phase I. Validate and verify NDI capability and perform limited probability of detection testing of any instruments built.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Can potentially apply to a multitude of NDI equipment that all branches of the military use.
Commercial Application: Commercial applications are also numerous, and would apply to any current NDI inspection.

REFERENCES:
1. T.O. 33B-1-1.

2. T.O. 33B-1-2.

3. MIL-HDBK-6870A.

4. MIL-HDBK-1823A nondestructive Evaluation System Reliability Assessment.

KEYWORDS: Nondestructive testing inspection, Eddy Current, Ultrasonic, Radiography, Probability of Detection (POD)

AF121-215 TITLE: Alternatives to Gold-Plate Engines for Test Cell Correlation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a more cost effective alternative in place of gold-plate engines for test cell correlation.

DESCRIPTION: Though a few United States Air Force (USAF) engines still trim to Engine Pressure Ratio (EPR) as a test cell performance health metric, the vast majority of engine Type-Model-Series (TMS's) measure thrust, airflow, torque and/or Exhaust Gas Temperature (EGT). The USAF methodology for certifying both field and depot test cells to measure these parameters has long been to run a "gold-plate" engine with known and consistent performance across a baseline (OEM traceable) test cell and another test cell for comparison at the same engine test points/settings. The data obtained from the engine runs can then be compared and a parameter (e.g. thrust, EGT, etc.) correction factor can be calculated to correlate the "certification candidate" test data to the baseline data. Many physical features in a test cell which affect airflow characteristics (e.g. paint, dampers and louvers, etc.) cannot be calibrated and, therefore, correlation factors are required to ensure engine performance data from various test cells is compared accurately. While this methodology is reliable and consistent with both FAA standards and OEM best practices, the cost to maintain and manage gold-plate engines for every TMS is vast. Budget constraints have driven the USAF to seek alternative methodologies for calculating correction factors to correlate engine test cell data. Possible solutions might be engine thermodynamic cycle models, analytical methods, or other comparative tools that are more cost effective than gold-plate engines.

PHASE I: Develop concepts to provide a methodology to accurately calculate test cell correction factors to correlate data sets across the USAF. Detail the concept feasibility, methodology, and criteria developed. Also, document any processes utilized and estimate savings for each concept suggested. Deliver any concept tools produced.

PHASE II: Further develop and prototype/demonstrate the methodology based on the concept approved in Phase I. Provide a final report that documents the results of the Phase II prototype/demonstration. The report should document validated results of the demonstrated correlation, measured metrics, final criteria, and benefits.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Methodology could potentially be applied to all military engines.
Commercial Application: Methodology could potentially be applied to various FAA or commercial engines.

REFERENCES:
1. Aerospace Recommend Practice (ARP) 741 Rev B, http://standards.sae.org/arp741b/.

2. FAA Advisory Circular 43-207,
http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/22600
.

KEYWORDS: Gold Plate, test cell correlation, test engine standard

AF121-218 TITLE: Designer Soap for Washdown of Work Areas Where Hexavalent Chrome Paints/Primers are Applied

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: To meet OSHA Standards areas where coatings are applied must be cleaned to eliminate potential Hexavalent Chromium (Cr+6) exposures. A "soap" that does not contain chelators is needed to clean areas where coatings with Cr+6 have been applied.

DESCRIPTION: Aerospace coatings such as paints are applied on aircraft and aircraft parts. These aerospace coating contain Hexavalent Chromium (Cr+6). OSHA Standards require areas that have been used to apply coating with Cr+6 must be washed down. The cleaning process is intended to reduce the exposure of workers to Cr+6. The waste water from the cleaning process is routed to an industrial waste water treatment plant.

At Hill AFB the chemical wastewater treatment plant has metal treatment and removal process for Cr, Cd, NI, and Cu. Removal of these metals is made difficult do to the chelators from many products such as detergent and soaps. A study has been performed to find a commercial soap that would not interfere with the wastewater treatment process. After testing 25 commercially availible soaps none were found not to interfere with the wastewater treatment process.

The following list has been found to adversely affect the chemical wastewater treatment plant processes: the "Designer Soap" needs to be free of: Wetting agents, Chelators, Citrates - citrus based degreasers, Citric Acid, Carboxylic Acid, Oxalic Acid, Phosphates, Phosphoric Acid, Alkaline etching solutions, Amines, EDTA, Diamines, Triamines, Ammonium Nitrate, Cyanide, Sulfamates, Tartrates, Gluconate, Hydroxyacetric Acid.

We are looking for a “soap” / cleaning procedure that is safe to use on concrete, structural steel, copper, plastic pipe, and will not adversely affect the processes of the chemical wastewater treatment plant. The “soap” / cleaning procedure is intended to clean areas where there might be aerospace coatings overspray, aircraft hydraulic fluid, and miscellaneous soils and dirt from sealed concrete floors.

PHASE I: Research and develop a suitable "soap" / cleaning process that would be safe on concrete, structural steel, copper, plastic pipe and does not interfere with the industrial waste water treatment processes and does not interfere with biological treatment at a publically owned treatment works.

PHASE II: Demonstrate and validate the cleaning ability, safety, and non interference with the industrial waste water treatment processes of the candidates identified in Phase I.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Most DoD paint/depaint operations run their waste water thru an industrial waste water treatment plant for treatment to remove regulated wastes. Each DoD facility would benefit from such a soap.
Commercial Application: Commercial paint and depaint facilities could benefit from a designer soap that would not interfere with the treatment of metals at the industrial waste treatment facilities.

REFERENCES:
1. AFMAN 48-155 OCCUPATIONAL AND ENVIRONMENTAL HEALTH EXPOSURE CONTROLS.

2. "Hill Air Force Base Industrial Discharge Permit Number 110", North Davis Sewer District, 4252 West 2200 South Syracuse, Utah 84041.

3. L. Hartinger - Handbook of Effluent Treatment and Recycling for the Metal Finishing Industry – 2nd Edition (1994) Finishing Publications Ltd., ISBN 0-904477-14-2.

4. Executive Order 12856 “Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements” Federal Register Vol 58, No. 150 August 6, 1993.

KEYWORDS: soap

AF121-219 TITLE: Chemical Treatment of Metal Finishing Industrial Wastes and Wastewaters in the Presence of Chelating Substances

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a low cost, reliable chemical treatment that will remove regulated metals in the presence of chelating agents for industrial waste water treatment facilities.

DESCRIPTION: The Hill Air Force Base (HAFB) Industrial Wastewater Treatment Plant (IWTP) currently utilizes a chemical treatment process called "Metal Hydroxide Precipitation" to remove heavy metals from the wastewater which is created by a myriad of aircraft and weapons systems maintenance procedures located on HAFB.

Process wastewater not only includes heavy metals from the plating process, but also contains both Volatile and Semi-Volatile Organics from painting and paint stripping processes. There are also a number of cleaners included in the waste water which chelates the metals. This chelation process actually holds the metal ions in solution so the present Hill AFB treatment process cannot remove the heavy metals. At present no known alternative treatment processes exist.

At this time, the only way to treat the chelators is to use a very strong oxidizer such as sodium hypochlorite to break down the chelators. This process takes approx. 24 hours to accomplish. The IWTP does not have the retention capabilities to accomplish this task when the chelators are mixed with the process wastewater. Currently, the IWTP attempts to segregate these chelating solutions via 300 gallon carboys which are both labor intensive as well as costly for EPA tracking criteria.

The received wastewaters from these chelator processes require pre-treatment prior to introduction into the IWTP. This pre-treatment is costly and can be dangerous to personnel as strong oxidizers are required. If a customer releases a chelator into the IW collection system, the end result is that the IWTP cannot treat the wastewater and the regulated heavy metals flow through the process, untreated, and into the Publically Owned Treatment Works (POTW). This contamination will kill the required bacteria that the sewage plant (POTW) uses for their treatment process and will result in millions of gallons of raw sewage per day being sent into the waters of the rivers, streams, or lakes that the sewage plant discharges into. The cost of such cleanup will be enforced upon the Government along with a Notice of Violation (NOV) and severe fines and cleanup costs.

The IWTP needs a low cost, reliable chemical treatment process that will remove regulated metals in the presence of chelating agents for industrial waste water treatment facilities. This effort needs to research and develop an innovative treatment technology to remove heavy metals in the presence of chelating compounds such as:

a) Citrates
b) Carboxylic Acid
c) Phosphates
d) Amines
e) EDTA
f) Ammonium Nitrate
g) Sulfamates
h) Tartrates
i) Gluconate
j) Benzenesulfonic Acid

The development of the treatment process will require that the separation of the metals from the chelators take place in a timely fashion such that the storage capacity of the influent wastewater is not hindered. It is preferred that this technology be utilized in the continuous treatment flow.

PHASE I: This effort needs to research and develop an innovative treatment technology to remove heavy metals in the presence of chelating compounds in an industrial waste water stream.

PHASE II: Demonstration and validation of the leading candidates from Phase 1 must show that the effluent wastewater from the process meet or exceeds the discharge permit concentrations of regulated constituents.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Removal of regulated metals from industrial waste water going to industrial waste water treatment plants.
Commercial Application: Removal of regulated metals from industrial waste water going to industrial waste water treatment plants.

REFERENCES:
1. "Hill Air Force Base Industrial Discharge Permit Number 110", North Davis Sewer District, 4252 West 2200 South Syracuse, Utah 84041.

2. "Chlorine Treatment of Zinc-Nickel Electroplating Rinsewaters" Michael J. McFarland etal. Air & Waste Management Association 104th Annual Conference and Exhibition June 21-24, 2011 Orlando, FL.

3. L. Hartinger - Handbook of Effluent Treatment and Recycling for the Metal Finishing Industry – 2nd Edition (1994) Finishing Publications Ltd., ISBN 0-904477-14-2.

4. Treatment of Metal Waste Streams 2nd Edition (1993) California State University Ken Kerri - Operator Training Manual.

5. Industrial Water Pollution Control (1989) W. Eckenfelder – McGraw Hill, Inc. ISBN 0-07-018903-X.

KEYWORDS: Industrial Waste Water Treatment Plant, chelating agents, chelation

AF121-220 TITLE: Physiological testing for Hexavalent Chrome exposure in the human body

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The objective of topic is to quantifiably determine the workplace exposure of the human body to Hexavalent Chrome using physiological (biomarkers) markers.

DESCRIPTION: At present there is a medical test that can determine the total amount of Chrome in the human body. There are no known physiological tests to determine the exposure of the human body to hexavalent Chrome (Cr+6). Hexavalent chrome is a human carcinogen and exposures are regulated by OSHA standard. This effort is to find biological markers for the human body that can indicate the exposure that the body has had to Cr+6. This test should be able to differentiate between Cr+6 and other valences of Cr.

The exposure routes for the Cr+6 include but may not be limited to inhalation of dust or paint over spray containing Cr+6, ingestion of particles containing Cr+6 and absorption of Cr+6 through the skin.

PHASE I: Determine the Physiological markers for exposure to Cr+6 and time frame between exposure and onset of markers. Characterize possible test methods to detect the physiological markers. Propose test methods that would be further evaluated in a Phase II.

PHASE II: Test, Demonstrate and Validate the proposed test methods for the physiological markers for Cr+6 exposure. Obtain acceptance of this testing from the NIH governing body.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Determination of exposure of personnel to Cr+6 and mitigation of exposure effects to personnel.
Commercial Application: Determination of exposure of individuals / industrial personnel to Cr+6 and mitigation of exposure effects to personnel.

REFERENCES:
1. 29 CFR 1910.1026 Hexavalent Chrome standard (OSHA).

2. AFMAN 48-155 OCCUPATIONAL AND ENVIRONMENTAL HEALTH EXPOSURE CONTROLS.

3. Standeven, AM; Wetterhahn, KE. (1989) Chromium(VI) toxicity: uptake, reduction, and DNA damage. J AM Coll Toxicol 8(7):1275-1283.

KEYWORDS: Hexavalent Chrome biological markers, hexavalent Chrome Physiological markers

AF121-222 TITLE: Hand Held Real Time Particulate Loading Sensor

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Low cost, durable, hand held apparatus with integrated climatic/environment sensors, determining Particulate Load/Size, Opacity of stationary and mobile sources, regulated by the Clean Air Act (CAA).

DESCRIPTION: DoD/Commercial facilities, are subject to environmental regulations. The most costly/difficult regulations to demonstrate compliance are air-related. Air sources are regulated under Title V (1990 Clean Air Act Amendments (CAAA) Ref 1). The most common being those that generate visible emissions followed closely by those regulated by the size of the particulate emitted, e.g. “No Emission over X microns, i.e. no more than 1 metric ton of PM 2.5/year”. The primary method for determining visible emissions (opacity) levels is via the US Environmental Protection Agency’s (EPA) Method 9 (Ref 2). There exists a need for Air Quality measurements of particulate size by volume of air. Due to the inherent cost of measuring particulate size, opacity (which does not measure particulate size) is used to screen sources for need, and “Best” Available Control Technology (BACT) or Maximum ACT (MACT) and is applied to the facility via a permit. Use permits control operations of all major equipment for any producer of visible emissions (including DoD). The factor determining the use of BACT vs MACT is knowing actual PM. If PM is unknown, MACT technology is required, otherwise BACT technology. The cost difference between BACT and MACT technology is hundreds of thousands of dollars.

This SBIR project seeks to develop and ultimately field test a low cost portable hand held apparatus that will determine PM load and size. By development of such a portable system, we will allow the technology user to fully characterize the visible emission, and implement cost effective solutions (BACT vs MACT). To maintain industrial throughput and compliance (which continues to become more challenging from the tightening of air quality indicator tolerances in non-attainment areas (Ref 1) like Davis/Weber Counties where Hill AFB is located) reductions in both the number of permitted sources as well as amounts of PM emitted are required. Indirect savings come in the form of increased productivity and the defensibility of visible emission characterization, as well as increased community awareness and transparency of military operations that effect the communities in which we all live. The government recognizes that: 1)technical feasibility of remotely sensing particulate matter is in question; 2) hand held requirement can compound the difficulty; 3)since regulatory acceptance of any resulting device is required prior to its use, a regulatory pathway, and approval are also significant risks.

The primary objective of the proposed visible emission particulate characterization technology will be to obtain high quality, real-time data that will support the regulatory reporting needs of Federal and State inspectors in the most cost effective manner. A second objective of the proposed integrated technology will be to evaluate and document the costs incurred in environmental compliance reporting due to delays associated with the current application of characterization technology. The final objective will be to assess and document the regulatory and economic advantages to United States Air Force (USAF) facilities in utilizing the advanced characterization technology within a portable data acquisition system.

PHASE I: Design a portable visible emission characterization system with the ability to determine and document PM load and particle size range of visible emission from fugitive PM sources.

PHASE II: Develop a prototype based on Phase I system design. Field demonstrate the visible emission particulate characterization tool to regulators & field operators under various climatic conditions with various types of regulated air sources. Evaluate the system architecture & security based on Air Force & DoD requirements. Illustrate economic advantages of increased characterization capability.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applicable to any Military, Government operation with maintenance or training related activities which invoke CAA Title V Compliance issues via visible emissions from opacity or fugitive dust.
Commercial Application: Applicable to any industrial entity with activities which invoke CAA Title V Compliance issues via visible emissions, manufacturing, cement, aggregate, development, agriculture, etc.

REFERENCES:
1. Reitze, A. W. (2001) Air Pollution Control Law: Compliance and Enforcement Environmental Law Institute Washington, D.C.

2. Federal Register (1971) "Method 9 – Visual Determination of the Opacity of Emissions from Stationary Sources" vol. 36 No. 247 December 23, 1971.

3. ASTM D 7520-09 Standard Test Method for Determining the Opacity of a Plum in the Outdoor Ambient Atmosphere.

KEYWORDS: Particulate, PM10, PM2.5, Sensors, Dust, Emissions

AF121-224 TITLE: Common Global Information Grid Interface for Electronic Warfare systems

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Create an interface that allows EW (Electronic Warfare) systems to share information on the GIG (Global Information Grid)

DESCRIPTION: Timely access to information is critical in warfare and having the right intelligence at the right time is extremely important to the outcome of an engagement. The Department of Defense (DoD) GIG was created to address this issue. One goal of the GIG is to allow all DoD electronic systems to share information seamlessly, providing warfighers the needed intelligence to execute their mission. A very important information subset is electronic signals. Electronic warfare systems that monitor and jam these signals will be an extremely important contributor to the GIG. A system-to-system interface is needed to fully take advantage of the information collected and to share the data with all authorized GIG users.

The effort should identify and develop novel and innovative interface architecture approaches allowing for reconfigurable and extensible interfaces over the widest possible classes of EW systems. If possible, this concept interface should have the capacity to be easily modified to work between any type of RF system and computer network.

PHASE I: Research and identify or develop novel and innovative concepts to meet the interface need. Based on the concept identified, develop a concept demonstration for assessing the program's feasibility for Phase II.

PHASE II: Further develop the concept, create and demonstrate a prototype of the interface capable of processing the information generated by an Air Force weapon system and operational mission scenario. The Air Force will provide the contractor the scenario and required data in order to demonstrate the prototype.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The interface hardware, software, and protocols may be applicable to other data inputs to the GIG.
Commercial Application: This could potentially be applied to the FAA and other types of transport industry where data from many sources must be shared to ensure safe operation.

REFERENCES:
1. DoD Directive 8000.01: "Management of the Department of Defense Information Enterprise" 10 Feb 2009, http://www.dtic.mil/whs/directives/corres/pdf/800001p.pdf

2. DoD Directive 8320.02: "Data Sharing in a Net-Centric Department of Defense" 23 Apr 2007, http://www.dtic.mil/whs/directives/corres/pdf/832002p.pdf

KEYWORDS: Wireless communications, electronic warfare, secure communication, battlefield management

AF121-225 TITLE: Just In Time (JIT) Aircraft Maintenance System

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

OBJECTIVE: Create a novel Just-In-Time (JIT) aircraft maintenance system to enhance existing aircraft maintenance capability.

DESCRIPTION: The Air Force's High Velocity Maintenance (HVM) initiative aims to better emulate industry's high daily rate of touch-labor maintenance and rapid return-to-service. The Warner Robins ALC selected the C-130 aircraft for it HVM Pilot Program due to the urgent need to improve this aircraft's availability. One barrier to HVM is scheduling of the maintenance. Currently, once an aircraft arrives at the depot, it spends time in the maintenance queue waiting for the problem to be identified. Identification of the maintenance issue requires a crew debrief and manually downloading on-board fault identification data. Once the faulty subsystem is identified the aircraft can then be routed to the appropriate repair station.

We seek a novel and innovative solution to use the C-130's on-board diagnostic functions to automatically collect and download the information needed to determine the required maintenance actions without a crew debrief. This information should be transmitted to the depot prior to aircraft arrival so the priority and sequence of maintenance actions can begin immediately upon aircraft arrival.

This just-in-time aircraft maintenance system should automatically collect, store, manage, and intelligently exploit the health status and maintenance records of the aircraft in a timely manner for the benefit of the aircraft maintenance personnel. The end result shall be to reduce the time to accomplish the necessary maintenance on the aircraft, thereby improving mission readiness. In general, the system shall analyze the current and historical data to determine and report aircraft health status, failures, and recommended maintenance actions. The system shall strive to improve its recommendations over time by exploiting additional maintenance data and learning "cause and effect" relationships. The system shall take advantage of new and existing computing and software technologies, e.g., Aircraft Maintenance Intuitive Troubleshooting (AMIT), see reference below, to minimize impact to the aircraft and maintenance process in terms of space, power, and weight. The system will ideally integrate seamlessly with existing maintenance processes and systems.

Initially, this may not be a whole aircraft solution, therefore an open architecture should be employed for the interface between the aircraft subsystems and the ground based databases. One possible initial application is the aircraft electrical subsystem failures. Currently, intermediate and flight-line maintenance personnel do not always have the benefit of the detailed health status and maintenance history of the aircraft at the time aircraft maintenance

is performed. For example, the results of computerized built-in-test functions are stored within the electrical subsystems and mission computers on the aircraft, but are not readily available to benefit the maintenance personnel. Also, the historical health status and maintenance records may not be fully utilized by maintenance personnel due to (a) the amount of information (either too little or too much), (b) the inaccessibility of the records, and (c) the lack of available time to access and digest the information. Typically, aircraft maintenance is dependent on a post-flight written and/or verbal debrief provided by the pilot(s). All too often, the maintenance personnel do not benefit from all of the existing aircraft health status and maintenance information.
Note that the Air National Guard and the U.S. Army have taken action in the past few years to apply wireless network technology to implement solutions that improve the performance of flight line maintenance. Refer to the references below. These are examples of good (although less comprehensive) solutions that address some of the problems described above and support the feasibility of pursuing the object of this research topic.

PHASE I: Research best concepts in both the commercial and military arenas to meet the program objectives. Based on the research performed, develop a concept demonstration for assessing the program's feasibility in Phase II.

PHASE II: Develop the detailed design and a prototype of the offer's proposed JIT aircraft maintenance system. The offeror shall demonstrate the prototype system using viable cases that clearly validate that the system will improve the performance of the aircraft maintenance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Develop production version(s) of the JIT aircraft maintenance system for integration into one or more US military aircraft and associated maintenance processes.
Commercial Application: Explore applications of the JIT aircraft maintenance system for commercial aircraft.

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KEYWORDS: Aircraft maintenance, fault isolation, mission readiness, maintenance history, just-in-time maintenance

AF121-226 TITLE: Next Generation Aircraft Simulation Technology

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop concepts and methodologies to provide high fidelity aircraft simulations using mobile devices (such as smart phones, tablets, ultra-mobile PC, notebooks, subnotebooks, or laptops) for use in trainers.

DESCRIPTION: We need a mobile aircraft simulation system that is not confined to a traditional classroom. A common design limitation of high fidelity aircraft simulations is tightly coupled hardware and software components. Many research projects have addressed the software issues through techniques like design patterns, object-oriented software, and parallel programming. However, the hardware platforms hosting the software continue to be monolithic, high-powered workstations that are confined to a single location. This approach limits availability in real world locations such as the flight line or forward operating bases and makes it difficult to quickly and inexpensively incorporate new hardware technologies.

The rapid advancements of the commercial mobile devices make it feasible to support complex aircraft simulations in a distributed computing environment. These mobile devices can use secure and encrypted network connectivity through a variety of COTS technologies. These new technologies can be exploited to move aerospace training from the classroom to the field by connecting distant resources and subject matter experts directly to deployed trainee.

We seek novel and innovative concepts applying mobile devices to open architecture aircraft simulations. The concept should be scalable and support plug-and-play type connectivity. The goal is to implement a high fidelity aircraft simulation suitable for conducting training. Ideally, to obtain the software support goal, the system should support an instruction set simulation for the target processor (for execution of OFP binary load files) as well as simulations for Line Replaceable Units (LRUs) and environmental stimuli. For the prototype system, the instruction set should model the Motorola PowerPC. The system must be scalable (in both hardware and software technologies) to adequately support multiple LRU simulations such as virtual control/display units, heads-up displays, and cockpit control panels. The system should support mixed network technologies with a minimum requirement of using Ethernet and 3G connectivity. The system comprised of multiple devices that may connect and disconnect throughout a session so a robust plug-and-play technology needs to be developed to support this dynamic network. This research effort will also result in the identification of weaknesses in the current mobile device technology to support high fidelity aircraft simulations which can be used to define future requirements for supporting distributed aircraft simulations.

PHASE I: Develop simulation concepts to demonstrate the feasibility of a distributed aircraft simulation using mobile devices and limited use of standard personal computers. The effort should clearly address concepts for detailed architecture(s) for extensible plug-and-play interfaces. The prototype system should support real-time performance requirements of the OFP. The government will provide the OFP binary load files for the Motorola PowerPC instruction simulation. The overall concept should accurately simulate the actual aircraft systems and support a high fidelity simulation of the aircraft flight dynamics necessary to satisfy training requirements.

PHASE II: Further define the concept and develop/demonstrate a prototype system based on the Phase I concept. The prototype system must demonstrate the following capabilities at a minimum:

- Generation of virtual aircraft displays
- Interaction via mobile device input methods (such as stylus, touch screen, keyboard)
- Connectivity with distributed training environment (Ethernet and 3G)
- View training documents and technical orders stored on remote servers
- Communication with instructor and other students (text messaging/email/website access)
- Execution of the OFP by instruction set simulator

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities to integrate the hardware, software, and protocols of the developed plug-and-play approach into aircraft simulations.
Commercial Application: Commercial benefits include improved competitive opportunities for more providers of aircraft simulations, consistent with the open systems architecture and possible application to the interactive entertainment industry.

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2. Laminar Research, “X-Plane Mobile” , http://www.x-plane.com/index_mobile.html

KEYWORDS: aircraft simulation, mobile devices, network connectivity, plug-and-play interface

AF121-227 TITLE: Common Operational Specific Emitter Identification (SEI) functionality for sustained Electronic Warfare (EW) systems

TECHNOLOGY AREAS: Sensors, Electronics

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Research, develop, and evaluate algorithms and techniques to provide Common Operational Specific Emitter Identification (SEI) functionality for sustained Electronic Warfare (EW) systems.

DESCRIPTION: Automatic emitter recognition is one of the most difficult tasks in radar signal analysis. Modern Electronic Support Measures/Electronics Intelligence (ESM/ELINT) systems employ classical signal identification techniques such as frequency, amplitude, pulse width, and pulse repetition rate. This limits the type of threats they can recognize especially if the enemy is using similar emitter technology. This creates chaotic battlefield situations since the operator cannot accurately identify the treat and therefore, will have only limited situational awareness and in some cases ambiguous/inaccurate information. This limitation is potentially life threatening in battlefield environments populated with mobile threat systems.

The Air Force is seeking novel and innovative ways to move beyond signal identification using classical techniques. One possible method of the radar identification with very high precision reorganization is SEI. SEI has great promise since it focuses on finding non-intentional modulations in the receiving signals and analyze the radar pulses and characterize those by extracting features that should be different for each emitter. The SEI technology insertion removes the element of uncertainty by eliminating the ambiguities and provides enhanced survivability.

PHASE I: Research best concepts to resolve the ambiguities related to specific threat identification. Based on these results, develop a concept demonstration for assessing the feasibility of implementing SEI technology into current EW systems.

PHASE II: Develop and demonstrate a prototype of an SEI enhanced EW system to specifically identify and differentiate between multiple “same beam – same mode” threat systems in a laboratory environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Enhanced spectrum management, situational awareness, threat warning and self-protection against radar-guided airborne and ground-based threats.
Commercial Application: Cognitive radio:
1. Electronic Countermeasures (ECM) systems
2. Electronic Support Measures/Electronics Intelligence (ESM/ELINT) systems
3. Radar Warning Receiver (RWR) systems

REFERENCES:
1. Kenneth I. Talbot, Paul R. Duley, and Martin H. Hyatt, “Specific Emitter Identification and Verification,” Technology Review Journal, Spring/Summer 2003.

2. J. Matuszewski, “Specific Emitter Identification,” Radar Symposium, 2008 International, 21-23 May 2008.

3. L.E. Langley, “Specific Emitter Identification (SEI) and classical parameter fusion technology,” Wescon/’93. Conference Record, 28-30 Sep 1993.

KEYWORDS: SEI, EW, Electromagnetic Spectrum, Machine Learning, Signal Analysis, Signal Processing

AF121C-123 TITLE: Transparency Sensor System (TSS)

TECHNOLOGY AREAS: Air Platform, Sensors

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop a broadband, noncontact radio frequency (RF)-based Nondestructive Evaluation (NDE) system for aircraft transparency systems to verify electrical performance and accurately characterize defects throughout the lifecycle of the aircraft.

DESCRIPTION: Aircraft transparency systems (canopies, windows, etc.) incorporate shielding layers that require inspection during manufacturing and throughout the life of the aircraft to ensure proper electrical performance is achieved and maintained. Current manufacturing inspections are conducted manually, are very time consuming, and do not cover 100% of the transparency surface. Once transparencies are fielded, they are subject to damage as a result of bird strikes, weather events, precipitation, static discharge, environmental exposure, and even routine maintenance activities. When transparency damages compromise the shielding layers, the damage must be characterized electrically to assess the impact to system performance and determine the proper course of action. Depending on the system impact, the transparency may be removed and replaced or repaired. Currently, a field inspection capability to assess transparency performance throughout its life and accurately characterize defects, damages, and repairs does not exist. This results in unknown transparency performance and increases removal and replacement rates, increasing program cost and maintenance.

This program will develop a broadband, noncontact RF-based NDE TSS to assess transparency electrical performance and accurately characterize defects, damages, and shielding layer repairs. The goal of the program is to develop a common TSS for manufacturing, depot, and field applications to the maximum extent possible; however, it is understood that multiple sensor set ups may be required. The NDE TSS must be portable, require minimal setup time, and be capable of inspecting 100% of the transparency surface, providing a quick means of performance verification. For depot and field applications, the NDE TSS should be capable of performing inspections of transparencies both while installed on the aircraft and off the aircraft. Reductions in transparency inspection time lines will reduce manufacturing span time and rework, reduce Direct Maintenance Man-Hours per Flight Hours (DMMH/FH), eliminate current capability gaps with field inspection of transparencies, and increase confidence in assessing transparency performance. It is recommended that potential vendors have the ability to handle, store, and conduct classified work or have the capability of receiving such approvals. Teaming with aircraft or transparency Original Equipment Manufacturer (OEM) is encouraged.

PHASE I: Develop NDE TSS concept based on requirements established above for manufacturing, depot, and field applications. Demonstrate feasibility of the inspection technique on representative transparency systems, and design methodology of the TSS concept.

PHASE II: Using the Phase I results, design, fabricate, and demonstrate a prototype NDE TSS on representative aircraft transparencies in both manufacturing and field environments. Develop a control system to automatically determine RF compliance and accurately characterize defects and damages. Deliver prototype TSS system, manuals, and all software/hardware for further testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Any weapons systems with a similar transparency system would benefit from the reduced DMMH/FH and increased confidence in the shielding properties as a result of utilizing a TSS.

Commercial Application: The TSS would have broad commercial applications. An RF-based TSS could be utilized to evaluate transparency systems with electromagnetic interference shielding requirements in the commercial aerospace industry.

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1. Michel Mardiguian, EMI Troubleshooting Techniques, McGraw-Hill, 1999.

2. L.F. Chen et al., Microwave Electronics: Measurement and Materials Characterization, Wiley, 2004.

3. Xingcun Colin Tong, Advanced Materials and Design for Electromagnetic Interference Shielding, CRC Press, Boca Raton FL, 2009.

KEYWORDS: advanced sensors, aircraft maintainability, electromagnetic material sensor, nondestructive evaluation (NDE), NDE, radio frequency (RF) material sensors, RF, transparency sensor system (TSS), TSS

AF121C-125 TITLE: Inlet and Exhaust Damage Registration Sensor

TECHNOLOGY AREAS: Air Platform

Technology related to this topic is restricted under the International Traffic in Arms Regulation (ITAR) (DFARS 252.204-7009). As such, export-controlled data restrictions apply. Offerors must disclose any proposed use of foreign citizens, including country of origin, type of visa/work permit held, and the Statement of Work (SOW) tasks to be performed. In addition, this acquisition involves technology with military or space application. Therefore, only U.S. contractors registered and certified with the Defense Logistics Services Center (DLSC), Federal Center, Battle Creek MI 49017-3084, (800) 352-3572, are eligible for award. If selected, the firm must submit a copy of an approved DD Form 2345, Militarily Critical Technical Data Agreement.

OBJECTIVE: Develop an engine inlet and exhaust cavity damage identification and registration system to reduce inspection time and improve defect and damage registration accuracy.

DESCRIPTION: The US Air Force is continuously challenged with developing capabilities to assess damage quickly and effectively to aircraft received during routine training, combat, and maintenance activities. Demanding operational tempos require near real time assessment of the aircraft operational status. End-of-day and end-of-week inspections are utilized to log new damages and defects on the aircraft exterior surfaces and determine their impact to the operational status of the aircraft. To address these requirements, partially automated health assessment systems have been developed and integrated into daily maintenance routines. However, many inspections are still conducted manually, including inspecting engine inlet and exhaust cavities. Currently, non-structural coating defect or damage characteristics, location, and orientation information is collected using hand measurements taken relative to a structural feature such as a fastener, door, or panel. Typical defects of concern in inlet and exhaust systems include damaged coatings such as cracks, missing material, scratches/gouges, or other surface flaws and structural damage. The defects are then manually transferred to an automated damage assessment system, typically using Mylar to trace and transfer the defects and damages. To properly restore the aircraft to full operational status, existing aircraft maintenance systems require accurate defect/damage location, orientation, and characteristics to assess and assign maintenance tasks accurately. Manual inspection and transfer processes are time consuming, costly, difficult to execute in engine cavities, and are susceptible to inaccuracies.

This program will develop a simple, cost-effective automated inlet and exhaust coating damage registration system (software and hardware) that captures the defect/damage characteristics (width, length, shape, depth, etc.), location, and orientation electronically relative to the aircraft coordinate system for transfer to existing aircraft maintenance health assessment systems. Desired defect/damage measurement tolerances are ±0.010 inches for length, width, and shape, ±0.001 inches for depth, ±0.1 inch for defect/damage centroid location, and ±0.5° orientation. The automated inlet and exhaust cavity damage registration system must be portable, quick and easy to set up and tear down, suitable for flight-line environment, and capable of rapidly inspecting new and emerging fighter aircraft inlet and exhaust. The goal of the automated damage registration system is to reduce inspection time and to improve accuracy

over the current baseline trace and transfer approach. Reductions in inspection time lines will benefit the US Air Force by reducing Direct Maintenance Man-Hours per Flight Hour (DMMH/FH), ultimately reducing the overall lifecycle maintenance costs. Teaming with aircraft Original Equipment Manufacturer (OEM) is encouraged.

PHASE I: Develop an automated engine inlet and exhaust damage identification and registration system based on requirements established above. Design, build, and demonstrate a bench-top system that proves feasibility of the inspection method by accurately capturing defect/damage characteristics, location, and orientation in an electronic format.

PHASE II: Using results from Phase I, fabricate a cost-effective prototype automated engine inlet and exhaust damage identification and registration system. Demonstrate the prototype system on representative aircraft components. Collect electronic data representing defect/damage characteristics, location, and orientation relative to the aircraft coordinate system that is compatible with current aircraft maintenance health assessment systems.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Any legacy or next generation fighter and bomber aircraft would benefit from the reduced DMMH/FH associated with an automated engine inlet and exhaust inspection system.
Commercial Application: An automated cavity inspection system could be utilized by private and commercial aerospace sectors to assess damage to internal structures accurately, which have limited access, allowing for a more effective, safer repair.

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1. Roman Louban, “Image Processing of Edge and Surface Defects: Theoretical Basis of Adaptive Algorithms with Numerous Practical Applications,” Springer Series in Materials Science, 1st Ed., ISBN-10: 3642006825, ISBN-13: 978-3642006821, Springer, 2009.

2. M.L. Smith, “Surface Inspection Techniques: Using the Integration of Innovative Machine Vision and Graphical Modeling Techniques,” Engineering Research Series, 1st Ed., Duncan Dowson Ed., ISBN-10: 1860582923, ISBN-13: 978-1860582929, Wiley, 2001.

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KEYWORDS: automated inspection, defect/damage identification, defect/damage registration, engine inlet and exhaust, nondestructive evaluation (NDE), NDE