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 am to 5:00 pm ET). For technical questions about the topics during the pre-solicitation period (26 April through 25 May 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 (26 May through 29 June 2011), 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/icle/Cle1.jsp?el. 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.aptac-us.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.

**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: 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).


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, 29 June 2011 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](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. In this regard, the SBIR/STTR site: (a) SBIR Success Stories written by the Air Force; and (b) Phase I and Phase II summary reports that are written and submitted by SBIR companies. Since summary reports are intended for public viewing via the Internet, they should not contain classified, sensitive, or proprietary information. Submission of a Phase I Final Summary Report is a mandatory requirement for any company awarded a Phase I contract in response to this solicitation.

AIR FORCE PROPOSAL EVALUATIONS

Evaluation of the primary research effort and the proposal will be based on the scientific review criteria factors (i.e., technical merit, principal investigator (and team), and Commercialization Plan). Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror. The 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](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.afsbirsttr.com](http://www.afsbirsttr.com)). The Small Business Area ([http://www.afsbirsttr.com/Firm/login.aspx](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 email 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 debriefing should be mailed to AFRL/XPP (SBIR), 1864 4th Street, Room 225, Wright-Patterson AFB OH, 45433-7130. Requests for debriefing should include the company name and the telephone number/email 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). 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](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
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.

PHASE I SUMMARY REPORTS

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

NOTE: Summary reports containing Intelligence, Surveillance and Reconnaissance (ISR) information will not be posted on the AF SBIR/STTR site.

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 AF112C-117

These special instructions apply only to topic AF112C-117, “Advanced Non-Contact Inspection for Rapid Measurement of Machined Structures”, 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 Phase I of this effort is to demonstrate the feasibility of developing, integrating and transitioning innovative manufacturing process technologies to support the production of DoD weapon system(s). For this effort, Phase I objective are to define the requirements necessary to establish an initial production capability to rapidly measure & evaluate large tools, parts, and assemblies to close tolerance engineering requirements utilizing a non-contact method (MRL 4 by Phase I completion). In addition to demonstrating the proposed technology solution, successful offerors should also consider the technical, business and transition plans necessary to lower the risk of technology insertion into the integration processes of a DoD weapon system.

The Air Force plans on awarding two Phase I contracts on this topic. Each Phase I contract will be limited to $150K. Phase I contract awards will be executed at a normal pace, a 9-month effort, with six months planned for the technical effort and an additional three months allowed for reporting. The Phase I
effort will identify and demonstrate the measurement technique and provide a plan for the overall system concept and architecture.

As this effort is focused on AF weapon system production, successful offerors may find it useful to dialog and/or partner with an AF/DoD prime in order to understand their specific system requirements, implementation risks and transition windows. Successful offerors may also benefit from consideration of technical as well as manufacturing readiness levels when preparing responses to the Manufacturing Critical SBIR.

The primary focus of Phase II is to develop and implement to MRL7 maturity, the non-contact inspection system defined under the Phase I effort. The Air Force plans on awarding one Phase II effort worth up to $4M. Examples of the additional information needed in the Phase II proposal package include the following: innovative technical approaches to address the critical processes and associated return on investment (ROI) and potential related uses. Also, it is expected that the Phase II proposal will include both a business plan and a transition plan. Phase II proposals will be by invitation only. For the Phase II proposals, contractors may work in a prime/subcontractor relationship or as partners. At that time, special instructions will be provided for the Phase II proposals.

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**SPECIAL INSTRUCTIONS for Topic AF112C-176**

These special instructions apply only to Air Force Topic AF112C-176, "High Temperature Electro-Magnetic Actuators", and are in addition to the regular instructions listed at the beginning of the AF section of the solicitation.

The Air Force plans to award no less than three Phase I awards on this topic. Each Phase I award will be limited to $150K each (total cost of $450K for all Phase I efforts). These Phase I awards will be nine-month efforts with six months planned for the technical effort and an additional three months allowed for reporting. The Phase I effort will Develop high temperature Electro-magnetic Actuators and develop a conceptual design to provide a plan for the overall system concept and architecture. Contractors should plan and cost a trip to WPAFB at about 6 months to present accomplishments to the government team.

The Air Force plans on awarding two Phase II efforts worth $2.0M each (total cost of $4.0M) with a period of performance of 24 months. The Phase II effort will demonstrate the capability of a prototype with a prototype system demonstrated in a turbine engine representative environment. Collaborative efforts are strongly encouraged with actuator manufacturers to reduce the transition risk of critical component technologies. Examples of additional issues to be addressed during the Phase II effort include: technical approach to address critical processes, lifing, estimated life-cycle cost, maintenance, weight, and size. Also, it is expected that the Phase II proposal will include both a business plan and a transition plan. Phase II proposals will be by invitation only. At that time, special instructions will be provided for the Phase II proposals.

The total cost of this project is estimated to be $4.95M.
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<th>Activity</th>
<th>Program Manager</th>
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<td>AF112-001 thru AF112-010</td>
<td>Air Vehicles Directorate AFRL / RB 2130 Eighth Street Wright-Patterson AFB OH 45433</td>
<td>Larry Byram (937) 904-8169</td>
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<td>AF112-011 thru AF112-014</td>
<td>Directed Energy Directorate AFRL/RD 3550 Aberdeen Ave SE Kirtland AFB NM 87117-5776</td>
<td>Ardeth Walker (505) 846-4418</td>
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<td>AF112-017 thru AF112-026</td>
<td>Human Performance Wing AFRL/RH 2610 Seventh, St, Bldg 441 Wright-Patterson AFB OH 45433</td>
<td>Sabrina Davis (937) 255-3737</td>
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<td>AF112-029 thru AF112-043</td>
<td>Information Directorate AFRL/RI 26 Electronic Parkway Rome NY 13441-4514</td>
<td>Janis Norelli (315) 330-3311</td>
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<td>AF112-046 thru AF112-093</td>
<td>Space Vehicles Directorate AFRL/RV 3550 Aberdeen Ave SE Kirtland AFB, NM 87117-5776</td>
<td>Danielle Lythgoe (505) 853-7947</td>
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<td>AF112-094 thru AF112-109</td>
<td>Munitions Directorate AFRL/RW 101 West Eglin Blvd. Suite 143 Eglin AFB, FL 32542-6810</td>
<td>Shirley Schmieder (850) 882-3362</td>
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<td>AF112-110 thru AF112-130</td>
<td>Materials &amp; Mfg. Directorate AFRL / RX 2977 Hobson Way, Rm 406 Wright-Patterson AFB OH 45433 Edwards AFB, CA 93524-7033</td>
<td>Debbie Shaw (937) 255-4839</td>
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<td>AF112-132 thru AF112-163</td>
<td>Sensors Directorate AFRL/RY 2241 Avionics Circle, Rm N2524 Wright-Patterson AFB, OH 45433</td>
<td>Claudia Duncan (937) 528-8510 Julie Harris (937) 528-8515</td>
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<td>AF112-165 thru AF112-184</td>
<td>Propulsion Directorate AFRL/RZ</td>
<td>Mary Kruskamp (937) 904-8608</td>
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AF112-177 thru AF112-181
1950 Fifth Street
Wright-Patterson AFB OH 45433
Barb Scenters
(937) 255-9255

AF112-182 thru AF112-186
Propulsion Directorate West
AFRL/RZO
5 Pollux Drive
Edwards AFB, CA 93524-7033
Debbie Spotts
(662) 275-5930

AF112-187 thru AF112-189
Arnold Engineering Development Center
AEDC/TTSY
1099 Schriever Ave Arnold AFB, TN 37389-9011
Dhruti Upender
(931) 454-7801

AF112-193 thru AF112-195
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

AF112-199, AF112-201
46 TW/XPXR
101 West D Avenue Bldg 1
Eglin AFB, FL 93524-6843
Ramsey Sallman
(850) 883-0537

AF112-205 thru AF112-206
Oklahoma City Air Logistics Center
OC-ALC / ENET
3001 Staff Drive, Suite 2AG70A
Tinker AFB, OK 73145-3040
Becky Medina
(405) 736-2158

AF112-212 thru AF112-214
Ogden Air Logistics Center
OO-ALC / LHH
6021 Gum Lane
Hill AFB, UT 84056-2721
John Jusko
(801) 586-2090

AF112-217 thru AF112-219
Warner Robins Air Logistics Center
WR-ALC / ENSN
450 Third Street, Bldg. 323
Robins AFB, GA 31098-1654
Frank Zahiri
(478) 327-4127
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| AF112-003 | Autonomous Landing Capability for Air-Launched Small RPA (Group 2 / 3) Technology (#2) |
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AF112-001 TITLE: Diagnostics and Health Management for Remotely Piloted Aircraft (RPA) Payloads

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors

OBJECTIVE: Develop and demonstrate a capability to determine the health and real-time capability of remotely piloted aircraft (RPA) sensor-based payloads for increased reliability and operational effectiveness.

DESCRIPTION: There have been many funded efforts over the last decade to develop prognostics diagnostic and health management tools for airplane subsystems. As a result, the means now exist to monitor the unavoidable degradation of a subsystem (engines, actuators, flight controls, etc.), know the real-time condition of critical components, and predict when the degradation will manifest itself as a fault on the platform such that maintenance will be necessary. The payoff of this capability is that maintenance can be planned and become proactive instead of reactive and routine time-based inspections can be eliminated so that only the platforms that reveal themselves as requiring maintenance actually receive it.

However, few if any efforts have been pursued to date to address the condition or degradation of the payload on a RPA/RPV which, it can be argued, are the most important elements on the platform; if the payload is not operating satisfactorily, then the mission cannot be completed or is not worth launching. Typically, RPA payloads are sophisticated sensor suites which differ from normal platform subsystems in that their performance can degrade through their own deterioration usually as a function of age and from external sources such as EMI and jamming. It is thus important for a mission commander, to know whether an adverse performance from a sensor suite is because of external influences or self induced. The mission commander also needs to know whether permanent damage has been inflicted on the vital payload system or merely temporarily degraded so that decisions can be made on pulling the asset back to base and replacing it or leaving it on-station and restoring whatever capability can be salvaged on the fly.

PHASE I: Identify ways and means to determine sources of degradation using output data from the sensor suite and any other available information. Identify tools and methodologies to provide commanders with accurate diagnosis and prognosis of sensor suite health & as much as possible done remotely to restore system health.

PHASE II: Develop & demo capability to monitor real time health of a sensor suite that can distinguish between externally induced degradation such as jamming or normal degradation because of system age or internal faults. A hypothetical but representative sensor suite can be used in place of an actual platform suite and typical data can be synthesized as opposed to real data from an actual system.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The military applications for the proposed technology includes remotely piloted aircraft, autonomous systems, automatic decision-making, and sustainment.

Commercial Application: Sensor payloads are critical to other non military agencies such as Homeland Security border patrol, drug reinforcement agencies, and even land based security monitoring devices.

REFERENCES:


3. (Removed from solicitation – 6/14/2011)

5. (Removed from solicitation – 6/14/2011)

6. (Removed from solicitation – 6/14/2011)


KEYWORDS: remotely piloted aircraft, unmanned vehicle, reasoning architecture, sensor degradation, prognostics and health management, sensor reliability, situational awareness, battlefield awareness, condition-based maintenance

AF112-002 TITLE: Aerial Distribution of Taggants

TECHNOLOGY AREAS: Air Platform

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

OBJECTIVE: Develop and demonstrate innovative methods to unobtrusively distribute taggants onto moving targets for tracking, locating, and identification purposes.

DESCRIPTION: Taggants are very small devices that emit an electro-magnetic signal. They can be applied to targets of interest and used to track/locate them in tactical situations. These targets of interest could be vehicles or personnel, which could be moving or stationary. To effectively “tag” the target, the taggant must be administered “unobtrusively,” meaning that the target should not be cognizant that taggants have been applied to them. Obviously, this application is more easily accomplished by some sort of ground agent, but it is desirous to be able to distribute taggants aerially via a small remotely piloted aircraft (SRPA). This is not as an easy task when factoring unobtrusiveness. The easiest, but obtrusive, means of delivery would be for the SRPA to “divebomb” the target or “shoot a paintball” at the target. The target would obviously notice a swooping SRPA and likely feel the sting of the well-placed pellet.

The key to “unobtrusiveness” for aerial application is the ability to deliver a “cloud” of taggants on the target’s location or directly in its path. In order to do this the taggants must be dust-like and have the ability to attach to the target. One method of distribution would be “crop-dusting” from a sufficiently high altitude (to avoid detection) and letting the dust-cloud fall on the target or in front of it if it is moving. This method would likely utilize a large amount of taggant to assure probability of successful tagging, although it might be useful when tagging a group of targets.

The next method would be to deliver a small munition close by and pneumatically blow a cloud of taggants on or in front of the target. The munition could potentially air burst above the application zone or emplace itself near the application zone and be proximity or command-detontated. These methods are given as examples; other innovative methods are also sought.
PHASE I: Design a feasible concept mechanism for unobtrusive aerial taggant distribution as described above. The feasibility of the concept capability must be validated by means of analysis and/or simulation.

PHASE II: Refine the Phase I results to develop the mechanism into a feasible configuration/prototype that can be employed by a SRPA. This phase must demonstrate the prototype’s capability to distribute taggants.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Counter-insurgency and global war on terror (GWOT), marking civilians to prevent collateral damage, marking coalition forces without Blue Force Tracker.
Commercial Application: Law enforcement and Homeland Security, wildlife tracking, remote or toxic chemical spill mapping.

REFERENCES:

KEYWORDS: tagging, tracking, locating; aerial distribution, small remotely piloted aircraft

AF112-003 TITLE: Autonomous Landing Capability for Air-Launched Small RPA (Group 2 / 3) Technology (#2)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an automated landing/guidance system that enables small unmanned aircraft systems (SUAS) to be ground-recovered covertly.

DESCRIPTION: SUAS present a wide array of challenges, which includes safe ground recovery of the asset so it can be reused. This ground recovery is likely to be accomplished in contested territory where covertness is key to the recovery team’s survival. This problem is compounded by the limited payload capability of these small UAS to include specific landing guidance equipment, so innovative solutions are sought to minimize the airborne hardware while also not overburdening the recovery team with excessive equipment. An ideal solution would leverage existing equipment from both SUAS and recovery team.

The Government seeks an innovative solution system capable of safely recovering the SUAS while operating in a global positioning system (GPS) denied environment. In order remain covert, the recovery of the aircraft has to be accomplished without radio frequency (RF) emission. As such, the on-board components of the system may not actively radio information to the ground operator, thus maintaining the covert nature of the landing. The autonomous landing capability shall not compromise the aircraft or the landing area. The system must be capable of landing multiple UAVs in proximity to one another within the landing area. While RF solutions are not feasible, optical solutions may be viable. Laser beam riding or infrared strobe seeking are potential solutions, but other innovative techniques are sought.

PHASE I: Develop innovative solution concept with analytical validation and demonstration of key technology in a laboratory environment. Analytical feasibility of system should be established through modeling and simulation and other risk reduction accomplished via the demonstration. Identify integration necessary with the existing SUAS autopilot system.
PHASE II: Develop a prototype covert auto-landing/guidance system as outlined in the objective above to be installed on a government-provided SUAS. Test and validate the proposed system’s software and hardware components and demonstrate its capability. If a government test bed platform is not feasible then a suitable contractor-provided surrogate should be proposed.

PHASE III DUEL USE COMMERCIALIZATION: Military Application: Air Force Special Operations Command (HQ AFSOC) has an interest in using this technology for potential operational use. Follow-on activities are expected to be aggressively pursued by the developer. The system will be demonstrated on a government test range using a government provided Group 2/3 asset or, if the government allows, a contractor surrogate.

Commercial Application: Potential commercialization opportunities could exist with the Department of Homeland Security e.g. border control, the Department of Justice e.g. law enforcement, or the traffic reporting industry.

References:
1. Defense Technology Area Plan for 2005; DoD Key Technology Areas (#1, #7); AFSOC/A5ZU Key Technology Areas – Autonomous Navigation without GPS.

KEYWORDS: SUAS, Air Launched SUAS, Off-board Sensing, Covert Landing, Autonomous Landing

AF112-004

TITLE: Advanced Analysis and Design Tool for Scramjet Air-frame Propulsion Integration

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop robust, credible multifidelity computational tools for comprehensive simulation to aid scramjet flowpath development, analysis, and design.

DESCRIPTION: Recent flight tests (X-43 and X-51) have conclusively demonstrated the feasibility of scramjet propulsion. Ongoing ground and flight experiments (HIFiRE-2) are advancing knowledge of the main processes that currently inhibit routine, sustained hypersonic flight. For many reasons, airframe and propulsion components of scramjets must be designed in an integrated fashion. A principal challenge for successful, sustained supersonic combustion arises from the extremely short residence time in the combustor, compounded by the diminishing mixing rates at high speed, and the tendency for combustion to engender instabilities which can propagate upstream. Viable designs utilize the external part of the vehicle underbody as an external compression surface to augment the pressure increase. The need to reduce flowpath length, and thus weight of the vehicle, necessarily generates compression designs that engender non-isentropic processes, often accompanied by flow separation, vortex formation and unsteadiness. Thus, a main factor determining scramjet performance “inlet distortion and its effects on combustion” is poorly characterized, and lack of understanding of this phenomenon precludes the development of optimized inlet-combustor combinations and injection strategies.

Computational methods will play an enabling role in scramjet flowpath design and optimization. Various levels of simulation fidelity are in vogue, from simple quasi-1D modeling of a single component to 3D high order large eddy simulations (LES) with relatively small numerical dissipation fully coupled to finite rate chemical models of the entire configuration. The simpler methods invoke assumptions that significantly degrade accuracy and limit
conditions, but provide rapid turnaround. The more sophisticated methods are computationally expensive and typically suited for one-of-a-kind analyses and cannot usually be employed for optimization.

A multifidelity integrated suite of computational tools should be developed to analyze and aid the creation of advanced scramjet flowpaths. The tool set should accept the output from traditional engineering design to execute from a low order Reynolds Average Navier-Stokes (RANS) methodology up through today’s state-of-the-art high order (4th or higher) LES level analyses, solve thermal nonequilibrium mechanisms, accurate subgrids scale (SGS) models, consider conjugate heat transfer, general finite-rate chemistry with ease to modify data base for hydrocarbon/hydrogen-air mixtures, high temperature, and multiphase effects, etc. In this manner, the flow distortion associated with the inlet can be exploited to actually enhance combustion by proper placement of injectors, whose configuration can be varied to avoid flash back and lesser instabilities. A comprehensive variable-fidelity, robust and well validated tool with easy to use interfaces is needed to explore and optimize innovative flowpath paradigms. The reduced order models as well as higher-fidelity approaches must be validated on canonical configurations. This tool must evaluate high angles of attack, predict heating and turbulent transition, structure interactions (ablation), inlet operability limits and ignition process, separated/reverse flows, high altitude and Mach number effects on complex geometries to prove multifaceted concepts and suggest proper modifications. A multifidelity tool capable of incorporating these many and varied factors will greatly enhance our ability to pursue routine, sustained hypersonic flight.

PHASE I: Identify the most significant parameters for optimizing fully coupled forebody/inlet/combustor hypersonic flowpath, develop suitable analytical/numerical procedures and demonstrate it for different canonical test cases, and assess its accuracy and efficiency at several fidelity levels.

PHASE II: Develop a GUI-based tool that integrates the various levels of fidelity into a seamless iterative tool combining high fidelity to generate reduced models, employed to optimize key performance of an integrated system. Verify the optimal solutions by high-fidelity analyses. Validate experimental efforts to ensure they are viable, cost-effective, and capable of alternatives to innovative concepts.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The codes and methodologies developed will be broadly applicable, with modest alterations, to different high speed propulsion devices, including combined cycles and pulsed detonation engines.
Commercial Application: Multiple applications of combustors, including turbojet aircraft as well as burners and augmenters. The modeling tool will be able to predict processes and aid efficiency.

REFERENCES:

KEYWORDS: high-speed propulsion, Scramjets, CFD, combustion, instability, optimization, inlet distortion, high fidelity, LES.
The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop adaptive active actuators for enhanced boundary layer/free stream momentum exchange for control of unsteadiness and separation associated with shock-wave/turbulent boundary layer interactions.

DESCRIPTION: Shock-wave boundary layer interactions are key limiting phenomena in supersonic and hypersonic flight. The consequences of the rapid pressure rise due to the shock wave on the low enthalpy near-wall flow result in flow separation, vortical structure formation, enhanced peak heating loads, and unsteady loading. These effects influence the aerodynamic properties of the vehicle as well as the propulsion system. In particular, deflection surface control authority and component fatigue life is substantially degraded. Flow distortion and loss of total pressure in the propulsion flow path reduces inlet and combustor performance measures with increased drag and reduced thrust.

In recent years, advances in experimental and computational techniques have provided new insights into the main mechanisms of shock boundary layer interactions SBLI. In particular, the range of unsteady scales observed has been classified into relatively high- and low-frequency phenomena. This understanding opens a significant opportunity for control with unsteady actuators utilizing relatively low power to selectively influence boundary layer superstructures and global instabilities of separated regions. At the same time, advances in power and electronic component design sensors and signal processing have generated exciting new possibilities for flow control with basis in the dynamics of plasmas as well as synthetic jets, which have proven highly effective in the low-speed environment. This effort should develop and demonstrate versatile, controllable actuators, together with an activation strategy, to exert authority on shock boundary layer interactions ranging from nominally two-dimensional (2-D) cases such as oblique and normal shocks impinging on flat and cylindrical surfaces, as well as three-dimensional (3-D) cases such as oblique grazing shocks impinging on 2-D side walls.

PHASE I: Identify actuators with power and frequency range capable of enhancing momentum transfer to control SBLI in a broad Reynolds number range for Mach numbers from 2 to 5. Perform analysis of alternatives and preliminary experiments and simulations to validate approach and develop control strategy.

PHASE II: Develop actuator components together with power supply and frequency control devices. Demonstrate and document effectiveness quantitatively by measuring unsteadiness, boundary layer health, separation suppression and surface load mitigation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High-speed air vehicles, including supersonic aircraft, scramjet inlets and combustors.

Commercial Application: Air transports, short- and long-range airlines, supersonic business jets.

REFERENCES:


KEYWORDS: shock waves, turbulent boundary layers, control, unsteady actuators, separation
TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Design and test a Tier 2 sized long-endurance VTOL UAV. Show how the design can be scaled and identify critical size/weight/endurance limits. Design control algorithms for all flight regimes.

DESCRIPTION: Design and demonstrate a long-endurance vertical take-off and landing (VTOL) unmanned air vehicle (UAV). Show how the design can be scaled and identify critical size/weight/endurance limits. The nominal design should be on the order of 10 ft wingspan, 5 hour endurance, 70 lbs gross take-off weight, 70 mph cruise speed and be able to launch/land in a 3m radius cylinder 5m tall.

As UAVs and their sensors increase in capability, the need to deploy UAVs from a greater variety of venues also increases. The ability to launch and land in confined spaces allows the deployment of UAVs in critical areas such as from forward operating bases (FOB). Many UAV systems have rail launchers and require runways or complicated capture devices for recovery. In addition, a long obstacle-free landing approach is required when landing on a runway or into a capture device. When such an approach path is not possible (such as coming over a large fence into a small operating area), a vertical take-off and landing aircraft is necessary. Additionally, a VTOL aircraft lessens the logistic footprint by eliminating the need for launch and recovery equipment.

The purpose of this topic is to investigate the vehicle design and control strategies necessary to achieve a VTOL UAV where the hover capability is mainly used during launch and land, i.e. we seek design trade-offs that yield the capability of a fixed wing UAV (in terms of endurance and payload) while allowing for vertical take-off and landing. A design study of the proposed configuration comparing its performance to a conventional VTOL rotorcraft (i.e. helicopter) and non-VTOL fixed wing aircraft is desired. Candidate designs must offer significant range and duration capability beyond conventional helicopters and approach that of the best fixed wing UAVs currently available. Additionally, an analysis of overall endurance as a function of percentage hover duration would allow new mission extensions such as communication relay, stationary surveillance, and remote payload emplacement. Designs that do not use exposed rotors are desired. The vehicle must be able to operate safely with human operators in close proximity and exposed rotors are not considered safe enough in the event of contact with personnel on the ground.

In addition to the vehicle design and analysis, development and demonstration of the necessary control strategies for hover, level-flight, and transition regimes are necessary. A focus on robustness to uncertainty, especially with regard to wind, should yield a controller with known safe bounds for launch and recovery. The control strategies are targeted for completely autonomous flight, so the UAV must be able to land even in the presence of loss of communication. As the UAV is to launch and land in a small, possibly confined space, often near humans, safety and failure modes should be well characterized. Finally, a statement as to the acoustic impact of the proposed design should be included.


PHASE II: Verification of control design (theory, simulation, and demonstration). Prototype vehicle built and tested with accompanying analysis of safety, noise level, robustness to disturbances, failure modes, scalability, and endurance trade-offs.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Work with Tier 1/2/3 vendors to develop VTOL capability in system of record.

Commercial Application: Homeland security, hazardous material monitoring, crop inspection, search and rescue.
REFERENCES:

KEYWORDS: vertical-takeoff-and-landing, flight-control, tailsitter, aircraft-design

AF112-007 TITLE: Design Methods for Simultaneous Aerodynamic Shape, Structural Topology, Subsystem Topology, and Structural Sizing of Aerospace Vehicles

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and evaluate multi-disciplinary methods that can produce shape, structural/subsystem layout, structural sizing, and control surface configuration designs simultaneously.

DESCRIPTION: Innovative concepts are sought to bridge the gap between: (1) Conceptual design and (2) high-fidelity analysis and design. Air vehicle design is a complex process that involves several stages [1,2]. To begin the development of a new air vehicle, a set of complex requirements and objectives are put forward. Once the high level set of requirements are established, the conceptual design of potential configurations that meet those requirements are explored. In the conceptual phase, the vehicle and its performance are represented by a series of parametric equations, empirical relations, and or historical databases.

Once the conceptual design study is completed, several attributes of the vehicle are obtained. The configuration(s) resulting from the conceptual phase need to be analyzed and the design refined to satisfy vehicle requirements associated with strength, stiffness, buckling, cruise performance, maneuver performance, static aeroelastic stability, dynamic aeroelastic stability, and controllability. In order to perform the design refinement at the critical set of flight conditions, higher fidelity, coupled, and/or chained analyses are required. The design parameters at this stage of the process are aerodynamic parameters, structural sizing parameters, structural layout, subsystem layout. A common practice is to employ a parametric associative representation of the configuration to perform the analyses and the design refinement.

Currently, there is a deep chasm between these two stages of the design: Conceptual representation and a representation that is necessary for a higher fidelity analysis. As a consequence, the state of the art is extremely time consuming and hands-on intensive. The structural layout and subsystem layout is mostly based on years of experience and company standards and practices. As a result, the design process is slow, partitioned, biased, and ultimately non-optimal.

Develop and test an multidisciplinary design optimization (MDO) methods that can simultaneously develop aerodynamic shape, structural layout, subsystem layout and structural sizing while considering constraints related to strength, stiffness, buckling, cruise performance, maneuver performance, static aeroelastic stability, dynamic aeroelastic stability, and controllability requirements. The developed methods shall be able to efficiently accommodate both commercial-off-the-shelf (COTS) or in-house computer software that perform the response analyses for the evaluation of each separate requirement. The resulting methods shall be demonstrated on a representative air vehicle design.

PHASE I: Propose an architecture that is suitable for simultaneous aerodynamic shape, structural/subsystem layout topology, and structural sizing optimization. Demonstrate this architecture by performing structural topology/layout optimization while considering local panel buckling and static aeroelastic constraints on a representative air vehicle configuration.
PHASE II: Expand the Phase I development by including subsystem topology (location of mass & volumes), aerodynamic shape, structural sizing and the number, size, and location of the control effectors as design variables and extend the constraint set to include vehicle performance, and dynamic aeroelastic stability/performance within the design optimization process. Demonstrate the full Phase I & Phase II capability on a representative air vehicle configuration.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: The developed methodology will be applicable to the design and development of military aerospace vehicles producing lighter weight vehicles with improved performance.

Commercial Application: The developed methodology will be applicable to the design and development of commercial aerospace vehicles producing lighter weight vehicles with improved performance.

REFERENCES:

KEYWORDS: Multidisciplinary Design Optimization, air vehicle design, topology optimization

AF112-010 TITLE: Physics-Based Models for Transient Behavior of Two Phase Flow Cooling Systems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Development of physics-based component models that allow system level parametric sensitivity analysis and parameter iteration to be evaluated for two-phase flow cooling systems.

DESCRIPTION: Current AF aircraft use single phase open loop cooling systems that have reached their capacity to successfully cool upgraded avionics systems and subsystems. Platform upgrades such as improved avionics cooling for advanced radar, electronic warfare, signal processing, and communication system will be required over the vehicle lifetime for F-22, F-35, and other aircraft for strike/reconnaissance/SOF/defense missions. Advancements beyond the current state of the art are required due to thermal limitations that affect mission success. The ability to predict system level performance of vapor compression thermal cooling systems is required for transition from any existing open loop single phase cooling system. Development of physics based component and system models that allow system level parametric sensitivity analysis and parameter iteration to be evaluated for transient, non-steady state, Two Phase Flow Cooling Systems. Develop characterization and scaling methodologies for advanced cooling system design and corresponding modeling tool that incorporates these scaling methodologies. Minimum system design must include pumped loop design, with the desired end state capability to predict performance of vapor-compression thermal cooling systems. The ability to design successful two-phase cooling systems is dependent on the ability to model and predict the system performance and capacity for growth based on the physics of platform dynamics and material properties.

PHASE I: Development of physics based component models that allow parametric exploration of working fluid, cooling loop components, heat exchanger, pumps, reservoir, physical dimensions and materials of the components. Include unpressurized and pressurized effects on components.

PHASE II: Demonstrate a Two Phase, Non-Steady state cooling system model. Perform sensitivity analysis on parameters to optimize system level operation. Develop characterization and scaling methodologies for advanced cooling system design and corresponding modeling tool that incorporates these scaling methodologies. Predict performance of advanced cooling system.
PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Better design of active cooling systems for use on existing fighters, bombers, reconnaissance, SOF and future air vehicles.

Commercial Application: There are several commercial requirements for improved thermal management that could be met with this effort in aerospace and other markets, including modeling for heat sinks or heat exchangers for server farms and electronics cooling applications.

REFERENCES:

KEYWORDS: transient two-phase flow physics, two-phase turbulence modeling, instantaneous two-phase flow, transient nonsteady state two-phase flow cooling systems, two-phase fluid dynamics simulation, two-phased flow computational methods, thermal management of cooling loop systems, system level modeling for active two-phased cooling systems, vapor-compression thermal bus, Lagrangian particle trajectories, Lattice Boltzmann methods (LBM), Peng-Robinson (P-R), equation of state.

AF112-011 TITLE: Innovative Aero-Optics Research and Development

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Develop novel laser turret designs and/or flow control methods to compensate for the intensity losses suffered when a high energy laser is propagated through aircraft-induced optical turbulence.

DESCRIPTION: This topic is applicable to high energy laser system (HEL) concepts for future airborne offensive or defensive applications. Potential aircraft platforms of interest are the next-generation gunship (B-1 as platform for the Electric Laser on a Large Aircraft (ELLA)), the Joint Strike Fighter or future Long Range Strike bombers. High performance (HEL) aircraft must incorporate large fields of regard in order to enhance mission capability and to provide for greater missile self-defense coverage. Unfortunately, aircraft motion perturbs the refractive index field over a significant portion of the aft field of regard near the HEL exit aperture. As a result, the outgoing HEL laser beam undergoes extreme disturbances due to shock waves, turbulent shear layers and regions of separated flow. The net effect of the large, rapidly varying wave front aberrations imposed on the HEL beam is to degrade the on-axis intensity of the HEL at the target. Since aero-optical turbulence contains a significantly high frequency content, current state-of-the-art adaptive optics (AO) systems cannot adequately compensate for these effects. The purpose of this effort is to investigate and develop new laser turret designs or flow control technologies that would ameliorate the optical effects associated with these turbulent flow fields, making it possible to employ the current state-of-the-art AO components. Some approaches may seek to mitigate, reduce or shift the frequency spectrum of the turbulence flow itself while a turret design approach might seek to prevent or minimize the turbulence formation altogether.
PHASE I: Develop a preliminary design for a turret concept that would either prevent/minimize the formation of turbulent shear layers in the aft looking direction, propose novel flow control technologies that could alter an already established flow or a combination of the two technologies.

PHASE II: Fabricate model(s) for the proposed turret or flow control technology concept, arrange for optical testing and validate turbulence reduction in a scaled wind tunnel experiment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Includes the Airborne Laser, (ELLA), Laser Strike Fighter, High Energy Liquid Laser Area Defense System (HELLADS), Relay Mirror, unmanned aerial vehicles (UAVs) and aircraft surveillance systems.

Commercial Application: Includes applications with requirements for atmospheric compensation such as astronomy, laser communications, power beaming, etc.

REFERENCES:

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

AF112-012 TITLE: Model-Based Systems Engineering Tools for Laser Systems

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop innovative software technology to support model-based engineering (MBE) for end-to-end field laser propagation systems for the purpose of ranging, imaging, and other military applications. These systems inherently involve multiple scientific and engineering domains and complex cross-domain interactions, some of which cannot be adequately modeled using standard multiphysics techniques.

DESCRIPTION: MBE has been identified by the Office of the Director, Defense Science and Engineering as one of four potentially “game-changing” technologies that could bring about revolutionary advances across the entire DoD research and development and procurement cycle. To be effective, however, MBE requires robust underlying modeling and simulation technologies capable of modeling all the pertinent systems, subsystems, components, effects, and interactions at any level of fidelity that may be required in order to support crucial design decisions at any point in the system development lifecycle. Very often the greatest technical challenges are posed by systems involving interactions that cut across two or more distinct scientific or engineering domains; even in cases where there are excellent tools available for modeling each individual domain, generally none of these domain-specific tools can be used to model to the cross-domain interactions. Some kinds of cross-domain interactions can be well-modeled using now-standard multiphysics techniques. These techniques generally make it possible to combine multiple domain-specific models using finite element modeling (FEM) to approximately solve coupled sets of partial differential equations (PDEs) appropriate to those different domains. In some other cases, the interactions
within distinct domains can be decoupled in a straightforward manner simply because they act on very different timescales. However, there remain important classes of systems where cross-domain interactions cannot be adequately modeled using standard multiphysics techniques, and cannot be decoupled based on timescales. For example, consider an imaging system or a laser beam projection system employing adaptive optics to sense and compensate for the aberrating effects of turbulence along the propagation path. Such systems can involve closely coupled interactions among structures, optics, thermal effects, atmospherics, target interaction, and non-trivial digital control logic. Some, but not all, of the cross-domain interactions can be modeled using standard multiphysics techniques, and some effects which cannot be modeled using these techniques, e.g., propagation delays due to the finite speed of the light, can be crucial to making accurate performance predictions for such systems. What is needed, therefore, is an innovative modeling and simulation technology that can incorporate the capabilities already provided by the existing domain-specific modeling tools, but which can also be readily extended to model any and all cross-domain effects and interactions at any level of fidelity that may be required in order to make sufficiently accurate performance predictions to address crucial design decisions.

PHASE I: Develop innovative software technology to support MBE for end-to-end field laser propagation systems for the purpose of ranging, imaging, and other military applications. These systems inherently involve multiple scientific and engineering domains and complex cross-domain interactions, some of which cannot be adequately modeled using standard multiphysics techniques.

PHASE II: Transition the MBE environment from Phase I into a deliverable software tool with sufficient documentation and testing to be used by non-expert programmers. Apply the tool within the context of a real world development effort for a large-scale field laser propagation system.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Model-based systems engineering for field laser propagation systems and other large-scale systems requiring multidisciplinary, multifidelity modeling. Commercial Application: Model-based systems engineering for advanced optical systems and other large-scale systems requiring multidisciplinary, multifidelity modeling.

REFERENCES:


5. Additional information from TPOC -- A Discussion of the SBIR on Model-Based Engineering, posted 5/17/2011.

KEYWORDS: Model-Based Engineering, MBE, laser system, wave-optics model

AF112-013 TITLE: Acquisition, Pointing and Tracking Applied to Optical Phased Arrays

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop a novel beam control approach for optical phased array systems.

DESCRIPTION: Over the past 6 years, a basic understanding of optical phased array technologies has been developed. The goal would be to draw from this and develop a fuselage conformal system for small, high-speed air platforms. These platforms will require substantial improvements in size, weight and power (SWaP). In this case, the improved SWaP stems from the ability to digitally add low resolution sub-aperture images to form a high
resolution image based upon the full aperture and the advent of high power fiber lasers that conveniently lend themselves as an easily packaged, distributed laser source. These advances eliminate the need for beam combining and beam expansion optics for imaging and beam projection respectively. This dramatically reduces SWaP. Add to this approach low-non-mechanical beam steering such as Risley Prisms and one can potentially replace the turret with a fuselage conformal window to eliminate unwanted weight, volume and aerodynamic effects of the turret.

Specific beam control technology advancements include Heterodyne interferometry for imaging and wavefront sensing, several approaches to coherently combine the transmitted beam, approaches for low-non-mechanical beam steering and an initial system level concept. The Air Force is interested in leveraging these advancements to develop phased array beam control architectures for target acquisition, pointing and tracking (APT). This multi-input/multi-output beam control architecture is substantially different than a traditional monolithic control loop where the discontinuous pupil forces the tilt and phase commands to be collected in an unconventional manner. Solutions should consider atmospheric, target dynamics, sensor bandwidth limitations, 19 and 43 sub-apertures, latencies associated with digital calculations and time of flight requirements, signal-to-noise realities and target radiometry.

PHASE I: Model a complete beam control system using realistic plant, sensor, disturbance and actuator models. Demonstrate that the architecture adequately addresses the fundamental principles and hardware limitations of the selected approach.

PHASE II: Using the model developed in Phase I, develop control algorithms and validate through modeling the feasibility of a phased array beam control system that accommodates APT in realistic environments. When needed, small validation experiments should be used to reduce risk of model uncertainty.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: To serve missions such as Close Air Support and Integrated Air Defense Systems which require a high energy laser system on a small high speed air platform.
Commercial Application: High resolution active imaging using a synthetic aperture on a small dynamic air platform will translate to compact sensors on commercial satellites and air platforms for earth sensing applications.

REFERENCES:

KEYWORDS: phased array, synthetic aperture, heterodyne interferometry, conformal beam directors, laser systems, air platforms, electronic steering

AF112-014 TITLE: System Identification for Jitter Algorithms in Beam Control Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons
OBJECTIVE: Develop fast system identification of the plant model and disturbances for performing diagnostics, controller updates and advanced pointing, tracking control and jitter stabilization algorithms.

DESCRIPTION: The Air Force is exploring and developing several aircraft mounted high energy laser (HEL) systems for precision strike and self-defense missions. All HEL systems require fast, accurate pointing, tracking and precise stabilization of the laser beam to be effective. Some of the most advanced pointing and precise stabilization algorithms require an accurate model of the system plant which includes base motion and disturbances in the system. In an airborne system, these system characteristics can change drastically depending on the operational environment. Therefore, the estimated system model is always uncertain, because of these disturbances and the lack of an absolutely correct system model. System identification of the system plant model and its disturbances can help at many levels, for instance, performing diagnostics, controller updates and as well as applications on advanced pointing and tracking control algorithms. The ability to accurately perform system identification to get an accurate system model of the plant would be a key component in achieving our algorithms most optimal effectiveness. System identification is a method of developing mathematical models of a dynamic system based on a set of measured stimulus and response data. One can use system identification in a wide range of applications, including mechanical engineering, biology, physiology, meteorology, economics and model-based control design.

One of the model-based control design process which is utilized for precision pointing, tracking and jitter mitigation is a real time adaptive lattice filter technique called Predictive Feed Forward Controller (PFFC). This technique involves identifying a plant model and disturbances, analyzing and synthesizing a controller for the plant, simulating the closed-loop system and deploying the controller to real-time hardware. Therefore, this technique requires a very precise system model for it to perform optimally.

PHASE I: Develop a design of a system ID algorithm for performing diagnostics, controller updates, pointing, tracking and jitter mitigation algorithms. Concept design for addressing the system performance and architecture implications as applied to an advanced tracking control for jitter reduction algorithm.

PHASE II: The goal of Phase II is to complete the system ID algorithm design, then build and test an engineering development unit running the Predictive Feed Forward Controller. Develop preliminary design of a flight-qualifiable version of the system identification technique coupled with the Predictive Feed Forward Controller that can be field tested. Unit will be delivered to the government for testing.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Beam stabilization is required for a laser system to be effective. A system ID algorithm coupled with an advanced pointing and tracking algorithm for jitter reduction can achieving this effectiveness.

Commercial Application: Any feedback and control application which operates under conditions where the system plant and disturbance models are changing dynamically would benefit from this development.

REFERENCES:
AF112-017  TITLE: Curved Sensor for Vision Systems (CSVS)

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop curved focal plane array digital sensor for visible thru SWIR with pixel types varying from intensity-sensing in center to motion-sensing away from center, and integrate with simple optic.

DESCRIPTION: Sensors integration into small form-factor applications, such as helmet mounted systems (HMS) and small uninhibited air vehicles (UAV), has been inhibited by limitations in optics and focal plane array technologies. Limitations in microelectronics fabrication technology have forced the focal plane arrays (FPA), the element within the sensor that converts photons to electrical signals, to be rectilinear flat. The problem is compounded by the necessity to design and use a complex objective optic (expensive train of lens elements) to convert the curved field-of-view (FOV) (e.g. 40º solid cone) of optical flux that arrives at the sensor aperture to a flat field required at the FPA plane. Volume, weight, and expense of the objective optics often prevents the integration of sensors into applications where weight and space are critical. 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. The results of this recent research (see references) indicate that a curved sensor sensitive to visible (VIS 0.4-0.7 µm), near infrared (NIR, 0.7-0.9µm), and shortwave infrared (SWIR, 0.9-1.8 µm), or to all three in one sensor, is now possible with image resolutions 1280 by 1024 or higher. The CSVS sought in this topic would be suitable for integration into an HMS with threshold (objective) performance of 1280x1024 pixels (2560 by 2048 pixels) spatial image resolution, 30 Hz (60 Hz) frame rate), VIS (VIS-NIR-SWIR) bands, 1-in. (0.5-in.) radius of curvature, monochrome (red-green-blue) color for VIS band, and D* comparable to flat FPA cameras for NIR and SWIR bands. Approaches based on organic, inorganic, and hybrid materials, and all pixel technologies, are sought. Space, weight, ergonomics, power, performance, and integration (SWEPP) must all be addressed in a single performance vector for the HMS application (threshold) and for other applications such as small UAV. Fabrication techniques and manufacturing technology, including a plan for scaling for eventual production must be addressed.

PHASE I: Design CSVS capable of being integrated to small formfactor applications to provide visualization capability to pilots and other warfighters. Novel materials, sensor pixel structures, array readout schema, and fabrication techniques should include proof-of-concept experiments. Develop roadmap.

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

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include head mounted display (HMD) systems for pilots (all aircraft), tankers, and dismounted combatants and sensors for small uninhabited air vehicles (UAVs).
Commercial Application: Commercial applications include cameras embedded in consumer electronics (computers, cell phones, camcorders), homeland security, and police.

REFERENCES:
2. (a) Seung-Bum Rim, Peter B. Catrysse, Rostam Dinyari, Kevin Huang and Peter Peumans, The optical advantages of curved focal plane Arrays, OSA Optics Express, Vol. 16, No. 7, pp. 4965-4971 (2008), http://ece661web.groups.et.byu.net/notes/curved_fpa.pdf; (b) Rostam Dinyari, Seung-Bum Rim, Kevin Huang, Peter
B. Catrysse, and Peter Peumans, Curved monolithic silicon for nonplanar focal plane array, Applied Phys. Lett. 92, 091114 (2008), http://apl.aip.org/resource/1/applab/v92/i9/p091114_s1?isAuthorized=no. Theoretical analysis and demo of 30-um silicon island pixels connected by silicon springs in 105 by105 pixel array deformed into a subhemispherical dome having 1-cm radius.

Program focused on exploiting materials and processing methods to create curved focal plane to reduce optical elements and need for image post processing,


KEYWORDS: curved focal plane array, digital retinal camera, hemispherical detector, bio-inspired vision, imaging system, short wavelength infrared

AF112-018  TITLE: Sensor-Processors-Display Sandwich (SPDS) for Near-Eye Visualization Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

OBJECTIVE: Develop integrated digital device for near-eye visualization comprising a sandwich with layers including a pixelated sensor focal plane array, processors (ROIC, IO, generator), and a microdisplay.

DESCRIPTION: Currently fielded night vision systems perform imaging (sensing, processing, display) in an integrated device train comprising a low workfunction phosphor, microchannel plate, fiber-optic bundle, and visible (green) phosphor. Examples include AN/AVS-9 and Panaoramic Night Vision Goggles (PNVG). The image sensed in these fielded systems is in-line with the eye: there is no off-set and users often think of their indirectly-sensed view of the world as if it were direct-view with an unaided eye. These current systems, base on so-called generation III near-infrared (NIR) vacuum tube technology, are not digital. Digital sensors (based on both solid state and vacuum device approaches) are beginning to appear that may match the scene image resolution provided by a Gen-III analog NIR tube, which is about 5 Mpx in a 40º field-of-view (FOV). Furthermore, these digital sensors can be sensitive to multiple bands: visible (VIS 0.4-0.7 μm), near infrared (NIR, 0.7-0.9μm), and shortwave infrared (SWIR, 0.9-1.8 μm), or to all three. Digital image processors and algorithms are now available that can handle at least 1280x1024 pixels at 60 Hz, with a path to handle 2560x2048 pixels at 60 Hz. Digital displays have appeared in multiple technologies at 1280 x 1024 pixels capable of 80 Hz, and higher resolution (4000 x 2000 pixels) are now possible. The maturity of the digital imaging components for sensing, processing, and display is now sufficient to initiate innovation towards a purely digital Sensor-Processors-Display Sandwich (SPDS) for Near-Eye Visualization Systems to replace the analog vacuum tube technology now used in fielded night vision equipment. These digital SPDS devices enable capabilities not available to the currently fielded analog technologies, such as image processing, fusion, recording, communication to/from the helmet system. Importantly, the SPDS provides these advantages of digital while retaining an in-line sensing of the world with the line-of-sight (no off-sets as in other current testbeds for digital near-eye systems). Space, weight, ergonomics, power, performance, and integration (SWEPPPI) must all be addressed in a single performance vector for the helmet-mounted application. Fabrication techniques and manufacturing technology, including a plan for scaling for eventual production must be addressed.

PHASE I: Design SPDS capable of being integrated to near-eye applications to provide visualization capability to pilots and other warfighters. Novel materials, structures, devices, processing schema, and fabrication techniques should be addressed via proof-of-principle experiments. Develop roadmap.
PHASE II: Build digital SPDS testbed system, including optics, with threshold (objective) resolution of 1Mpx (5Mpx). Address fabrication, integration, and packaging to the extent budget permits. Compare testbed capabilities with analog tube-based systems. Establish a plan for development into a product for military and commercial applications with an industrial base for affordable production.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include helmet-mounted and helmet-integrated visualization systems for pilots, dismounted combatants (handheld systems, rifle sights, head-mounted vision), and vehicle operators.
Commercial Application: Commercial applications include camera viewfinders embedded in consumer electronics (computers, cell phones, camcorders), homeland security, and police.

REFERENCES:

KEYWORDS: Sensor-Processor-Display Sandwich, SPDS, near-eye visualization system, in-line digital night vision module, digital image intensifier, replacement for analog Gen-III tubes

AF112-019 TITLE: Expert System for Training and Simulation Visual Display System

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Research task-based requirements for simulator visual display systems, and prototype an expert system to aid defining and measuring these systems.

DESCRIPTION: The acquisition and validation of visual display systems as a key capability of U.S. Air Force (USAF) training systems is a complex process. Accurate mapping of high-level user requirements into system and device level performance requirements is challenging. Over-specifying drives unnecessary cost, while under-specifying results in system performance that does not support the needed training. Vague training system specifications can lead to disagreements in required system characteristics, cost estimates, and adequacy of performance in the delivered system. Additionally, although USAF end users may have very good descriptions of particular tasks that need to be trained in a simulation environment, the correlation of these operational training tasks with particular attributes of the simulator visual display subsystem fidelity has to date been only anecdotal. The ultimate objective of this topic is to prototype an expert system/database that will aid users in assessing the tradeoffs and what-if decisions necessary for generation of visual display system performance criteria based on training tasks, cost, schedule, and other resource constraints. This task will consist of (1) researching task-based training system
requirements for simulator visual display designs, (2) establishing standard specification parameters and verification methods, and (3) prototyping an expert system as an aid to users and acquisition engineers in specification of required visual display system performance based on training task requirements as inputs. Enabling objectives are to develop standardized attributes for specification of visual display system performance, and standardized verification methods for each attribute. This effort is particularly focused on research of requirements for such an expert system, development of novel measurement/assessment methods to be incorporated which do not require specialized or vendor/specific equipment, and design of the enabling software architecture. The intent is to develop a new paradigm in which an expert system can be used to assess key high-level criteria which will thoroughly characterize a visual display system for simulation and training. Visual system components to be considered include databases, image generator, imaging hardware (e.g., projectors, head worn displays) for both daylight and night vision applications. Selection of key performance parameters should be based on the best available research and documentation. Additionally, successful completion of this proposed effort will involve new research to: (a) standardize a set of objective (i.e. measurable), and achievable performance criteria, and (b) establish empirical linkages between those criteria and specific training tasks.

PHASE I: Research training tasks and visual simulation system attributes for fighter aircraft and develop a design approach for an expert system. Deliver a technical report summarizing results.

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 USAF for further research and evaluation.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Development of an expert system to aid acquisition and acceptance testing of visual simulation systems would have military aviation applications. Commercial Application: Development of an expert system to aid acquisition and acceptance testing of visual simulation systems would have commercial aviation applications.

REFERENCES:
4. Relative Effects of Five Display Design Variables on Aircraft Identification Range in Daylight
5. A Model of the Relative Effects of Key Task and Display Design Parameters on Training Task Performance.

KEYWORDS: simulator display metrics

AF112-021 TITL E: Colorless Opaqueable Visor (COV)

TECHNOLOGY AREAS: Sensors, Human Systems

OBJECTIVE: Develop neutral-density complex curvature visor that fails clear but is opaqueable to block up to 90% of ambient illumination using advanced optical structures, materials, and fabrication techniques.

DESCRIPTION: Helmets for fighter pilots have traditionally had two passive visors (one clear, one dark) to enable operation over seven orders of ambient illumination ranging from very dark (0.01 lx, moonless overcast night) to extremely bright (108 klx, full sun day). Dimmable visors, activated either by photonic flux or electrical excitation, have been sought for over 35 years (see references) to enable a single visor design. Unfortunately, no effort to date
has yielded an approach that fails clear, provides controllable transmission of the ambient illumination ranging from at least 10 percent to less than 90 percent, and dims light equally at all visible wavelengths (i.e. colorless, so-called neutral-density, light filtration). Recent advances in optical micro- and nano-structures, quantum optoelectronics, organic and inorganic materials, and novel fabrication techniques including molecular self-assembly, provide new opportunities to achieve colorless opaqueable visors (COV) and windows. Potential approaches include novel microelectricalmechanical system (MEMS) structures such as micro-blinds or fluid-suspended nanorods, advanced photochemicals and electrochromics developed by combining quantum theoretical molecular modeling and synthesis with device fabrication and evaluation, various polymer dispersed liquid crystal (PDLC)-based devices, nano-structured semiconductor materials, and porous nano-crystalline films. Efforts to develop energy-efficient windows for buildings and cars provide additional approaches to be explored for helmet visors. This topic is focused on the discovery and development of effective, affordable technology enabling an opaqueable, complex curvature, single-visor pilot helmet design. Threshold performance is demonstration of fail-clear with minimum clear-state (dimmed-state) transmission of 10 percent (90 percent) uniform across all visible wavelengths on a flat and on a single-radius-of-curvature visor substrate material. Intermediate performance sought includes threshold goals plus demonstration on a complex dual-radius-of-curvature visor substrate material. Objective performance includes the intermediate goals plus compatibility of all materials and structures with the application of fixed-wavelength optical filters. The threshold (objective) transition time sought is 400 ms (100 ms) for transition from the clear state (>90 percent transmission) to the maximally dimmed state (<10 percent transmission), or the reverse (same times). This transition time corresponds to eye blink (corneal reflex). Removal of the activation energy source that controls dimming (e.g. ambient illumination or electrical power) should result in transition to the clear state within the afore noted transition times. Transition from the maximally clear state to the maximally dimmed state should be continuous and selectable via pilot vehicle interface (PVI) control. Visor must be trimmable along the bottom edge (e.g. by including a clear, non-photoelectric region) for custom fit to each pilot. Space, weight, ergonomics, power, performance, and integration (SWEPPI) must all be addressed in a single performance vector for the helmet-mounted fighter pilot COV application. Fabrication techniques and manufacturing technology, including a plan for scaling for eventual production must be addressed. Commercial applications and markets must be demonstrated that make the technology viable and affordable to military applications. Partnership with large businesses that develop helmet systems for DoD program offices must be demonstrated to ensure a technology transition pathway.

PHASE I: Design COV capable of being fabricated in a single-piece with complex-curvature for military aviation helmet. Novel optical structures, materials, and fabrication techniques should be addressed via proof-of-principle experiments. Develop COV roadmap including iterative fabrications/demonstrations.

PHASE II: Fabricate COV and demonstrate performance in laboratory environment. Perform evaluation experiments and compare performance to published transparency control technologies for visors, goggles, and windows. Demonstrate technology readiness level (TRL) and revise roadmap leading to products. Evaluate potential of COV in commercial applications to create industrial base for affordable production.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include helmet systems for pilots, window/canopies in aircraft and vehicles, and dust goggles and other eye protection wear (sunglasses) for dismounted combatants
Commercial Application: Commercial applications include helmet systems for pilots, window/canopies in aircraft and vehicles, motorcycle helmets, and dust goggles and other eyewear (sunglasses) for dismounted combatants.

REFERENCES:
1. John P. Dobbins, “Variable-Transmittance Visor (VTV) for Helmet-Mounted Display,” final report (Jul 1976), DTIC Accession No. ADA027177, on contract to Rockwell Intl in Anaheim CA; claims to be first effort to develop VTV responding controllably with rapidity; based on liquid optronic medium in a sandwich-cell visor running on 28vdc aircraft power; accommodated 80:1 external lumiance variations.
http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA027177

3. “Smart glass,” http://en.wikipedia.org/wiki/Smart_glass provides a review of devices, materials, and techniques used to enable electrical control of the amount of light passing through a window material.

4. Neutral color e-Tint lens based on high-performance dichroic dyes developed by AlphaMicron, Inc. in Kent OH is reported to be in field test for flight deck goggles with a sealed power supply and in research for fighter pilot visors, http://www.alphamicron.com/military/fighter_pilot_visors.html (accessed 1 Oct 2010).

5. Electrochromic devices with switching ranges of 70 percent in sizes up to 16 x 24-in. are reported by Eclipse Energy Systems, Inc. in St Petersburg FL, http://eclipsethinfilms.com/prodsservices_available.aspx (accessed 1 Oct 2010).

KEYWORDS: colorless opaqueable visor, COV, helmet systems, neutral-density filter, variable transmission windows, indoor/outdoor transition lenses for eyewear

AF112-022  TITLE: Fusion, Management, and Visualization Tools for Predictive Battlespace Awareness and Decision Making

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

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

OBJECTIVE: Develop improved fusion management and visualization environment, toolset for common operating picture development and mission planning, course of action evaluation, execution and after action review in first responder environments.

DESCRIPTION: This effort will develop tagging and fusion methods and demonstrate visualization technologies and tools to enable decision making and improved data management for predictive command and control awareness, information fusion, correlation, critical mission planning, execution evaluation, damage assessment, and after action review. Large scale disasters and humanitarian operations require a capability that fuses and manages the most current and relevant information for planning to meet commanders intent. COPS are typically visualizations of a variety of data from disparate sources integrated into an actionable product that provides a broad picture of friendly actions. For this effort we envision a capability that can tag, fuse, manage and display data as diverse as instant messaging/chat, voice, application sharing, video, electronic whiteboarding, file sharing, database synchronization, and alerts as examples. Visualization methods such as 2 and 3D displays and multidimensional representations such volumetric displays and virtual sand tables are potential visualization media for examination. We expect a successful effort to develop and demonstrate the following: 1) a robust schema for tagging various sources of data and 2) an intelligent data management model that fuses and integrates the information based on mission objectives, and 3) a visualization model that displays and continually updates the operations picture based on incoming data. This technology should be developed in the context of first responder/homeland security operations and show how this technology could be applied to other data/information management applications such as: cyber or information operations. At the present time, watch and on scene commanders are severely limited in their ability to effectively evaluate alternative courses of action and to evaluate mission plans and scenarios using COPS in real time and with the level of fidelity necessary to visualize predictive outcomes for mission execution evaluation and after action analysis. Data from current operations indicate that teams in a Emergency Operations Centers (EOCs) and other decision planning and execution cells do not have the fusion or visualization tools to evaluate and assess mission strategy and execution potentials prior to actual decision and execution. This effort will develop a next generation and generalizable data management, fusion, and visualization environment and toolset for COPs and for watch commanders COA evaluation and after action analysis.
PHASE I: Will investigate and develop a scheme for tagging several sources of data that allows for information fusion. Phase I will design the intelligent data management and visualization model architectures that can fuse and display information from a variety of sources based on the tagging schema. The effort will result in a proof of concept in a representative first responder scenario that demonstrates the major components of the technology.

PHASE II: Phase II will build upon Phase I to fully develop, refine, test and evaluate the data tagging capabilities, fusion, integration and visualization models, in an integrated system for first responder operations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Areas of potential application include any data rich environments with multiple sources of data such as intelligence, cyber space, and ar combat operations.
Commercial Application: High value for commercialization as there is no accepted standard for fusing and managing large data and separate data sources for decision making and for visualization of the operating environment.

REFERENCES:


4. Additional Q&A from TPOC in response to FAQs, posted in SITIS 5/25/11.

KEYWORDS: data fusion management, data visualization, course of action (COA) evaluation, execution and after action review (AAR), decision making, predictive battlespace awareness, common operating picture
approaches that define the simulator/fidelity/requirements tradespace are needed. This new process should include measurement techniques for determining changes in pilot and sensor operator behavior and performance. Finally, the software tool should have the capability to use the performance metrics to update a decision model and make more accurate decisions in the future about fidelity tradeoffs for RPA training. This effort should focus on developing a technology solution for the MQ-1 and MQ-9 RPAs but have the capability to be applied to other platforms as well. At a minimum, relevant Mission Essential Task Lists (METLs), Training Task Lists (TTLs), and Mission Essential Competencies (MECs) for these aircraft should be considered in proposing and developing a solution along with any other relevant supporting documentation deemed appropriate for this effort.

PHASE I: Define an automated process for determining simulator system effectiveness. This includes developing metrics to determine the effectiveness of the simulation and specifications for the software tool to measure the effectiveness for tasks associated with ISR and tactical RPA missions against training requirements. Develop a software proof-of-concept that demonstrates the feasibility and major components of this technology.

PHASE II: Fully develop the prototype software technology, verify, and demonstrate the processes, tools, and algorithms used to conduct the effectiveness evaluations, demonstrate the capability to isolate the effects of simulator system performance on trainee behavior and performance, and develop an algorithm that feeds this data back into the model to improve future decision making system capabilities.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Provides a research and data driven effectiveness measurement tool for better decision making. (Evaluating aircraft systems and subsystem effectiveness using simulation during design and testing)
Commercial Application: Includes application of these processes and tools to commercial agencies (such as airline companies) for determining flight simulator systems effectiveness.

REFERENCES:

KEYWORDS: RPA simulator training, combat mission training, training effectiveness evaluation, training effectiveness metrics, unmanned aerial systems, unmanned aerial vehicles, remotely piloted aircraft, MQ-1, MQ-9,

AF112-024

TITLE: Listener Performance Modeling in Urban Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop computational/statistical models (empirical models that account for human/environmental effects) to predict the ability of a human observer to detect auditory targets in sound environments.
DESCRIPTION: The purpose of this effort is to acquire predictive modeling and capabilities needed to simulate human detection of air vehicles in a variety of tactical environments. Specific research topics of high interest include: (1) tools and methods for the prediction of human aural detection of air vehicles; and (2) techniques and processes for modeling, numerical code and validation.

Current state-of-the-art methods for auditory detection prediction are based upon classic psychoacoustic/psychophysical models of the ability of a human listener to distinguish a target against extraneous sounds in simple or quiet acoustic settings. What are lacking are mathematical models, computational, empirical or both, that account for the complex and non linear aspects of listener recognition of auditory targets in complex environments with rapidly changing, transient spatial, spectral and temporal envelopes (urban setting sound environments). Models are needed to predict a human listener's ability to recognize specific auditory targets within acoustically complex urban environments based on dynamic ambient listening environments and the target sound (aircraft).

PHASE I: The goal of Phase I will be to produce a detailed description and explanation of an auditory model that can predict the ability of a human listener to identify auditory targets (aircraft) in complex listening environments. The proposed model should explicitly extend current state of the art methods. The description of the proposed model should describe how it differs from traditional models, how it is novel, and why it should provide improved prediction. It should account for the auditory identification of complex acoustic targets in complex acoustic environments by human listeners. Phase I should also identify and describe the methodology by which the model can be validated and assessed.

PHASE II: The goal of Phase II is to develop, validate, and demonstrate a computer model that predicts human listeners’ ability to identify complex acoustic targets (aircraft) in complex auditory environments. The model will be validated based on the methodology described in Phase I. A successful demonstration is defined, but not limited to, obtaining a Pearson correlation coefficient (r) that is equal to or greater than .8, or alternatively, has a predictive accuracy of 64% when compared to human listener performance. Additionally, Phase II will produce a sensitivity analysis to examine how predictive variability relates to different inputs to the model. This analysis will be key to understanding the robustness of the auditory model.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The development and fielding of an auditory detection model has broad implications for military aerospace and automotive technologies. Such models can be used to predict sound source detection and identification, and location in military environments, and will provide predictions across a wide variety of background noise environments or soundscapes. Auditory detection models may also prove useful in military training simulators, which have traditionally relied mostly on visual information and cues.
Commercial Application: The development and fielding of an auditory detection model has broad implications for automotive technology areas, the FAA, and the U.S. Department of the Interior/National Park Service. It will provide these agencies with the ability to accurately predict auditory detection of aircraft and automobiles across a wide variety of locations, including residential areas, parks, and commercial zones.

REFERENCES:


KEYWORDS: auditory detection prediction, psychoacoustic, psychophysical, temporal envelopes

AF112-025 TITLE: Hardware Accelerated Code for Hybrid Computational Electromagnetics

TECHNOLOGY AREAS: Information Systems, Biomedical, Sensors

OBJECTIVE: Develop a graphics processing unit (GPU) approach for solving advanced computational electromagnetic problems.

DESCRIPTION: Electromagnetic devices have become commonly used in modern society. Accordingly, there has been a great amount of research as to the safety of these devices. In recent years, computational electromagnetics software has been increasingly utilized by engineers to help design such devices, and to study their propagation characteristics in complex environments. Furthermore, computational electromagnetics has been crucial for understanding the health and safety aspects of these technologies, and ensuring compliance with national and international standards. However, the computational methods most appropriate for field propagation analysis (e.g. Ray-Tracing) may not be most appropriate for a detailed analysis of field interaction with, for instance, a human anatomical model. Therefore, some researchers have proposed hybrid approaches which attempt to merge the benefits of two or more computational methods, each being applied to a portion of the computational domain.

Even with a hybrid approach, some problems may prove to be intractable due to excessive computational runtime. However, recent research using GPUs has shown that they can often provide great speed increases compared to a central processing unit (CPU). In fact, many computational electromagnetic methods are ideally suited to GPU computation. A GPU-enabled implementation of a hybrid electromagnetic software would allow users to simulate a broad-range of electromagnetic problems in a much shorter time frame than previously possible.

Antenna engineers, biomedical scientists, health and medical physicists, and bioenvironmental engineers would all benefit from software that enabled electromagnetic analysis across a variety of problem domains. Ideally, the software should be portable to both the CPU and a GPU, include a user interface for creating simulations and viewing output, and be robust enough to solve for near/far field behavior, propagation, and field interaction with complex geometrical features, as well as calculating hazard zones and the potential for biological impact of this energy.

PHASE I: Determine the computational methods to be used, and develop prototype software that illustrates the effectiveness of the chosen method. Construct a hybridization scheme that allows computational methods to be used, each being applied appropriately in a subdomain of the problem space.

PHASE II: Extend the software created in Phase I to allow for a broad range of antenna structures and environments to be modeled. Extend the software to allow for CPU or GPU simulations. Develop a graphical user interface (GUI) for creating simulations and viewing results. Validate the developed software against empirical data.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Use by engineers and health physicists to study antenna propagation through complex environments and to understand potential health and safety risks. Commercial Application: Use by engineers and health physicists to study antenna propagation through complex environments and to understand potential health and safety risks.
REFERENCES:


KEYWORDS: computational electromagnetics, radio frequency radiation, dosimetry, GPU

AF112-026  TITLE: Cognitive Approaches to Integrated Intelligence Production

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop cognitively-derived analyst tools to support the production of more fully integrated intelligence products of greater relevance to the warfighter.

DESCRIPTION: Data overload is a significant factor in the generation of intelligence products. Multiple collection systems, both tactical and national, overwhelm exploitation and analytic capacities. Their numbers are increasing while new capabilities are becoming operational. Yet additional collection systems are programmed to become operational in the future. At the same time, consumers (war fighters and policy makers) are demanding more fully integrated intelligence products which are both timely and highly relevant to their individual needs. The analytic community is faced with both increases in data input and greater complexity in product content.

Current operational operational-state-of-the-art is generally limited to single source (e.g., electro-optical sensor full motion video) and product integration is often limited to generating overlays of graphics and/or alphanumerics to selected still image underlays. Production metrics are generally limited to "tallies" of the number of planned collection target images exploited and do not reflect either the cognitive complexity of the exploitation task or the degree to which the required essential elements of information have been satisfied because of the resultant integrated intelligence product.

Emerging technologies may offer some promise in remediating (or, at least, ameliorating) the complexities of data overload in intelligence production. As examples, the study of macrocognition may offer exploitable insights into the cognitive demands of complex analysis performed under conditions of data overload / product integration while adaptive neural network applications may support the rapid typing and cross matching of related information and provide relevant context to complement newly collected information.
Research is required to identify and assess the relevance of cognitive sciences theories and methods which may be applicable to gaining a deeper understanding of analyst cognitive demands. Research is required to identify and assess automated and adaptive techniques which may aid the analyst. Research is required to develop cognitively-derived measures of effectiveness (MOEs). Specific MOEs which will be used to assess progress toward Topic solution may include capability to generate alternative hypotheses to explain the intelligence input, capability to perceive subtle cues within complex imagery, capability to comprehend the social and temporal context of the observations, and capability to infer the intent of the observed activity. MOEs which also reflect the capability to remove or at least remEDIATE possible analyst biases are also desired. Research is required to explore the interaction between the analyst and the aiding technologies within the context of realistic intelligence production tasks.

New data visualization and relational understandings between information sources are required to assist with improving the understanding as well as supporting techniques to comb through multiple data sources pulling relevant information together for the analyst without the ongoing related keyword to keyword linking.

The resulting exploitation and analysis software package must incorporate a user interface that accommodates the less experienced analyst without limiting the productivity of a more experienced analyst. The non-expert should be able to create or adapt workflows to a specific production tasking without in-depth knowledge of the system. However, the frequent user should be able to create new products quickly and efficiently.

The MOEs shall be used to assess progress toward the development of an effective analyst toolset.

PHASE I: Conduct applied research to identify and define opportunities for inserting analyst-aiding technologies appropriate to complex analytic tasks and data overload. Apply the MOEs to assess progress.

PHASE II: Develop and demonstrate cognitively-derived analyst tools to support the production of more fully integrated intelligence products of greater relevance to the warfighter.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Intelligence, surveillance and reconnaissance exploitation; mission planning, target nomination, counter insurgency operations. Commercial Application: Civil engineering surveys, land use management, urban planning, disease management, multinational collaboration

REFERENCES:


KEYWORDS: cognitive systems engineering, data overload, intelligence production, analyst-aiding, adaptive neural networks

AF112-029 TITLE: Countering Future Cyber Threats to Air Force Weapon Systems
TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop innovative methods to mitigate Weapon System susceptibility to cyber threats.

DESCRIPTION: Ensuring confidentiality, integrity, availability, non-repudiation, and authentication of Weapon Systems is essential to establishing and maintaining trusted platforms. These platforms may operate in networked or non-networked environments which are vulnerable to threat sources of network-based attacks, inadvertent or malicious insider threats due to data propagation through removable media devices and vulnerabilities introduced through the supply-chain. In addition, the effort to detect and repair systems after cyber attack exacts a tremendous burden through man-hours, software costs, and lost processing time due to processor overhead, system downtime and potential loss of data.

Weapon Systems have unique information assurance needs that cannot be met by existing commercial intrusion detection/prevention and anti-virus applications. For instance, virus scanning software is developed to be unique to a particular operating system, and as such is not applicable to many application-specific devices. Also, many systems devoted to performing critical tasks cannot be burdened to perform virus scans or intrusion monitoring, in addition to procedures for keeping the required virus and attack signatures up to date. More importantly, signature detection may not be a form of protection at all, as zero-day attacks account for an ever-increasing percentage of the attack vectors used to compromise these systems. Lastly, introducing information assurance controls to Weapon Systems is limited by availability of system resources including processing cycles, memory and storage capacity.

An innovative solution is needed to implement system assurance in Weapon System IT assets supporting the mission of the target system without adding burdensome overhead to mission-critical devices. These systems generally have static software and/or hardware configurations, and are only updated as new updates are added to the baseline utility software.

A novel approach to Weapon System assurance should focus on the mission requirements of the individual platform. By ensuring the correct functionality and protecting the mission of each of the identified mission-critical systems within a platform, the overall mission of that platform can be assured. This means both avoiding environmental threats, as well as surviving attacks that produce unknown or unanticipated system states. Since susceptible mission-critical devices may be any device able to interface with the transmission or storage of critical information, the information flows into and out of these systems must be assured as well.

As such, an approach must:
1. Protect the mission-required portions of critical devices and thus the system as a whole
2. Minimize the impact on mission-critical hardware/software functions
3. Assure onboard devices are only used to accomplish their mission

Such a solution should protect the functions of mission-critical Weapon System devices, including denying privilege escalation, blocking the addition of unauthorized accounts and alterations to onboard applications, and refusing interoperability with added devices. The goal for these tools is not to duplicate existing operating system controls or those currently available through commercial applications such as antivirus or traditional white listing, but to enable the system to avoid and/or survive extraordinary conditions which may induce unexpected or undesirable states into the system.

PHASE I: Develop preliminary design based on intended implementation. Detail how design will be used to assure mission essential functions, critical data flows and information processes into and out of the system without interfering with mission essential devices and processes.

PHASE II: Develop the designed tool as a means of allowing mission-critical devices and processes to avoid and/or survive malicious attacks and subversion of the system. Show robustness of tool to unexpected system states.
potentially introduced by bad input parameters consistent with a cyber attack and extraordinary conditions. Likewise, show the cost-effective benefit of the design to real-world applications.

PHASE III Dual Use Applications:
Military Application: The mission assurance provided by this research could provide a more robust, secure and mission-assured weapons platform.
Commercial Application: This research could likewise improve security and robustness of commercial information and infrastructure systems.

REFERENCES:


AF112-030 TITLE: Applying Security Assertion Markup Language (SAML) to non SOAP protocols

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a method for applying the Security Assertion Markup Language (SAML) XML-based standard to non-SOAP based protocols (e.g., RESTful web services).

DESCRIPTION: DOD has placed significant investment in specifying security architectures that rely on the Security Assertion Markup Language (SAML) XML-based standard for asserting authentication and authorization information. While this standard works well for SOAP based transactions, it is not readily applicable to "lighter weight" protocols. With the push toward usage of Representational State Transfer (RESTful) web services, which are implemented using HTTP and simple Uniform Resource Identifiers (URIs), the method to apply a SAML authentication or authorization statement to a request is not well defined.

Previous informal research initiatives have attempted to include a binary representation of the SAML statement as part of the HTTP cookie; however, size limitations are encountered with network routers and firewalls that effectively truncate the information from a request. While limited success has been achieved applying a binary SAML statement representation in a HTTP header, the ability for this approach to scale for use across the various COTS vendor products used within DOD network infrastructures remains a significant risk.

While novel approaches to apply SAML statements to HTTP based transactions may continue to be assessed, it is unlikely those attempts will result in a methodology that is widely accepted across industry and government.

Other approaches to security for RESTful transactions include the use of OpenID Authentication and OpenID Attribute Exchange specifications. While these standards are the basis for authentication in social frameworks and have gained significant momentum in the commercial environment for securing RESTful transactions in recent years, they have not been widely promoted or used with DOD applications. To remain standards based, DoD must
provide a way to leverage the new specifications (e.g., OpenID) within the present operating environment to foster the use of light weight transaction protocols.

To effectively enable the use and implementation of secure of RESTful services within DOD, the ability to bridge between multiple authentication and attribute exchange specifications must be supported. For example, DOD user attribute stores (e.g., LDAP directories) that presently provide SAML attribute assertions must also provide a method for obtaining such information using OpenID Attribute Exchange. A demonstration of the ability to bridge between the two standards to achieve confidentiality, authentication, integrity, and authorization is an overall objective.

PHASE I: Prototype an simple authentication and authorization example for a RESTful web service using the OpenID and OpenID Attribute Exchange using the existing SOAP based web services within DoD (e.g., PKI authentication services, and Net-Centric Enterprise Services (NCES) user attribute stores).

PHASE II: Integrate the simple authentication/authorization capability with the DOD/IC tactical integration framework (i.e., DCGS Integration Backbone (DIB)). Demonstrate interoperability with existing security policy enforcement/decision points (e.g., IBM DataPower) to provide access control at the web service (e.g., access to invoke WSDL) and data levels (e.g., filter results based on user attributes).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Security Assertion Markup Language (SAML) allows authentication and authorization to services and information in Joint and federated service environments. The evolution to IP-based tactical networks offers tremendous tactical advantage but enterprise security standards such as SAML must be adapted to ensure security. Integrating SOA security in the tactical environment (e.g., iPhone) requires a lightweight, effective, & standard based authentication alternative to SAML/SOAP. Commercial Application: Companies operating in a web environment today often develop their own RESTful approach to authentication/authorization (Amazon). A standard approach would facilitate commercial interoperability.

REFERENCES:

KEYWORDS: OpenID, RESTful, security, web service security, SAML, Information Assurance, Authentication, Authorization, tactical SOA
to users. The use of different clouds to provide computing performance, scalability, service levels etc is promising. However, there are several drawbacks as well. Federated cloud environments present a myriad of security concerns. One of which is that the user does not own or maintain control over any of the equipment that is processing, storing or transmitting their sensitive information. There have been efforts to protect these clouds by incorporating anti-tamper technology into the computing nodes and encrypting the communications among the nodes. Many potential weaknesses still remain, including but not limited to: cloud resources being damaged or destroyed, spoofed, subjected to a distributed denial of service attack, or nodes that are uncompromised and yet provide erroneous data.

The primary goals related to this SBIR effort are to develop a way to gauge the trustworthiness of individual cloud elements or aggregate cloud resources without access to the physical cloud elements and to create a mitigation strategy. An example scenario might be the need to determine in real time how much trust to place in a particular application running in the cloud. A potential solution is to use fuzzy testing/assessment to provide immediate feedback on the trustworthiness of the application. The proposed solution should be scalable and applicable across as broad a range of cloud elements as possible.

PHASE I: 1. Research and develop concept for determining trustworthiness of cloud resources and the ability to assess a degree of trust in transmitted information. 2. Provide design and architecture documents of a prototype system. 3. Provide a minimal software prototype demonstrating the capabilities.

PHASE II: 1. Based on the results from Phase I, refine and extend the design of the trusted querying prototype to a fully functioning solution. 2. Provide test and evaluation results based on an actual cloud and demonstrate the scalability of the system (proof of scalability may be based on simulated results).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The desired product is a robust tool capable of assessing DoD federated cloud environments operating within the Global Information Grid (GIG) infrastructure. Commercial Application: A trust assessment tool for federated cloud environments supporting commercial sector applications such as for transportation, shipping, e-commerce, and robotics.

REFERENCES:

KEYWORDS: trust, information assurance, cloud computing, trusted cloud computing, network security
Data exfiltration, unintentional actions or mistakes, configuration errors, unauthorized software loaded on systems, unpatched application vulnerabilities, malware, etc. Data exfiltration further describes the unauthorized and often covert transfer of this information out of a system. A specific example of the data leakage problem might include small tidbits of data sent via chat or email when collected together could provide classified or operationally sensitive information. Another example may be improper settings for security features which result in data which it expected to be sent in encrypted form being released in non-encrypted, cleartext format. The successful implementation of this technology would detect the violation, remove the sensitive data from the stream and notify the user/administrator.

Data Leak (or Loss) Prevention (DLP) refers to the practice of identifying, monitoring, and protecting data in use, data in motion, and data at rest through techniques such as deep content inspection, application filters, outbound message checkers, content analysis, document matching, fingerprinting, policies, least privilege, encryption, auditing, logging, behavior evaluation, managed file transfer, transaction monitoring, content monitoring/filtering, layered protection, incident response alarms, extrusion detection, digital rights management (DRM), white/blacklisting, etc.

With the ubiquitous use of information systems in military environments and the increased reliance on interconnections and interoperation between other services, allies and civilian organizations and many levels of security the likelihood of data loss or leakage increases. New techniques need to be explored to detect, stop and identify the sources of data leakage.

PHASE I: Identify and design mechanisms that could be employed to detect and stop data leakage when data is in transit.

PHASE II: Prototype hardware and/or software and demonstrate its effectiveness in detecting and stopping leakage when data is in transit.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Detection and elimination of data leakage in military networks.
Commercial Application: Detection and elimination of data leakage in civil or commercial networks.

REFERENCES:


KEYWORDS: Data leakage, data leak prevention, data loss prevention (DLP), data exfiltration, covert communications

AF112-033 TITLE: Airborne Network Orderwire

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms

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OBJECTIVE: Development of a communications control channel orderwire to support autonomous mobile network management.

DESCRIPTION: Future Joint Aerial Layer Networks (Ref. 1) will be composed of mobile nodes interconnected by heterogeneous communication links such as directional common data links, omnidirectional tactical targeting network technology and Inmarsat. Management of these interconnected nodes and interconnecting links to gain effective and optimal use for future warfighting needs will be a major challenge. Frequency or time slot allocations must be made so as to avoid cosite and spatial/spectral interference, yet allow for frequency re-use. Navigation data and communication state information of the airborne nodes can be used to estimate future network conditions and proactively change operating parameters (e.g. frequency, power, data rate/time slot assignments, routing tables) or inter-node connections (e.g., antenna directions) to avoid interference and path loss, optimize throughput or minimize latency. Node positions/velocities and communication performance information may be exploited for enhanced network topology formation and routing.

Recent airborne networking SBIR developments and Joint Capability Technology Demonstrations (CABLE, Ref. 2) have identified the need for an orderwire. The orderwire is a communication among all participating nodes (Ref. 3 & 4) that will support autonomous mobile network management. It may be transmitted by an out-of-band channel as well as over in-band communication links. It is used to exchange navigation data, node communication capability, current performance state and other data among network participants.

The collection of nodes’ states, obtained from the orderwire, may be used by a centralized or distributed topology management capability to dynamically determine frequency, transmit power level and time slots allocations and point directional antennas toward appropriate neighboring nodes. Additional information carried by an orderwire might identify an application flow's source, destination and Quality of Service (QoS) requirements to guide the formation of connections to support high-priority flows. The orderwire may also be used to transport user data, serving as a low-data-rate backup to the main communication links.

Innovative concepts are needed for an orderwire architecture and waveform definition that will interoperate with heterogeneous communication terminals and mobile networking protocols for dynamic link connection (topology) management and routing. Interoperability with heterogeneous communication systems means the ability to be transported over them as well as (indirectly) control their operating parameters through mobile networking (e.g., topology/link management) protocols. The orderwire must support the entry and exit of nodes to and from a network, the merging and splitting of networks, and associated IP address assignment/reclamation.

The orderwire must operate over an extended range to reach all nodes in the network. The orderwire must be scalable to support a large number of network participants. In omnidirectional broadcast mode, it should be capable of LPI/LPD operation. The orderwire data format should integrate seamlessly into the framing format of existing radio and satellite systems and keep overhead to a minimum. Its form factor must be suitable for operation on small drones.

Technical criteria guiding this research include coverage range, capability vs. overhead tradeoffs, covertness, and interoperability with military radios, GPS/navigation systems and existing/emerging mobile networking protocols.

PHASE I: Develop an orderwire architecture, protocol and concept of operation. Determine the feasibility of the orderwire in supporting autonomous network management. Simulate performance, in conjunction with mobile networking protocols, in a network composed of heterogeneous communication links.

PHASE II: Extend phase I simulations with higher fidelity. Refine processes for data compression and performance enhancements. Develop a prototype orderwire capability. Demonstrate orderwire operation with selected radio and satellite terminals in a mobile environment. Identify transition opportunities.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: An airborne network orderwire will support the implementation of the JALN (1) high-capacity backbone and distribution/access/range extension components, including sensor networks composed of drones.
Commercial Application: An orderwire may support airborne networks composed of links between commercial aircraft for the exchange of aviation information and extending the internet into remote areas, such as over the oceans.

REFERENCES:
4. W. M. Bynoe, et. al., Implementation and Performance of a Network Control Plane for Airborne Networks, MILCOM 2007

KEYWORDS: airborne network, orderwire, autonomous network management

AF112-034  TITLE: Performance Enhancing Proxies for use on the Cyphertext Side of Inline Network Encryptors

TECHNOLOGY AREAS: Information Systems

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OBJECTIVE: Definition, development and demonstration of performance enhancing proxies operating with on the cyphertext side of in-line network encryptors.

DESCRIPTION: In-line Network Encryption (INE) is a process for providing data confidentiality for IP data communications. INE’s encrypt at the network layer (layer 3) of the protocol stack. INEs operate with IPSec (Ref 1), a framework of open standards for protecting communications over an IP network. IPSec supports network-level peer authentication, data origin authentication, data integrity, data encryption, and replay protection.

There are two modes of INE operation: transport mode and tunnel mode. In transport mode, the user data payload field of the IP datagram is encrypted, but the IP header, containing the hosts’ IP addresses, TCP ports, protocol and QoS level, are not. Transport mode is typically used for end-to-end (host-to-host) encryption. In tunnel mode, the entire user IP datagram, including the header and data payload, is encrypted and inserted into the payload of another IP packet with a different header. The source and destination IP addresses are those of the INEs. The addresses of the originating and destination host(s) along with application TCP port numbers and protocol are encrypted. Typically, tunnel mode is used for connections between routers through an untrusted network with the formation of a virtual private network between host enclaves connected to routers at each end. End-to-end and enclave-to enclave encryption over vulnerable networks is being promoted by the Defense Information Systems Agency (DISA) (Ref. 1) and is being adopted in the architectures of many programs.

Performance Enhancing Proxies (PEPs) are typically located within enclaves, on the clear-text side of the INE, where the PEP can readily access the destination address, protocol type being transported, type of service required, IPv4 options field (or IPv6 header extensions), contained in the plain-text IP datagram header, and the flow details contained in the TCP or UDP header. Operating in a tunnel mode, these fields are not available on the cyphertext side of the INE. If only remote enclave authenticated traffic is allowed to enter an enclave, and no information is available from the intervening network, components within that enclave receive limited information on transport conditions within the intervening network. This limits a PEP, located within an enclave, in its ability to respond to dynamic, link-specific conditions in the intervening network.
Innovative approaches are needed to define and develop INE cipher-text-side (enclave external) PEPs for transport and tunnel mode operation. Applications whose performance can be enhanced with external PEPs need to be prioritized for PEP development. The pros and cons of cypher- vs. plain-text-side PEP operation need to be analyzed for each identified application. Performance of internal versus external PEPs should be quantified for each application under dynamic link conditions of the intervening network. Multi-functional PEPs that are capable of enhancing the performance of several applications simultaneously should be explored.

PHASE I: Determine applications where performance may be enhanced with a cipher-side PEP operating with INEs in transport as well as tunnel mode. Identify any plain-text-side components needed. Simulate performance of black PEPs for multiple applications and contrast against a plain-side PEPs.

PHASE II: Extend phase 1 performance simulations of external PEPs with higher fidelity and select a suite of applications for further development. Develop and demonstrate PEP operation with IPSec operating in transport as well as tunnel mode. Compare against enclave-internal PEP equivalents.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: External PEPs would be widely used in military IP networks. This architecture is promoted by DISA, and adopted by development programs.
Commercial Application: PEPs developed from this research could be used in commercial, wireless mobile IP networks.

REFERENCES:

KEYWORDS: performance enhancing proxy, PEP, in-line network encryption, INE, airborne network, mobile network

AF112-035 TITLE: Multicast on a Black MANET

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Concept development for secure, dynamic, and efficient multicast services (voice, video, data) over heterogeneous black airborne networks.

DESCRIPTION: Airborne network architectures are focusing on implementing "black" Internet Protocol (IP) backbone networks for transporting all information among tactical edge networks (see Ref 5). Inline Network Encryption (INE) devices will encrypt traffic at each red user edge/domain. INEs encrypt at the network layer (layer 3) of the protocol stack, operating with IPSec (see Ref 4), a framework of open standards for protecting communications over an IP network. IP ciphertext traffic will be transported across the black backbone network between user domains, with decryption and distribution of the resulting plaintext information occurring within the end-user networks. The backbone transport network will comprise a variety of point-to-point, broadcast, and hybrid radio links. Mobile ad hoc network (MANET) (or equivalent) routing protocols will be used to route IP packets efficiently over the resulting backbone network.

Current approaches to implementing multicast services over such a dynamically mobile network include broadcasting multicast traffic over all links (using, for example, Simplified Multicast Forwarding), or using sparse
mode Protocol-Independent Multicast (PIM). The first approach tends to utilize scarce transmission resources very inefficiently, particularly if most multicast groups are small (few users). However, sparse mode PIM requires establishing and maintaining “rendezvous points” at strategic routing points within the network – the feasibility of which is uncertain in a rapidly changing mobile network. Techniques for efficient multicast transport across dynamic and heterogeneous airborne networks must be developed and assessed.

A second issue is support for multicast services. INEs are generally designed to support IP multicast only when connected to individual host systems; they are not designed to provide multicast services to networks. INEs will not pass required end-user and network multicast signaling packets between the red (plaintext) and black (ciphertext) sides. Current multicast implementations establish multiple Generic Routing Encapsulation (GRE) tunnels among participants in each multicast group; this non-scalable approach requires intensive manual coordination and consumes precious bandwidth. A scalable approach for multicast transport across dynamic airborne networks is required.

PHASE I: Review techniques for secure IP multicast over airborne networks; identify key technical/operational issues and alternative concepts. Develop integrated architecture for secure IP multicast in dynamic, heterogeneous airborne networks. Identify/proposal changes to related protocols/software.

PHASE II: Modify networking protocols/software to support laboratory implementation configurations. Evaluate proposed architecture and modified protocols using a combination of networking and radio hardware/software and radio link emulation of representative operational scenarios for airborne networking. If necessary, INE networking features may also be emulated, with or without packet encryption.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Secure IP multicast transport is critical for effective and timely dissemination of ISR and C2 video, voice, etc., among tactical edge users, and for implementation of planned net-centric services. Commercial Application: Efficient transport of multicast video, voice, and data across mobile networks (air and surface) for commercial airlines, disaster response teams, etc.

REFERENCES:

KEYWORDS: airborne, networking, multicast, IP-multicast, MANET, INE, NETSEC, mobility

AF112-036 TITLE: Enabling visualization of events from unstructured text (HUMINT) on maps

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Enable visualization of events from unstructured text on maps by advancing Text Extraction technology in the areas of event coreference/consolidation, and extraction/association of locations to events

DESCRIPTION: Intelligence analysts need an automated capability to visualize events from unstructured and semi-structured textual data sources -such as Human Intelligence (HUMINT) reports, Significant Activity Reports (SIGACTS), Initial Phase Interpretation Reports (IPIRs) and other relevant reports and documents- on maps. This
would help alleviate textual data overload, the current situation in which analysts get more information in than they can possibly process manually in the time available. As a result, textual data with potentially valuable event information literally "falls on the floor".

This problem impacts a number of different types of intelligence analysts. It impacts strategic and operational level Command and Control (C2) analysts who want to see "what has changed" when they look at events displayed on a map for their area of interest (AOI). It affects Special Ops Forces (SOF), who need to assess activities in their AOs and identify potential threats. It also impacts analysts in Air Operation Centers (AOCs) and named commands, who need to quickly process 1,000s of documents near real-time, to achieve operational-pace assessment. This would enable AOCs to determine how effective previous targeting cycles were, and to better stay apprised of the current battlefield situation. In summary, a key aspect of developing and maintaining situational awareness is quickly becoming apprised of what events are occurring where.

The R&D goal of this SBIR Topic is to advance the state-of-the-art of Text Extraction technology, in regards to enabling visualization of event information from unstructured and semi-structured text, on maps. This is to be accomplished by addressing one or more of the major technology gaps associated with achieving this capability. These include, but are not necessarily limited to: location-tagging of events (the ability to correctly determine the location of an event, and correctly associate that location with that event), nominal event extraction (extraction of events in the form of noun phrases), and event co-reference resolution (the ability to determine all event mentions that refer to the same real-world event, to enable consolidation of all information pertaining to that event, including location). R&D may be proposed against a different technology gap, but it will be up to the offeror to explicitly identify the technology gap being addressed, and to successfully demonstrate the significance of addressing that gap in order to achieve the objective of this topic.

PHASE I: Conduct research and experiments to determine the most promising techniques for high accuracy location extraction, event extraction, and location-tagging of events from unstructured textual data sources. Design a prototype capability enabling visualization of event information on maps.

PHASE II: Perform in-depth research and development of techniques for high accuracy location extraction, event extraction, and location-tagging of events from unstructured and semi-structured textual data sources. Develop a prototype capability demonstrating how this new technology enables visualization of events from text on maps. The government's intent is to find a user with real data to support this.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Operational assessment, command and control, indications and warnings, trend analysis, homeland defense, special ops forces. Commercial Application: Business intelligence, trend analysis, law enforcement, medical and health organizations monitoring and analyzing health-related events and outbreaks.

REFERENCES:


KEYWORDS: event extraction, event coreference, location extraction, information extraction, text extraction, spatial annotation
AF112-037  TITLE: Jam-resistant Waveform for Transponded Satellite Communications

TECHNOLOGY AREAS: Electronics, Space Platforms

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OBJECTIVE: Develop advanced waveform techniques that ameliorate the effects of jamming and are suitable for use in transponded SATCOM applications.

DESCRIPTION: Transponded military satellite communications (SATCOM) is beginning to play an increasingly critical role in support of applications such as warfighter battlefield telecommunications, and AISR (Airborne Intelligence, Surveillance and Reconnaissance). As the benefits of transponded SATCOM grow, adversaries may potentially become interested in developing capabilities to develop transponded SATCOM DOS (Denial of Service) attacks. The purpose of this topic is to solicit jamming protection solutions to transponded satellite communications. Hardware and algorithms must be capable of meeting all existing SATCOM waveform restrictions including the presence of adjacent sub channels, EIRP (Effective Isotropic Radiated Power) restrictions, frequency hopping, BER (Bit Error Rate) and designated SATCOM frequencies. Specifically, proposed solutions must not lead to adjacent channel interference, nor exceed downlink power restrictions. Proposed waveforms may include spread-spectrum, frequency hopping, chaotic modulation or other methods designed to afford protection in hostile electromagnetic environments. Research should address relevant operational issues such as clock recovery, frequency offset and transmission effects. Because research may involve terminal modifications, proposed solution should strive to minimize the impact to the existing space and terrestrial terminal infrastructure by incorporating user friendly 'plug and play' solutions which readily adapt terminals to new waveforms without requiring extensive retrofit.

PHASE I: Investigate transponded satellite communications design techniques that mitigate the effects of jamming. Design innovative transponded SATCOM component and verify through modeling and simulation.

PHASE II: Fabricate prototype and characterize for SATCOM performance, reliability, size, weight, power, and ease of installation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This research is for existing transponded military satellite communications programs like the Wideband Global SATCOM program.
Commercial Application: Commercial programs utilizing transponded SATCOM could also benefit from this research.

REFERENCES:


KEYWORDS: satellite, communications, transponder, transponded, anti-jam, jamming, jam-resistant, jam-resistance, waveform

AF112-038  TITLE: SATCOM X-band Digital Beamforming Network

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TECHNOLOGY AREAS: Electronics, Space Platforms

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OBJECTIVE: Develop X-band digital beamformer suitable for use in satellite communications applications.

DESCRIPTION: Future generations of high data rate digital Satellite Communications (SATCOM) systems will require advanced digital beamforming networks at X-band (7.9-8.4 GHz) to maximize the benefits of frequency reuse and bandwidth efficient modulation. The Digital Beam Former (DBF) design should support seamless integration into phased array antennas with the ability of controlling large numbers of independent beams at X-band each with a minimum of .5 GHz instantaneous bandwidth. The DBF design should also enable bandwidth efficient modulation formats such as QPSK (Quadrature Phase Shift Keying) and 16-QAM (Quadrature Amplitude Modulation). The DBF system should also be capable of producing multiple simultaneous narrow beams to support spatial diversity for frequency re-use. Additional DBF design goals include mitigation measures for co-channel interference, effective nulling and capability to support both left and right hand circular polarization waveforms.

PHASE I: Identify and develop candidate beamformer/combiner architectures and perform wideband testing and characterization methodologies.

PHASE II: Develop prototype beamformer that implements at least 16 channels of the architecture developed during Phase I and characterize for bandwidth, operating frequency range, data rates and depth of nulling.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include Wideband Global SATCOM system.
Commercial Application: Commercial applications include commercial SATCOM programs as well as avionics.

REFERENCES:

KEYWORDS: digital beamformer, satellite communications, X-band, beamforming network, QPSK, QAM, nulling

AF112-039 TITLE: High Assurance SATCOM Policy-based Network Management

TECHNOLOGY AREAS: Information Systems, Space Platforms

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OBJECTIVE: Develop the next generation of Policy-based Network Management (PBNM) tools for commercial and military satellite communications.

DESCRIPTION: Commercial and military satellite networks generally include the satellite constellation(s), corresponding terrestrial-based facilities, such as the mission control center and gateways, and a diverse set of terminals located on airborne, terrestrial (fixed and mobile) and sea-based platforms. Next generation commercial...
and military satellite communications architects are faced with a disparate set of design objectives. First, SATCOM (Satellite Communications) must be user-friendly and readily accessible to a consortium of multi-national forces, including the U.S. and its allies and their associated ISR (Intelligence, Surveillance and Reconnaissance) platforms. Second, commercial and military SATCOM must be capable of withstanding protracted penetration attempts from one or more technically savvy adversaries to protect from industrial and military espionage. Third, SATCOM must support a broad range of capacity, connectivity, coverage and Quality of Services (QoS) objectives associated with the rapid set-up and tear-down of disparate networks using a diverse set of protocols. Finally, there is an acute need to keep SATCOM services affordable in the face of stagnating or declining budgets. The purpose of this topic is to support next generation PBNM tools capable of meeting the challenges of user friendly, robust, secure, flexible, adaptable, and affordable military satellite communications. Research performed should address the expanding military SATCOM infrastructure (i.e. additional terminals, satellites, and the capability to meet existing and projected QoS performance attributes of military networks including WIN-T (Warfighter Information Network – Tactical). That military SATCOM infrastructure is generally considered to consist of three classes of systems. Narrowband SATCOM systems operate in the Ultra High Frequency (UHF) band, and support secure voice and data communications at relatively low data rates (kilobits per second) for both mobile and fixed users. Wideband SATCOM systems operate in the Super High Frequency (SHF) and Extremely High Frequency (EHF) bands, and support multichannel, secure voice, and high data rate (megabits per second channels). Finally, Protected SATCOM operates in the EHF band and supports survivable voice and data communications not normally found on other systems. Additionally, commercial SATCOM systems are leased by the military to augment the bandwidth available from military SATCOM. Furthermore, each of these disparate SATCOM systems consists of not only the satellites themselves, but also the control stations and user terminals. Taken as a whole, the satellite communications enterprise that the military depends upon is therefore an enormously complex system of systems and its management is understandably a very complex task. Today that complexity is handled largely in brute force fashion by treating systems as stovepipes. While this divide and conquer approach may simplify the problem by treating it as multiple independent tasks, it also makes it much more difficult to optimize the use of available SATCOM resources. Technical advances across the spectrum of SATCOM management processes, from planning (e.g. optimization techniques, modeling & simulation, etc.), to monitoring (e.g. management protocols, data distribution standards/mechanisms, data mining, etc.) to control/reconfiguration (distributed agents, PBNM, etc.), would make it much easier to address the SATCOM infrastructure as a system of systems and are all potential parts of solutions of interest for this SBIR topic.

**PHASE I:** Evaluate existing and projected SATCOM networks for capacity, connectivity, and QoS characteristics. Design a PBNM solution addressing one or more SATCOM enterprise performance requirements.

**PHASE II:** Develop a prototype of the High Assurance PBNM solution for SATCOM and evaluate its performance on a simulation and/or emulation testbed.

**PHASE III DUAL USE COMMERCIALIZATION:**
Military Application: This research could make military SATCOM more user-friendly, robust, secure, and adaptable.
Commercial Application: Commercial: This research could likewise make commercial SATCOM more user-friendly, robust, secure, and adaptable.

**REFERENCES:**


**KEYWORDS:** policy based network management, SATCOM, satellite communications, global information grid, Policy enforcement point, satellite network, satellite network management
TITLE: Quality of Information Services for Trusted Service Oriented Architecture Systems

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Research and develop Quality of Information (QoI) mechanisms needed for the fielding of trusted information services in Service Oriented Architecture (SOA) based environments.

DESCRIPTION: New capabilities, efficiencies, and agility have motivated the Air Force and DoD to replace legacy, stove-piped systems with networked components in a Service Oriented Architecture (SOA). SOA-based systems decouple information consumers from producers and allow for dynamic coalitions among Air Force, DoD, civilian, and international communities. This decoupling interrupts the established chains of trust in information. Decision makers need to know they are using authoritative sources of data, even when the particular source is dynamically selected or personally unknown to them. In most cases, the quality of a piece of information cannot be assessed solely by inspection. Some sort of trusted pedigree information (metadata) must accompany the data. For example, if a message is received on the location of insurgents in a commander's Area of Responsibility (AOR), some metadata that indicates the source and timeliness of this information would be required in order to act upon it with any certainty. It is not enough to just know the insurgents identity and location. It is also imperative to know if the source of the information is reliable, and if so, whether or not enough time has elapsed for the insurgents to have fled the area. Needed are QoI solutions to establish trust in the information provided by critical enterprise SOA services. A central architectural decision is whether QoI information (pedigree/provenance) should be stored and retrieved (as with any other data) by a separate service, or be a more fundamental aspect that is “baked into” core information services. If a separate pedigree service (for example, a web service) is provided, the onus is on end users and developers to make use of the pedigree data whenever QoI is an issue for the underlying information. Whenever new information is produced, and presumably stored or distributed via a web service, the producer is responsible for alerting the corresponding pedigree service (which will then store the pedigree data). This required “orchestration” of service calls complicates Information Management (IM) in general, and goes against the spirit of providing a minimal set of universal IM services to users in order to simplify client concerns. The producer, for instance, may not know what the appropriate life cycle is for the pedigree data, but rather, this is up to the consumers of that data based on their needs. Further, separating data and pedigree (metadata) services requires intimate communication between them to ensure synchronization and ACID (atomicity, consistency, isolation, and durability) constraints. On the other hand, requiring most or all core IM services to be pedigree-aware involves a development investment and overhead when creating services. This tradeoff is not as severe as it may seem, however, as core services must already handle metadata that could include in-line storage of pedigree data. Questions of scalability, access control to pedigree data, and integrity of pedigree data must be investigated for comparative assessment of each of these approaches to address the technical challenge of rapidly determining the relevance, value and trustworthiness of information and services.

PHASE I: Investigate architectural models & simulations provisioning of QoI services within SOA environments, perform trade-off analyses, research implementation & deployment processes for services within large enterprises. Document lessons, research & develop a design for Phase II prototype implementation.

PHASE II: Based on Phase I design activities, implement and demonstrate one or more proof-of-concept QoI service prototypes. Design an experiment to measure prototype performance characteristics and document the results. Research results should identify and recommend areas requiring further investigation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Reliable tracking of pedigree for QoI opens up a large field of new possibilities for QoI-driven policy enforcement, workflow management, and warfighter decision support.
Commercial Application: Cloud computing and software (security) as a service (SAAS) are example domains for the commercial application of QoI. In particular, pedigree services would be of benefit to the field of medicine.

REFERENCES:


KEYWORDS: SOA, pedigree, provenance, quality, information, trust, service

AF112-042 TITLE: Multiple Target Tracking (MTT) of Objects Exhibiting Significant Nonlinearities

TECHNOLOGY AREAS: Information Systems, Sensors

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OBJECTIVE: Develop and demonstrate Multiple Target Tracking (MTT) algorithms to improve the ability to track objects in scenarios exhibiting significant dynamic and measurement model nonlinearities.

DESCRIPTION: Current sensor systems are capable of providing detections for multiple targets within their field of view. Moving Target Indicator (MTI) techniques then allow the isolation of the detections of moving targets. Multiple Target Tracking (MTT) techniques then attempt to process these detections correctly into tracks. Application areas of interest in the military domain include MTT of sensor outputs for Air Moving Target Indicator (AMTI) and Ground Moving Target Indicator (GMTI). Current systems generally do well for MTT of targets that are exhibiting linear motion. However, they have difficulty maintaining track for targets that are exhibiting nonlinear motion. These nonlinearities come not only from nonlinear dynamic motion, but also from nonlinearities in the measurement model. In addition, these nonlinearities cause decreased performance in the association process, where current detections need to be associated with developed tracks. Errors in association interfere considerably with the MTT process. Current systems generally use the Kalman Filter or variants such as the Extended Kalman Filter (EKF) as tracking filters. These perform well in linear scenarios but have problems in nonlinear scenarios. Efforts at improving the ability of systems to deal with nonlinearities have focused on a number of areas. One area has been to develop filters that perform better in the face of nonlinearities. These include the Unscented Kalman Filter (UKF) and the Particle Filter (PF). Another direction of study has been to set up a suite of filters which have different capabilities for dealing with nonlinearities and also vary on other dimensions. The concept is to base the choice of filter on MTT results as a scenario unfolds. Research has also looked at the degree to which MTT performance can improve. The Cramer-Rao bound has been studied relative to MTT in order to determine the degree to which MTT performance can be improved. Part of this process consists of making estimates of the inherent level of nonlinearity in a given scenario. Approaches to this problem have included such methods as curvature measures of nonlinearity as well as use of the Normalized Innovation Squared (NIS) metric. While work has been done to develop and explore novel ideas within areas involved with MTT for nonlinearities, comprehensive work has not been done towards incorporating these and other techniques in a comprehensive manner. This program seeks to explore novel concepts and develop innovative technology to coordinate the MTT process in the face of nonlinearities so as to improve overall MTT performance across a wider regime of operational situations.

PHASE I: Design innovative concepts for Multiple Target Track (MTT) of objects exhibiting significant nonlinearities using algorithms providing advanced reasoning & processing. The Phase I research will identify the critical technology challenges and define Phase II.

PHASE II: Develop prototype software tools and algorithms for Multiple Target Track (MTT) of objects exhibiting significant nonlinearities to optimize tracking. Test and verify the tools against a government provided scenario and
data set. Demonstrate these tools and algorithms in an operationally representative and stressing scenario; provide evaluation results with final recommendations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Persistent surveillance of targets exhibiting significant nonlinearities can ensure maximum coverage for situation awareness and to maintain track of hostile targets.
Commercial Application: Improved Multiple Target Track (MTT) of objects with nonlinearities can be used by Police Departments and Homeland Defense to assess traffic delays and track criminal activity.

REFERENCES:


KEYWORDS: Multiple Target Track (MTT), Nonlinear Filtering, Moving Target Indicator (MTI), Air Moving Target Indicator (AMTI), Ground Moving Target Indicator (GMTI), Cramer-Rao Bound.

AF112-043 TITLE: High-Speed Data Transmission in Multimode Fiber

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Development of a high-capacity multimode fiber optical transmission technology for avionics.

DESCRIPTION: Multimode fiber exists in many military platforms for broadband onboard communication [1]. Multimode fiber exists in many military platforms for broadband onboard communication [1]. Multimode fiber (MMF) has much large mode field diameter and numerical aperture. Therefore, MMF can relax alignment tolerance for high-efficient coupling. It is robust and low-cost. As a result, MMFs are extensively deployed in both airborne and naval platforms. In addition, MMFs can potentially provide high-capacity.

However, MMFs do have serious limitations for high-capacity multimode fiber optical transmission, namely, modal dispersion and mode coupling. Modal dispersion limits the bandwidth-distance product since different mode will travel at different speeds. Wavelength-division multiplexing (WDM) [2] has been used to extend the capacity of MMF transmission capacity. This is achieved by transmitting multiple low-data rate bit streams on different wavelengths. Each wavelength operates within the MMF bandwidth-distance product. The composite data rate is then increased by the number of wavelengths used. This solution, although technically feasible, leads to high cost. WDM technology is extensively used in telecommunication and therefore very expensive.

Mode coupling does not affect optical transmission unless one explores the multiple orthogonal modes in MMFs to independently transmit information through mode-division multiplexing (MDM) [3]. MDM transmitter technology has been demonstrated qualitatively for example using different angular excitation. But if the theoretical orthogonal

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modes of the ideal fiber couple to each other due to imperfections of the real-world fiber, cross talk among the modes essentially render MDM impractical.

In recent years, electronic and digital signal processing has been exploited in long-haul fiber optic communication systems. It is thus desirable to develop low-cost and reliable electronic solution to combat modal dispersion (for high-speed transmission in legacy MMFs in existing military platforms) and potentially tame mode coupling (to use low-cost multimode optics for higher-speed transmission in future military platforms). It should be noted that modal dispersion and mode coupling are very much analogous to multi-path interference in wireless communication and therefore much of the signal processing technologies developed for wireless communication might be applicable in MMF transmission. Such technology will have dual-used applications as low-cost MMF transmission technology can be used for last-mile applications in fiber to the home. Mode fiber (MMF) has much large mode field diameter and numerical aperture. Therefore, MMF can relax alignment tolerance for high-efficient coupling. It is robust and low-cost. As a result, MMFs are extensively deployed in both airborne and naval platforms. In addition, MMFs can potentially provide high-capacity. This is because MMFs supports multiple orthogonal modes which can independently transmit information.

However, MMFs do have serious limitations for high-capacity multimode fiber optical transmission, namely, modal dispersion and mode coupling. Modal dispersion limits the bandwidth-distance product since different mode will travel at different speeds. Wavelength-division multiplexing (WDM) [2] has been used to extend the capacity of MMF transmission capacity. This is achieved by transmitting multiple low-data rate bit streams on different wavelengths. Each wavelength operates within the MMF bandwidth-distance product. The composite data rate is then increased by the number of wavelengths used. This solution, although technically feasible, leads to high cost. WDM technology is extensively used in telecommunication and therefore very expensive. Mode coupling does not affect optical transmission unless one explores the multiple orthogonal modes in MMFs to independently transmit information through mode-division multiplexing (MDM) [3]. MDM transmitter technology has been demonstrated qualitatively for example using different angular excitation. But if the theoretical orthogonal of the ideal fiber couple to each other due to imperfections of the real-world fiber, cross talk among the modes essentially render MDM impractical. In recent years, electronic and digital signal processing has been exploited in long-haul fiber optic communication systems. It is thus desirable to develop low-cost and reliable electronic solution to combat modal dispersion (for high-speed transmission in legacy MMFs in existing military platforms) and potentially tame mode coupling (to use low-cost multimode optics for higher-speed transmission in future military platforms). It should be noted that modal dispersion and mode coupling are very much analogous to multi-path interference in wireless communication and therefore much of the signal processing technologies developed for wireless communication might be applicable in MMF transmission. Such technology will have dual-used applications as low-cost MMF transmission technology can be used for last-mile applications in fiber to the home.

PHASE I: The proposed alternative solution to WDM should be analyzed and evaluated in detail in simulation. It is highly desirable to demonstrate a proof of principle prototype with experiment to prove the feasibility of the proposed methodology and provide a pathway to reach the desired performance goals.

PHASE II: Demonstration of a prototype MMF fiber-optic link with performance tests to verify the validity of the Phase I design. Improve the system design based on the test results. The MMF fiber-optic link should be tested with input signals simulating the avionics environment, and if possible, on a military platform.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Improve the system to address packaging, reliability and design for manufacturability. 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:


KEYWORDS: Multimode Fiber, Fiber-Optic Communication, Wavelength-Division Multiplexing, Fly by Light.

AF112-046 TITLE: Solid-State Accelerometer for Reentry Vehicles

TECHNOLOGY AREAS: Electronics, Space Platforms

OBJECTIVE: Develop technology and prototype for a high-sensitivity, high-accuracy, and rugged, solid-state accelerometer with high reliability for ballistic reentry vehicles.

DESCRIPTION: The U.S. Air Force is interested in developing high precision, robust, solid state accelerometer technology that is suitable for use in reentry vehicles. The accelerometer technology should be suitable for use in navigation and fuze applications. The accelerometer technology must be capable of high precision and accuracy (goals of 5µ-g sensitivity with a scale factor of 5ppm). In addition, the accelerometer technology must be capable of operating in adverse environmental conditions including vibration (~100g in all 3 axis), temperature (~20°C to 80°C), and radiation (neutron, gamma, and X ray) while maintaining Mean Time Between Failures (MTBF) in excess of one million hours. The accelerometer technology must be capable of being miniaturized (goal of less than 150cm3) and have limited power consumption (goal of less than 5W) during flight.

PHASE I: Identify and study potential accelerometer technologies to be developed to meet the accuracy and environmental goals. Evaluate the cost and schedule to develop the candidate technology identified to the desired performance goals.

PHASE II: Develop an initial prototype accelerometer focused on meeting the environmental operating conditions. Develop a plan for meeting accuracy requirements of 5µ-g sensitivity with a scale factor of 5ppm. Identify technical issues arising from prototype development and develop a forward resolution plan.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Could be used as a replacement in the current strategic system or in a future system requiring highly accurate terminal guidance.
Commercial Application: Rugged accelerometer technology can be used for crash-and shock-testing of vehicles and safety devices.

REFERENCES:

KEYWORDS: accelerometer, solid state, rugged, reliable, reentry vehicle, inertial navigation, nuclear
TITLE: Automation of Nuclear Arsenal Awareness

TECHNOLOGY AREAS: Information Systems, Weapons

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

OBJECTIVE: Design and demonstrate an intelligent decision support system capable of portraying the current situational awareness.

DESCRIPTION: Many operations centers rely on warfighters to analyze data from a plethora of segregated systems to determine the current situational assessment of the enterprise. This data runs through stovepiped networks at various classifications, in unique formats, with no standard way of correlating information. Currently warfighters use gray matter to correlate the data and develop the current situational awareness. An automated system needs to be developed that automatically feeds the data from these stovepiped systems through a fusion engine and out to a display, where the information is portrayed in an actionable format for the user. This fusion engine would need to process correlated/uncorrelated, streaming and static data on a continuous basis. This would range from statistical/raw operational data from weapons systems to analyzed data. This must be accomplished in a net-centric fashion, with the primary user interaction happening within a common/user defined operating picture (C/UDOP). The fusion engine would need to be able to correlate data from various timestamps to check for inconsistencies or ‘disparities’ within the fused information, before displaying it to the user. Disparities may involve mismatched data, accidently correlated due to an error connecting systems, or inherent human error from one of the sources. Data formats will be provided in a Phase I, with actual data samples being provided in a follow-on Phase II allowing for real-world system development. The framework must utilize an extensible plug-in system which will allow future developers to add capabilities in increments. Technical risk occurs within the fusion engine where developers must bring together non-deterministic data, both validated and unvalidated data, and data with uncertainties in a probabilistic fashion, capable of replacing human correlation. This problem has not been addressed in an automated fashion [via software algorithms] and thus has no basis for prior comparison (subjective metrics only).

PHASE I: Determine the data sources pertinent to the mission; Develop preliminary algorithms to ingest and fuse these data sources; Depict the data in a format conducive with user decisions (i.e. present options for the user to take based on current situation).

PHASE II: Develop and demonstrate the design conceptualized in Phase I. This will include a prototype of the technology that can be taken by a Systems Program Office (SPO), matured, and transitioned into the operational environment. The typical technology readiness level (TRL) for transitioning into a program office is at least 6, with clear progress toward higher levels.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This system can be used to improve situational awareness and command & control within operations centers across any domain. Its implementation will effectively increase productivity for all users.
Commercial Application: Commercial aviation and maritime coordinators would be able to adapt the same technology to track and control current operators throughout their respective domains.

REFERENCES:


KEYWORDS: Intelligent Decision Support Systems, Data Fusion, Situational Awareness, Net-centric, State of Health

AF112-049 TITLE: Satellite Conjunction Post Analysis

TECHNOLOGY AREAS: Information Systems, Space Platforms

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

OBJECTIVE: Research and develop new techniques to post-process conjunction results and determine what conjunction events are most critical to monitor and react against.

DESCRIPTION: When the space fence comes on line, it is estimated that the catalog will grow to 100,000 objects. In addition, the new High Accuracy Catalog (HAC) is expected to produce an estimated 400,000 element sets a day. As these two efforts come on line, the operator will soon be presented with 15,000 conjunctions a week to screen and monitor. With each conjunction, the operator must determine the likelihood of the conjunction, the associated risk level, and the appropriate course of action. When determining the likelihood of a conjunction today, the operator primarily considers two factors--probability of collision and miss distance. Each of these metrics has its own inherent problems. Miss distance cannot be solely considered since two conjuncting assets may have a miss distance less than 20km; however, if the covariance matrix for each object is small, then the risk factor of the conjunction is relatively small. Conversely, the miss distance could also be large, but if the covariance matrix for one of the objects is larger than the miss distance between the two objects then the conjunction still has a relatively high risk factor. There are similar concerns when considering probability of collision. A low probability of collision can result from both an unlikely event and a large covariance matrix. Physical object characteristics need to also be considered. An active asset conjuncting with a large secondary object is much more critical than two rocket bodies conjuncting and likewise two rocket bodies conjuncting is more important to track than two small <10 cm pieces of debris. Each of those conjunctions calls for vastly different courses of action. The first conjunction has a direct impact on the mission and may require the asset to maneuver. The second conjunction is less critical than the first; however, it is still important to track since it has the potential to create a large amount of new debris that could later affect the mission. The third conjunction is of very little importance. This is a very involved process for the operators to conduct against the hundred or so conjunction events currently seen each week. This is a difficult task for the operators when considering more than 15,000 events a week. Methods need to be developed to determine which of those conjunctions are most critical and probable. A capability needs to be developed that will filter the information presented to the operator down from the thousand conjunctions/week to only the conjunctions with high risk and impact factors. The capability also needs to be very dependable in the sense that the operator needs to be able to trust that the system is presenting to the operator the most likely and highest risk conjunctions, and not filtering out any events that will eventually be an issue. Another consideration is how to display the filtered data effectively to the user.

PHASE I: Research and develop initial prototype to screen and monitor potential conjunctions, along with quantitative analysis to reinforce validity of the approach chosen. Scalability and compatibility with the ESC JSpOC Mission System (JMS) infrastructure is highly desirable.
PHASE II: Phase II will culminate in a high fidelity prototype demonstration of the system that clearly shows the utility to Space Situational Awareness (SSA) and Defensive Counterspace missions as supported by conjunction analysis.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This topic is addressing Space Situational Awareness and Defensive Space Control. The initial target customer for this technology is the JSpOC Mission System (JMS) Program Office of ESC.
Commercial Application: The associated technologies would be applicable to many NASA missions particularly those that have to deal with large amounts of debris within their regime.

REFERENCES:
1. ESC JSpOC Mission System (JMS) Strategic Technical Plan (STP).

KEYWORDS: Defensive Space Control, Space Situational Awareness, Conjunction analysis, Covariance

AF112-050
TITLE: Catalog Filtering for Conjunction Processing

TECHNOLOGY AREAS: Information Systems, Space Platforms

OBJECTIVE: This effort will look at new ways to filter the objects that need to be compared during conjunction analysis, as well as the ability to analyze the cost savings of any given filter.

DESCRIPTION: Once the space fence and the new Joint Space Operations Center (JSpOC) Mission System (JMS) High Accuracy Catalog (HAC) comes on-line, the number of new element sets or Vector Covariance Matrices (VCM)'s published each day will explode from 5,000 to 10,000 up to over 400,000. Breaking this number down, that means the system will be publishing element sets at the rate of 277 per minute. In the absence of filtering, the JSpOC would need to perform conjunction analysis for 27 objects against the entire 100,000 objects within the catalog every minute in order to keep up with the data. On top of that, the addition of new sensors like SST and SBSS only exacerbate the problem as these sensors are already finding new objects that are not currently within the catalog. 400,000 element sets being generated daily on a 100,000 object catalog would require 40,000,000,000 object comparisons to be made within a day in order to keep up with the data. Compare this with the 48,000,000+ object comparisons that JSpOC currently conducts every day.

There are many people within the community that do not think it will be possible to keep up with the data in the not-too-distant future. The JSpOC currently uses a few very simple analysis techniques to reduce the number of objects that need to be compared using the more complex conjunction analysis techniques. These simple techniques are referred to as conjunction filtering. Filtering techniques consist of quickly analyzing the orbital elements of two different objects to identify the possibility of the two objects colliding. These filtering techniques can be very complex or very simple. To date, the only filtering technique that is used operationally is the simple apogee/perigee filter. Going forward, the usefulness of this technique will be reduced since the majority of the catalog growth will be confined to a single orbital regime.

New innovative filter techniques that are both effective and computationally quick need to be researched. Research needs to be done to identify more complex orbit phasing filters, which are capable of eliminating comparisons that need to be made between objects of the same orbital regime. Computational optimization of these techniques also needs to be considered to ensure these filters can be applied in a timely manner. In the absence of a maneuver, these types of filters could also be used to assist an operator in anticipating when they should expect to see a given conjunction again.

The research should also include aspects looking at the computational complexity of the filter and the anticipated reduction in the number of conjunction analysis comparisons. Work also needs to be done to quantitatively
characterize what conjunctions are missed by each filter, what filters provide overlap, and what filters can be utilized in combination to provide complete coverage.

PHASE I: Phase I will research techniques to quickly and optimally determine the relative orbital relationships between two objects. These identified relationships should then be used to authoritatively eliminate or identify the need to conduct conjunction analysis between the two objects within a given time window. A proof-of-concept demonstration on a limited scale is highly desirable.

PHASE II: The filter approaches will be developed and implemented within Continuous Anomalous – Orbital Discriminator (CAOS-D) as pluggable filters. An analyst tool will be created to analyze filter effects on the Conjunction Analysis (CA) data. Phase II will culminate in a high-fidelity demonstration of the system that clearly shows the utility towards CA and the minimization of CA comparisons.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This topic addresses Space Situational Awareness and Defensive Space Control. The initial target customer for this technology is the JSpOC Mission System Office of Electronic Systems Command (ESC). Commercial Application: The associated technologies would be applicable to many NASA missions, particularly those that have to deal with large amounts of debris within their regime.

REFERENCES:
1. ESC JSpOC Mission System (JMS) Strategic technical Plan (STP).

KEYWORDS: Defensive Space Control, Space Situational Awareness, Conjunction Analysis, Covariance, Catalog, Filter

AF112-053  TITLE: Active Network Security Situation Awareness and Impact Mitigation

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop innovative situation awareness for active cyber network security and impact mitigation techniques of adversarial attack against a cyber network.

DESCRIPTION: The use of military and commercial networks in the United States has been growing explosively. Because these networks are vulnerable to various types of attacks, there is an urgent need for cyber network security. “Cyber Security: A Crisis of Prioritization” lists network monitoring and detection as one of the ten top priorities for both civilian and military cyber security. There are several challenges associated with cyber network security situation awareness (SA). First, the network data and alerts are often uncertain, ambiguous, and even incorrect, and they often come from sensors of different modalities. Second, network attack and various observations of an attack often evolve over time as determined by attack model’s dynamics. Third, given a large number of dubious network alerts from many intrusion detectors, network SA needs to be conducted in a selective and active manner to identify the most informative alerts to use so that a potential attack can be detected quickly to minimize its damage. Finally, it is important to identify the optimal mitigation strategy so that the impact of an attack can be minimized.

The existing methodologies for network SA analysis and attack detection are usually based on the conventional pattern recognition techniques such as neural networks, regression techniques, etc. While useful, these techniques do
not necessarily have the capability to effectively handle the noisy and temporally evolving data as well as to account for the important domain-specific prior knowledge. Hence, the existing methods suffer from high false positives, difficulty in detecting highly complex attacks, and inability to adapt for detecting new types of attacks. Moreover, the existing methods often perform attack identification in a passive manner by only using the available alerts instead of actively seeking the most useful alerts to use. Another aspect that is lacking with current methods is their inability to provide the effective mitigation of a network threat. For current methods, recommendation of mitigation is usually provided in an ad hoc and heuristic manner, often independent of the SA process.

To overcome these limitations, there is a need for a generalized framework with the aim of handling simultaneously network security awareness, mitigation, and prediction. Specifically, with respect to the first and second challenges, the framework proposed here shall provide a coherent and fully unified framework for representation of network data, their uncertainty and dynamics, and for integration of data from different sources including attack alerts, human intelligences, subjective knowledge, environmental factors, and contextual knowledge. For the third challenge, some advances in variation analysis of information theory may be used to selectively identify the most informative data or alerts to acquire in order to maximally reduce the network SA uncertainty in a timely and efficient manner. Finally, for the last challenge, the proposed solution should identify an enabling decision-making capability from which the resulting mitigation strategies effectively minimize the impact of the perceived network security threat. The performance of proposed algorithms for cyber network security SA and impact mitigation needs to be evaluated by simulation and real data.

PHASE I: Develop and demonstrate the feasibility of a proof-of-concept and associated decision support algorithms that automatically assess the situation of a large-scale cyber network and mitigate the impact of any cyber attacks. Characterize performance metrics and utility of the technology proposed herein.

PHASE II: Optimize the results and its scenario from Phase I for cyber network security situational awareness and impact mitigation. Develop a complete prototype system. Evaluate the performance of the prototype by realistic metrics, real data, and operational constraints.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Framework for network situation awareness & impact mitigation is critical to cyber network defense for military applications contending with complex malicious network attack and data theft protection. Commercial Application: These anticipated technologies directly apply to protecting enterprise networks and supporting critical national infrastructures; i.e., electric/nuclear plants, financial systems, air traffic control.

REFERENCES:

KEYWORDS: Active network security, cyber situation assessment, cyber impact assessment, cyber attack, information fusion, game theory, intrusion detection

AF112-054 TITLE: High-Performance, Low-Profile Antennas Utilizing Advanced Engineered Materials

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

OBJECTIVE: Develop a wideband/multiband, low-profile antenna for wideband (Ku/Ka/Q) communications links on airborne platforms.

DESCRIPTION: The Air Force is interested in the developmental pursuit of a low-profile, wideband/multiband antenna for high-data-rate data links on the Airborne Warning and Control System (AWACS), Joint Surveillance Target Attack Radar System (JSTARS) and other airborne platforms. These links can achieve large data rates (up to 8 Mbps for Advanced Extremely High Frequency (AEHF)) with high directivity apertures. Commercial antennas capable of providing high gain at Ku and above frequencies are large and protrude into the airstream, significantly increasing drag. Additionally, they require large cut-outs in the airframe that introduce high installation complexity and cost.

This topic seeks highly innovative antenna concepts to address this challenge. Advanced materials have properties that can enable conformal antennas as well as antennas that have greater functionality from a single aperture. For example, recent maturation of electromagnetically-tailored materials called “metamaterials” has introduced many new antenna possibilities. Through engineering of the permittivity and permeability of materials on a meso-scale, metamaterials have been proposed for miniaturization of footprint and profile, multiband operation, active frequency control, and increased bandwidth, gain & directivity. Emerging materials are flexible and can conform to the surface of the airframe. While many antenna advances have been realized individually by utilizing the properties of new materials, it remains a major technical challenge to combine multiple benefits into one coherent system. Emphasis will be on the innovative use of emerging material technology to improve performance, lower cost, and minimize platform footprint.

Additional requirements are as follows. Specific frequencies of interest for DoD platforms include 20.2 to 21.2 GHz Receive, 29 – 30 GHz Transmit, and 43.5-45.5 GHz for satellite communications. LOS and BLOS applications at Ku Band are also frequencies of interest. Antenna solutions should minimize protrusion while providing beam pointing from 20 to 90 degrees in elevation (threshold) with 0 to 90 degrees in elevation desired (objective). Coverage in azimuth should be 360 degrees continuous. Beam position updates need to support stable beam pointing to the satellite throughout aircraft maneuvers. Sidelobe peaks should be IAW ITU-R S.732. Size, weight and power requirements are expected to vary, dictated by the solution's capabilities--i.e. miniaturization, frequency handling, data rate, etc. Cost vs. benefit tradeoffs are also factors to consider in this development. The cost of developing and integrating a wideband, low-profile antenna—instead of purchasing a derivative commercial antenna—should be justified by the benefits.

PHASE I: Develop low-profile, wideband/multiband antenna design concept. Through numerical simulation and analysis, perform initial investigation of electrical parameters and limits. Demonstrate the feasibility to meet design and performance goals, and analyze technical challenges of proposed concept.

PHASE II: Refine concept from Phase I, optimize for Phase II requirements. Conduct comprehensive testing and analysis on hardware demonstrator, with attention to effects of advanced material application on antenna function. Report and recommendations based on these results. Provide AFRL access to hardware for verification and validation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Any military platform that requires low-profile, high-performance antennas, to include manned and unmanned air, space, sea and land platforms. Addresses ever-increasing senior leader data rate needs. Commercial Application: Same as military, in order to provide conformal, low-drag, high data rate communications antennas to commercial aircraft, seacraft and automobile industries.

REFERENCES:


KEYWORDS: antennas, low-profile, conformal, wideband, multiband, K-band, Q-band, engineered materials, metamaterials

AF112-055

TITLE: Ensuring Optimal and Secure Routes, Packet Forwarding and Spectrum Utilization through Synthesis of Tactical Wireless Broadband Systems

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Secure reliable route discovery, packet forwarding, spectrum bands and allocate them to communication links with most important information. Quality-of-service metrics for performance delay, packet quality and security issues.

DESCRIPTION: To achieve greater interoperability among system controls, data products, and data links on unmanned systems, including tasking, processing, exploitation and dissemination, a natural next step is to design, develop and demonstrate enabling technologies for a common secure communications system, integrating a wide variety of unmanned systems control and sensor product data, such as voice, video and data, onto a common infrastructure. There are major obstacles to overcome; however, since system controls and data products not only have drastically different traffic characteristics, but also extremely diverse quality-of-service (QoS) requirements. Important measures are the amount of packet delay incurred during transmission, and the fraction of packet loss caused by buffer overflow. System controls (also known as real-time) traffic is rather sensitive to delay, but can sustain some packet loss, whereas data product (also known as best-effort) traffic can tolerate some amount of delay, but is quite vulnerable to packet loss. As such, innovative admission control, routing, scheduling and flow control are necessary to intelligently manage network resources to evaluate the relevant QoS measures; e.g., delay performance, packet loss, etc., thus reliably addressing the impact of long-ailed traffic characteristics and interaction between real-time and best-effort services.

This topic seeks integrated solutions and enabling technologies pertaining to the following research foci: i) bandwidth fluctuation: on the packet time-scale, the transmission capacity is shared by several traffic streams and some packet traffics may exhibit long-range dependence and self-similarity over a wide range of time scales. Minimal emphasis is on the issue of how scheduling algorithms may be used to neutralize negative effects from long-ailed traffic phenomena; thus, the general principle of traffic, system and performance metric time-scales together that determine the set of candidate traffic models would be desirable; ii) a-priori traffic specification: on the flow time-scale, robust admission control schemes that would require no a-priori traffic descriptors are needed to investigate the impact of flow arrivals and departures on QoS; thus shifting the task of traffic characterization from the user to the network; iii) route discovery and packet forwarding: hostess routing protocols and cognitive algorithms are needed in order to unselfishly discover and maintain routes between faraway nodes using information on the energy required and QoS possible; thus allowing them to communicate along multi-hop paths; and iv)
frequency spectrum allocation and management: the spectrum in which unmanned systems communicate shall exhibit an agility to hop around in the spectrum to ensure robust and secure communications.

Compressive sampling mechanisms, distributed sensing and fusion, and decentralized consensus optimization for cooperative cognitive radios (CRs) to overcome high sampling rates for wideband processing, limited power and computing resources per CR, frequency-selective wireless fading, and interference due to signal leakage from other coexisting CRs are of central importance, thus reducing inadvertent interference of the data links.

PHASE I: Develop notional concepts of operations and candidate prototypes using universal and flexible radios. Only limited demonstrations expected include RF wireless network communications simulations that can talk to each other using autonomous protocols and frequencies in highly dynamic environments.

PHASE II: Optimize design and development of the selected prototype. Demonstrate performance robustness in emulated/experimental air and/or space-borne environments with EMI, line-of-sight, and non-line-of-sight. If applicable, extend feasibility of the technology for non-RF communications that further utilizes infrared and ultraviolet free space optical technologies, which are much less susceptible to electromagnetic interference and frequency deconfliction issues.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integrate the technologies and solutions with possible encryptions, such as Advanced Encryption Standard (AES), Federal Information Processing Standard (FIPS), Type 1, etc., for persistent situational awareness, force application, net-centric and protection in coordination with ESC and its offices with assistance from DOD prime contractors.
Commercial Application: Resource allocation in integrated-service networks, opportunistic communications, and high-speed communication systems.

REFERENCES:


KEYWORDS: Admission control, routing, scheduling, spectrum allocation, quality of service, autonomous bandwidth, multi-frequency communications

AF112-056 TITLE: Highly-Reliable, Radiation-Hard Laser Diode Active Materials

TECHNOLOGY AREAS: Materials/Processes, Electronics, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.
OBJECTIVE: Develop new III-V semiconductor active materials for highly-reliable, radiation-hard pump laser diode designs for high power pumping for advanced space lasercom applications.

DESCRIPTION: Facet reliability of high power laser diodes has continued to improve, so that laser diode reliability is now limited directly by the active material as opposed to mirror-or process-related failures. Increasing this reliability is particularly critical for applications, such as for high-power pump laser diodes used in advanced military space applications, and to operate the pump laser diodes at increased power levels for which reliability may otherwise suffer. III-V semiconductor growth techniques have so far been unable to eliminate point defects in conventional laser diode active materials, such as in lattice-matched and strained quantum well hetero-structures that may lead to defect growth, and new approaches to forming highly-reliable, radiation-hard laser diode active materials are sought. In addition, insights into the intrinsic failure mechanisms of existing high power laser diodes can lead to further improvements in reliability.

The goal of this topic is to demonstrate multi-mode pump laser diode chips with novel gain media in the emission wavelength of 915 - 980 nm with a typical emitter width of 100µm. Device characteristics should include maximum output powers of over 10W, slope efficiencies of over 0.9 W/A, and power conversion efficiencies of over 60% at room temperature under CW operation. Expected lifetime of pump lasers is over 20 years at output power of 5W and heat sink temperature of 50°C with a FIT of less than 500 (60% confidence levels). Pump lasers should be radiation resistant to over 500 kRad (Si).

PHASE I: Investigate new active material designs addressing intrinsic failure mechanisms due to point defects that exist directly in the laser diode active materials. Produce prototypes of the new laser diode materials to study point defects and defect growth during laser diode operation and life-testing.

PHASE II: Implement the new material into laser diode designs useful for high-power optical pumping with broad-area, single-stripe laser diodes. Test and evaluate the new materials for applications in pumping with state-of-the-art facet passivation and coating processes.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The high-power laser diodes are considered as pump lasers of high-power optical transmitters for high-bandwidth lasercom applications for MILSATCOM.
Commercial Application: The high-power laser diodes enjoy strong commercial markets for solid-state and fiber-laser pumping used in manufacturing for materials processing. Examples include Yb-doped and Er-doped fibers.

REFERENCES:

KEYWORDS: Quantum dot laser, quantum well laser, pump laser, high power laser, high reliability laser, radiation hard laser

AF112-057 TITLE: Next-Generation Micro-chip Carrier for Cooling of Satellite Payload Electronics

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

OBJECTIVE: Develop innovative chip carrier cooling solution that efficiently reduces heat flux levels generated by high-power satellite components to levels manageable by the spacecraft’s thermal control system.

DESCRIPTION: In order to provide the U.S. warfighter with the most capable satellite communications, payload processing power is expected to grow in density for the foreseeable future, with higher gate counts producing increased levels of waste heat. The anticipated increase in heat flux generated by next-generation electronics components is driving the need for greater heat spreading capability in the carriers to which these high-heat flux chips are mounted. The goal of this project is to develop an innovative spreader that maximizes the capacity of the carrier to reduce the heat flux for efficient transport of waste heat to the spacecraft primary thermal management system. This spreader must maintain a sufficient coefficient of thermal expansion (CTE) match with foreseen high-heat flux devices that may be mounted to it. The specific objectives are to:
- Spread heat fluxes >300 W/cm² (objective) or >100 W/cm² (threshold) at the chip to levels manageable by primary thermal control system (<10 W/cm²).
- Minimize the temperature drop between the chip and primary thermal control system.
- Survive temperatures from -60 C to 60 C, operate in temperatures from -20 C to 50 C.
- Require zero input power for operation and control.
- Have tailorable CTE from 4 - 17 /C (objective) or a CTE that sufficiently matches foreseen high heat flux devices (~6 - 8 ppm/C).

Current conduction-based heat spreading devices do not provide adequately high conductance in the x, y, and z directions and an adequate CTE-match to meet the requirements of future electronics components. Therefore, the proposed carrier should be a two-phase device that allows efficient heat transfer at the evaporator and condenser surfaces. Two-phase micro-loop heat pipe and heat pipe devices should be considered. The design of the spreader should be scalable and would ideally be versatile enough to be applied to a variety of packaging configurations; however, proposers may select a single relevant packaging style if necessary. Proposed solutions must have high-reliability and maintenance-free operation for lifetimes exceeding ten years. The device must also be compatible with the space environment and conform to space-qualification requirements, including high vacuum, microgravity, radiation, atomic oxygen, low outgassing and high launch loads. Proposers are encouraged to team with system integrators and payload providers to ensure applicability of their efforts and to provide a clear technology transition path.

PHASE I: Develop and show the feasibility of concepts or designs for a chip-carrier cooling solution that can reduce the heat flux generated by future electronics components to levels manageable by the spacecraft’s primary thermal control system.

PHASE II: Finalize the detailed design, manufacture prototype hardware and validate the Phase I solutions through testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Virtually all military satellites could benefit from this research by more efficiently managing payload waste heat.
Commercial Application: Commercial satellite and avionics industries could benefit from this research, which allows higher density packaging.

REFERENCES:


KEYWORDS: thermal control, electronics cooling, micro loop heat pipe, heat spreader

AF112-058 TITLE: Ultra-High-Efficiency, Multi-Junction Solar Cells for Space Applications

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop and demonstrate radiation-hard space solar cells with Air Mass Zero (AM0) efficiencies greater than 40%.

DESCRIPTION: Solar cells with higher efficiencies are needed to reduce array mass, stowed volume, and cost for Air Force space missions. The current state-of-the-art crystalline multijunction solar cells and Inverted Metamorphic (IMM) solar cells are limited by the increasing material and structure complexity to a maximum conversion efficiency of approximately 35% AM0. The desired new solar cell would be lightweight, and radiation hardened, with emphasis on improved performance metrics at the solar array level (>1000 W/Kg) over current state of the art devices. The goal for the new approach would be >40% efficiency AM0. Technologies involving organic-based designs are not expected to be feasible.

The overall goal of this solicitation is to develop innovative technology solutions for ultra-high-efficiency solar cells. In addition to cell performance, AFRL is also interested in realizing a cost-effective design. System level array and integration issues should be considered in the technology design. 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.

PHASE I: Develop and validate innovative approaches for producing thin, flexible, ultra-high-efficiency space solar cells.

PHASE II: Apply the results of Phase I to develop a prototype demonstration of the production process.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: All DOD Spacecraft use multijunction space solar cells for electric power generation. 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.

REFERENCES:


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KEYWORDS: High-Efficiency Solar Cells, Thin Multijunction Solar Cells, Space Power, Solar Arrays

AF112-059  TITLE: Active Vibration Control for Enhanced Satellite Communications

TECHNOLOGY AREAS: Electronics, Space Platforms

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OBJECTIVE: Develop a space-qualifiable, active vibration control system for enhanced Satellite Communications (SATCOM) optical beam pointing.

DESCRIPTION: As battlefield demands grow for higher satellite communications data rates to support enhanced warfighter situational awareness, future military satellite programs must increasingly rely on improving the pointing accuracy of the optical beams used to transfer data between satellites, aerial vehicles and ground components. Due to the data transmission distances involved, which can reach tens of thousands of kilometers, and the broad range of vibration sources, including mechanical switches, solar array drives, thrusters and antenna repositioning, minimizing the vibration at the optical telescope is a critical need for the Air Force. While vibration isolation has traditionally been accomplished passively, recent advances in space-qualified sensors, actuators, and processors has raised the possibility of incorporating active vibration control in future SATCOM systems through a combination of hardware, such as soft mechanical “isolators”, and algorithms, such as Multiple Error Least Mean Squares (LMS) and Clear Box. The purpose of this topic is to explore innovative vibration control hardware and software algorithms and implementations leading to improved communication satellite vibration management. The proposed solution must enable significantly higher data transmission rates, with little or no impact to the overall spacecraft Size, Weight and Power (SWAP) overhead. The technology should support 10 microradian pointing accuracies and vibration suppression exceeding 20 dB. The proposed solution must be capable of handling all relevant mass properties associated with the spacecraft optical pointing and tracking systems while on orbit. In addition, the proposed solution must be capable of withstanding the full range of launch vibrations, and long term (>15 years) exposure to the geosynchronous space environment, including operating temperature range -40 deg. C. to +80 deg. C with up to 1Mrad total dose radiation tolerance.

PHASE I: Explore Satellite Communications (SATCOM) architectures to determine attributes of vibration isolation system. Design vibration isolation system in relevant SATCOM area.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation and optimization of a prototype vibration management system. Fabricate vibration isolation system and characterize for vibration isolation over operational range of frequencies.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications for vibration isolation include space, air and terrestrial systems that utilize highly directed optical beams.
Commercial Application: Applications for vibration management include laser communications pointing and tracking systems, telescope pointing and tracking for celestial observations and camera pointing for photography.

REFERENCES:

KEYWORDS: spacecraft, satellite, vibration, vibration control, vibration management, optical communications, pointing and tracking, vibration isolation

AF112-060 TITLE: Satellite Optical Communication Crosslinks Adaptive Bandwidth System

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: Develop hardware and/or software algorithms suitable for use in satellite communications adaptive bandwidth optical communications applications.

DESCRIPTION: On-orbit optical communications is a critical technology that enables high capacity satellite communications to support anticipated growth in warfighter demands for battlefield communications. The advantages of optical communications over microwave communications include: reduced physical size, reduced weight, reduced power, greater bandwidth, greater immunity from interference, and ability to effectively communicate with a higher number of satellites in any given orbital slot. Optimizing optical satellite-to-satellite crosslink performance through adaptive bandwidth control is of great interest as on-orbit satellites can periodically experience beam displacement due to pointing errors from vibration, which can be caused by a variety of sources such as mechanical switches, solar array drives, thruster firing and antenna repositioning. While the effects of vibration can be reduced through stabilization and additional transmitted power, these solutions add complexity, power consumption, size and weight, and waste heat, while reducing overall reliability. The purpose of this topic is to support research into adaptive bandwidth optical satellite communications crosslink hardware and algorithms to mitigate the effects of impaired optical crosslink performance. Proposed solution must maintain adequate Quality of Service (QoS) performance, including Bit Error Rate (BER) below 1 X 10-9 errors/bit. Proposed hardware solution must be capable of withstanding long term exposure to the geosynchronous space environment, and operate reliably between -40 deg. C to +80 deg. C.
PHASE I: Develop an innovative adaptive bandwidth solution supporting robust optical communications crosslinks and validate through simulation and modeling where possible.

PHASE II: Construct hardware and/or software prototype. Characterize for ability to maintain requisite optical link QoS during the full range of operation beam direction excursions, bandwidth, latency and operating temperature range.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include communications satellite programs potentially capable of block upgrades to optical crosslinks, like Advanced EHF and Wideband Global SATCOM programs.
Commercial Application: Commercial applications include satellites and avionics communications applications in which optical links are being considered.

REFERENCES:


KEYWORDS: satellites, satellite communications, crosslinks, adaptive beamwidth, beamwidth, optical transmitter, optical receiver, laser transmitter, electrooptic receiver

AF112-061 TITLE: Development of Ultracapacitors with High Specific Energy Density

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop an ultracapacitor with specific energy density > 30 Wh/kg that can potentially be used as a standalone power system in a space platform.

DESCRIPTION: The need for efficient energy storage systems in space platforms is paramount as expected lifetime and power needs continue to increase. Ultracapacitors have several advantages over traditional batteries including, cycle life in excess of 500,000 and extremely high charge/discharge rates with no degradation to lifetime. However, ultracapacitors do not have very high specific energy density. Current production ultracapacitors are < 10 Wh/kg. In order for ultracapacitors to be considered as a standalone energy storage system, the specific energy density needs to be increased to values comparable with that of NiCd batteries. This proposal seeks innovative materials for use as electrodes and electrolytes for ultracapacitors that can demonstrate energy density > 30 Wh/kg, while maintaining the advantageous properties of current ultracapacitors (e.g. cycle life, specific power density). The end goal of this technology will be as an energy storage system with the capability of supporting a 15-year mission in Geosynchronous Earth Orbit (GEO) and 5 years in Low Earth Orbit (LEO) after 5 years of ground storage.

PHASE I: Develop, evaluate, and validate innovative materials for use in an ultra-high, specific energy density ultracapacitor.
PHASE II: Optimize the materials and processes learned from Phase I to produce a prototype ultracapacitor with demonstrated specific energy density > 30 Wh/kg while demonstrating high cycle life (>100,000) and high charge/discharge capabilities.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Spacecraft require energy storage. Ultracapacitors with energy densities of Ni-Cd can be enabling for long lifetime missions requiring many charge/discharge cycles or high power applications.
Commercial Application: Commercial communications spacecraft and NASA spacecraft would use this technology.

REFERENCES:

KEYWORDS: ultracapacitors, supercapacitors, specific energy density

AF112-062 TITLE: Analog-to-Digital Converter for High Depth of Nulling SATCOM

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: Develop an analog-to-digital converter suitable for use in space and able to support waveform processing to neutralize high-power jammers.

DESCRIPTION: As Satellite Communications (SATCOM) jamming technology continues to advance, satellite payload demodulation processing must provide increased signal resolution during satellite processing to maximize the jammer depth of nulling. Because the analog-to-digital converter (ADC) plays a pivotal role in maintaining signal resolution, the Air Force seeks innovative ADC designs that support the depth of nulling required to counter Radio Frequency (RF) signal jamming. In addition, the ADC fidelity must support RF processing of modulation modes such as 16-Quadrature Amplitude Modulation (QAM) while minimizing errors and spurious signals. The ADC must reliably operate over a mission duration that can reach 15 years in an environment that includes temperature extremes and high radiation exposure associated with geosynchronous space operation. The objective of this topic is to develop a high depth of nulling, low-power, analog-to-digital converter capable of an effective resolution bandwidth (ERBW) > 1 GHz (sample rate >2 GSPS) and Effective Number of Bits (ENOB) >16 bits. This implies a state-of-the-art aperture uncertainty of < 100 fs. Additional goals include linearity (.5 LSB), gain flatness <.1 dB [TBR], channel-to-channel isolation >80 dB, operating temperature range -40 to +80 deg C., power consumption <10W and radiation total dose tolerance > 1 Mrad (Si) across a wide temperature range of -55C to +125C.

PHASE I: Evaluate satellite communication-based applications and design an analog-to-digital converter meeting design objectives identified above that enable High Depth of Nulling SATCOM. Where possible, validate design through modeling and simulation.
PHASE II: Leverage Phase I results to develop a prototype and characterize for all important parameters, test and validate the characteristics.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High-data-rate, analog-to-digital converters could find use in high-speed data processing for communications applications.
Commercial Application: This research also benefits commercial consumer electronics requiring high precision analog-to-digital converters.

REFERENCES:

KEYWORDS: analog-to-digital converter, effective number of bits, sample and hold, conversion rate, flash converter, resolution

AF112-065 TITLE: GPS Autonomous Micro-Monitor

TECHNOLOGY AREAS: Battlespace

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

OBJECTIVE: Design/develop an advanced, GPS-based, extremely small, lightweight, low-power, fully autonomous ionospheric monitor.

DESCRIPTION: Ground-based Global Positioning System (GPS) measurements of ionospheric total electron content (TEC) and ionospheric scintillation are today the major source of data supporting the specification and forecasting of ionospheric effects and impacts on DoD radio-based systems, including communication, navigation, surveillance and geolocation. However, availability of GPS monitors is extremely limited in oceanic regions and in warfighting theaters. Thus, specification and forecast of potential impacts to DoD radio-based communication, navigation and surveillance systems may be least available where most needed.

A new generation of advanced GPS-based ionospheric monitors is required to address this shortfall. These monitors require innovative design to exploit miniaturized 2-frequency GPS technology, GPS receiver software techniques, ionospheric measurement algorithms, and robust housing. These GPS-based ionospheric monitors must be lightweight, low-power, fully autonomous, and able to provide fully processed and highly accurate ionospheric TEC and scintillation parameters in near-real-time (at least 5-minute updates) in highly compressed, small data packets suitable for relay via low-data-rate satellite link. Host platforms would be stationary or low-dynamic, such as: existing and new oceanic monitoring buoys, remote solar-powered unmanned sites, and disposable monitors deployed into theater locations. Monitors must have robust capability for autonomous cold (re)-start, and operation on host platforms lacking any inbound communication or control.

Ionospheric products needed include: absolute ionospheric TEC, ionospheric amplitude scintillation index: “S4”, and ionospheric phase scintillation: “sigma-phi”, as well as uncertainty estimates for these products. Monitors will also need robust capability for autonomous detection, calibration, and, mitigation of error sources for ionospheric products and capability to track and report system health/status information.
Specific technical challenges are:
1. Miniaturization. A key improvement needed is to incorporate the needed functionality in a very low-power, small footprint, host platform friendly component, since ionospheric measurement applies unique constraints on the antenna, receiver, and processing.
2. Autonomous operation. A key improvement needed is capability for measurement auto-calibration, and autonomous assessment of products’ quality and system health.
3. Packaging. A key improvement needed is design of a small yet robust packaging configuration that incorporates an antenna, possibly tailored specifically for ionospheric measurement, a 2-frequency GPS receiver, and required processing. Monitors must operate in extremes of temperature, moisture and salt corrosion.

Develop a design, demonstrate required technology, build, and field-validate a new generation of light weight, low power, autonomous, GPS-based ionospheric monitors.

PHASE I: Design and develop advanced light-weight, low-power, autonomous, GPS-based ionospheric monitors.

PHASE II: Develop, build and test autonomous ionospheric monitors. Validate accuracy of reported ionospheric parameters and robustness of autonomous operation. Deploy monitor(s) to appropriate field location(s) to demonstrate performance in field conditions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Space weather monitor retrofits on commercial or Navy ships. Space weather monitors (disposable) in theaters, or on bouys.
Commercial Application: Ocean buoy monitoring of tropospheric water content. Ocean-based monitors to expand FAA’s Wide Area Augmentation System (WAAS) and other commercial navigation augmentation systems.

REFERENCES:

2. Seo, Jiwon Seo; Walter, Todd; Marks, Edward; Chiou, Tsung-Yu; and Enge, Per, "Ionospheric Scintillation Effects on GPS Receivers during Solar Minimum and Maximum," International Beacon Satellite Symposium 2007, Boston, MA, 11-15 June 2007.


KEYWORDS: GPS, ionosphere, ionospheric monitor, autonomous, micro, disposable, total electron content, TEC, scintillation, space weather, ionospheric impacts, RF systems

AF112-066 TITLE: Fusion of Space Weather Data with Satellite Telemetry

TECHNOLOGY AREAS: Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.
OBJECTIVE: The objective of this effort is to develop algorithms that would correlate space environmental impacts with telemetry data.

DESCRIPTION: Many satellite anomaly conditions are hard to characterize by examination of only telemetry data. Anomalous conditions can occur because of internal satellite malfunction or telemetry data can be erroneous due to environmental conditions. The objective of this topic is to develop an innovative, non-deterministic toolset that would fuse and correlate telemetry events with space weather and other external context information. This toolset should leverage existing interface standards (such as XML) to facilitate successful integration with existing programs. In addition, it should take into account visualization and scalability to provide the operator and decision-makers with intuitive situational awareness on global effects across satellite constellations. The resulting system would fuse multiple and disparate sources of data to accurately assess a given abnormality cause and its associated confidence interval, while continuously providing real-time Blue force status updates. An area of increased recent emphasis is assisting operators and decision-makers in understanding the time varying situation as unpredicted, highly improbable (i.e., Black Swan) events unfold and determining the extent of mission impact. These highly improbable Black Swan events must be able to be discerned from the more probable space weather events. Past efforts in telemetry monitoring include the application of neural networks to the problem of anomaly detection. Of interest would be how this data can be fused with space weather data for enhanced anomaly and threat assessment.

PHASE I: Phase I expectations include development and demonstration of an unclassified proof of concept, plus design for an operational system.

PHASE II: Expectations include prototype implementation of the Phase I design, including demonstration of software on realistic data sources and scenarios of contractor's choice with government guidance. Algorithms must be flexible to be adapted to new data sources without recoding and have the ability for external user configuration.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The technology would be applicable to both the Space and Missile Center Space Superiority Wing and the Electronic Systems Center JSpOC Mission Systems (JMS) program. Development must be compatible with the JSpOC Mission System and ready for AFRL validation and verification (V&V).
Commercial Application: Commercial versions of this technology could also be deployed. While there might be differences between the data sources, outputs of both versions should be compatible and interoperable.

REFERENCES:

KEYWORDS: Satellite anomaly assessment, Space weather data, Data Fusion, Satellite-as-a-Sensor
bands. Development of a robust detector that responds from 0.3 to 1.55um could simplify laser warning receiver concepts as well as ambient temperature multispectral surveillance sensors. Silicon-based detectors that respond out to 1.55 microns have been developed by incorporating other semiconductor materials with silicon material using a femtosecond-laser to irradiate the silicon. When this is done in a sulfur hexafluoride (SF6) atmosphere, the resulting silicon comprises a high-sulfur-doped, nanostructured surface layer that exhibits room temperature photoconductive gain and enhanced Infrared (IR) absorption. Other semiconductor materials may improve the SWIR response. In the visible region, the photoconductive gain rivals that of an avalanche gain. If used in a Time Delay and Integration (TDI) mode, the readout noise could then be less significant. Before this technology can be considered for a space application, it needs to be characterized thoroughly. This project would develop a model of the detector material performance; verify that model so that its performance in a large array could be predicted; and then build an array that could be used either in a staring mode or a TDI mode for test. The model would need to address linearity, frequency response, thermal dissipation, cross talk, uniformity, radiation and laser hardness, spectral sensitivity and noise sources. The desired array size is 128 square or larger to provide an adequate sample. With silicon detectors, with the expanded spectral range and photoconductive gain, measurement of the properties would be feasible.

PHASE I: The respondent would create a model of a silicon-based detector that responds from 0.3 to >1.55 micron.

PHASE II: The respondent shall design and fabricate a prototype silicon array that detects 0.3-1.55 micron radiation. It is desirable that the contractor mates the detector array to a suitable readout chip, tests the array and documents the results. The array design should support both staring and TDI modes. The array developed and test results shall be made available to AFRL for independent testing by AFRL.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Silicon-based detectors that respond from 0.3 to > 1.55 um are needed for detection of lasers in this range for MDA and AF applications, such as universal situational awareness, and surveillance.
Commercial Application: Digital night vision for homeland security/law enforcement, solar cell inspection, plastics sorting for recycling, noninvasive blood-chemistry monitoring, free-space communication, J band study, etc.

REFERENCES:

KEYWORDS: Silicon, Black silicon, visible detector, SWIR detectors

AF112-069 TITLE: Autonomous On-Board Control of Satellites for Space Superiority

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Research and develop flight software technologies to enable real-time autonomous on-board constraint and model-based planning of spacecraft activities to enhance satellite responsiveness.

DESCRIPTION: Current satellite operations are labor-intensive and are not equipped to respond to real-time events. Without embedded flight autonomy, the time to image locations, send the data to the ground, and then to identify and respond to events can be on the order of days. Surveillance missions are less than effective with increased
timelines resulting in the inability of warfighters to respond to observations. In support of future Responsive Space and Space Superiority missions, monitoring and command and control functionality, which traditionally has been hosted on the ground, needs to be migrated on-board the satellite. Investments have been made in developing specialized sensors to detect specific threats. What is needed is a more robust capability to detect opportunistic events on-board, plan resulting actions and then execute activities. This leads to a requirement for automated software in several areas, which would include sensor processing and control, on-board planning, task execution and data fusion. The objective of this topic is to research and develop the capability to perform autonomous planning of spacecraft activities based on events such as processed imagery, threats, and spacecraft Bus anomalies. Autonomous Planning is a complex field of Intelligent Systems that requires innovative solutions for all but simple scenarios. The reason for this is that most comprehensive solutions to the problem are NP-Complete. Event characterization can be determined from the fusion of on-board processing of sensor data with other information of interest, including historical information, telemetry readings and environment data. To properly scope this topic the focus is only on research and development of autonomous planning technologies that can determine courses of action to mitigate events encountered. Technologies to actually detect events or anomalies are outside the scope of this topic. To correctly perform this planning function, embedded knowledge of satellite state, environment, operating constraints and mission objectives must be very accurately maintained. This on-board knowledge base is necessary to robustly plan resulting actions. Once these activities are determined, they must then be properly executed in the correct sequence and at the appropriate times. This topic seeks to research, develop and demonstrate Artificial Intelligence (AI) Planning technologies to enhance embedded satellite autonomy. Dependent on the proposed effort, the research and development may be ITAR restricted.

PHASE I: The objective of Phase I is to research and develop a robust and scalable on-board planning system architecture that would enable real-time response to events as described in the objective. A proof-of-concept demonstration using a subset of reasoning techniques at a lower TRL is highly desirable.

PHASE II: Build on the architecture developed in Phase I and increase the technology readiness level by demonstrating the technology in either an Air Force Research Laboratory (AFRL) or Operationally Responsive Space (ORS) Goddard Space Flight Center Mission Services Evolution Center (GMSEC) testbed. Use of real data sources and subsystem models is envisioned.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This topic is addressing Space Superiority and Responsive Space missions. The initial target customer is Operationally Responsive Space, however the research is applicable to future SMC missions. Commercial Application: The technologies would be applicable to many NASA missions particularly those that are in deep space where bandwidth limitations are inhibitors to responsiveness and requiring autonomous operations.

REFERENCES:

KEYWORDS: Responsive Space, Autonomous Sensor Processing, Space Situational Awareness, Satellite Autonomy

AF112-071 TITLE: Innovative Rapid Response Multi-Mission Space Vehicle Bus Technologies

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: This topic seeks to identify, develop and demonstrate innovative technologies enabling rapid design, development, assembly, integration, test and operations of small space platforms (busses, components, subsystems, modeling, simulation, hardware and software). Current capabilities in this topic area are overly complex, non-standard, use excessive mass and power, are limited in flexibility and application and typically require years to acquire. This topic seeks novel capabilities to reduce the impediments and increase operational flexibility while maintaining performance.

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 for anticipated needs and within several months to no more than a year for unanticipated needs. This capability is essential to meet operational needs to provide for rapid transition from development to delivery of new or modified capabilities, fill unanticipated gaps in capabilities, exploit new technical and operational innovations, and respond to unforeseen or episodic events for a variety of space missions.

It is desired to develop technologies that, while maintaining mission assurance, could cut integration time in half, decrease satellite costs to under $10M (vice current thresholds of $40-$70M) for a small satellite bus and “out-of-the-blue” order delivery to under 12 months (average long lead for components is 14 to 20 months) for a small satellite that has a payload of 150 kg requiring 1200 W (130 W Orbit Average Power), and reduce overall bus mass from current objectives of 250kg to under 100 kg. Subsystem/component innovation areas of interest are in: software modeling and development tools to reduce development, test and operation capability; thermal subsystem components/management providing rapid implementation and adaptive control over a variety of orbits; electrical power systems, including advanced solar array capability, batteries, power distribution systems to reduce lead time, mass, and volume while maintaining power delivery capability; advanced structures reducing analysis requirements and increasing scalability and flexibility; autonomous operations reducing manpower requirements and decreasing operational complexity; advanced test techniques and capabilities reducing time to operational capability while maintaining mission assurance; advanced flight software and algorithms and high speed low power command and data handling components to meet real-time operations of advanced payloads and sensors; innovative control systems, including sensors, momentum and torque control devices to provide lower mass, lower power, low jitter, and high response rates; and advanced propulsion capability for high-velocity changes and rapid control.

The objective space vehicle architecture for these technologies will be inserted into standardized interfaces, modular hardware and software components, and have configurations compatible with a variety of small launch vehicles (air and ground launched). The desire for the bus is to be flexible and adaptable while maintaining rapid response with acceptable mission assurance and performance at low total program cost.

Contractors are strongly encouraged to work closely with the Operationally Responsive Space (ORS) Office and its contractors to ensure technical efforts are consistent with overall responsive satellite development goals. Proposed concepts should strive for prototypes that can eventually achieve or support rapid response system development and flexible system integration for the widest range of relevant satellite capabilities.

PHASE I: Identify, model, and demonstrate a proof-of-concept unit for the proposed technology concept which should lead to a significant reduction in cost, lead time, power, mass, development to operational capability or increase in flexibility or performance while maintaining mission assurance. Utilize test results to identify key technical challenges, develop a mitigation strategy, and develop the Phase II program plan.

PHASE II: Design, build and test a prototype-level concept that meets the ORS Office’s responsive space program functional and interface requirements.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The proposed effort would develop satellite bus component and process technologies that are applicable for ORS and other military satellites.

Commercial Application: The developing contractors will also market their products to commercial satellite vendors, as well as NASA and other civil space developers, providing rapid low cost access to space.

REFERENCES:
1. Baghal, Lisa (Student) and Swenson, Eric (Associate Professor) (Air Force Institute of Technology); Finley, Charles J. (DoD Operationally Responsive Space Office), "Streamlining System Level Test for Responsive Spacecraft: Results and Lessons Learned from the ORS Rapid AIT Demonstration," Responsive Space 8 paper, AIAA-RS8-2010-2001.

2. Finley, Charles J. (DoD Operationally Responsive Space Office) and Bhopale, Apoorva (Milennium Engineering and Integration Company), "The 7-Day Solution: How ORS Will Answer The Rapid Call-up Challenge," Responsive Space 7, Paper Number RS7-2009-6003.


KEYWORDS: Satellite bus, modular satellite, standardized satellite interfaces, spacecraft, satellite, responsive space, responsive bus, operationally responsive space, ORS, modular open standards approach, MOSA, space vehicle

AF112-072 TITLE: Programmable Frequency Satellite Transceiver for Small Spacecraft

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: The objective of this research project is to develop a satellite radio transceiver suitable for small spacecraft for which the operating frequency can be programmed prior to launch or while on-orbit.

DESCRIPTION: For satellite radio transceivers, the frequency allocation and approval process can take over 36 months. This precludes assured knowledge of the frequency prior to procurement and integration of crystal-based transponders (transceivers). Spectrum management now relies more on off-channel assignments within the Space-Ground Link System (SGLS) band and is converting satellite services to Unified S-Band. Therefore, satellite manufacturers can no longer rely on anticipating a frequency assignment to conform to the availability of off-the-shelf crystals. This poses a significant technical and programmatic risk to the Air Force.

It is desired that users be able to program the transceiver and lock to an assigned frequency within the SGLS band or the Unified S-Band as late as 30 days prior to launch or even while on-orbit. This will enable the Space and Missiles Systems Center’s Space Test Program (STP) and other space programs to continue space vehicle integration and testing in parallel with the frequency approval process. Once a frequency assignment is complete, the satellite manufacturer should be able to program the installed transceiver either through a test port on the space vehicle or through the command path. This level of flexibility constitutes a considerable advantage over the current state-of-the-art for satellite radio transceivers, and is the primary technical goal of this research effort.

Additionally, this effort is focused on small spacecraft, including pico-satellites (10 kg) and cube-satellites (1 kg). It is imperative that key performance metrics (the size, weight, power, and cost) be minimized through the development of innovative designs and packaging, and by leveraging advancements in the state-of-the-art in space electronic components.

A key technical barrier is that the transceiver must enable compliance with National Telecommunications and Information Administration (NTIA) standards, and must be compatible with SGLS and military communication protocols. Secondly, the transceiver design should be space-qualifiable, launch-survivable and operate in a low Earth
orbit for at least 3 years. Finally, the proposed solution should be able to replace existing transceivers and interoperate with existing ground support equipment without imposing additional requirements on the spacecraft.

The Space and Missiles System Center Space Test Program (SMC/STP) plans to identify a minimum of two spacecraft with different frequency allocations for possible implementation and demonstration.

PHASE I: Contractor shall demonstrate key performance metrics of their proposed design using non-space-qualified components. Space-traceability should be demonstrated by analysis. Interface compliance should be validated by analysis.

PHASE II: During Phase II, the contractor shall build, test, and qualify a prototype device. The contractor shall deliver the prototype device for integration, and support a flight experiment (to be identified by SMC/STP) to evaluate performance of the transceiver.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The programmable transceiver is applicable to future Department of Defense operational spacecraft and research missions that utilize small spacecraft.
Commercial Application: The programmable transceiver is applicable to future NASA, commercial, and university spacecraft and research missions that utilize small spacecraft.

REFERENCES:

KEYWORDS: Programmable Transceiver, Satellite Communications, Unified S-Band, Space Test Program, Responsive Space

AF112-073 TITLE: High-Efficiency Thin Film Solar Cells for Spacecraft

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Increased efficiency of thin film solar cells for Air Force space applications.

DESCRIPTION: Presently, CIGS and amorphous silicon (a-Si:H) solar cells are being integrated into lightweight flexible-thin-film photovoltaic arrays for space applications. However, these technologies are much less efficient than state-of-the-art multijunction solar cells. Amorphous Silicon and CIGS solar cells have continued to make steady increases in cell efficiency since the late 1970’s, with top Air Mass Zero (AM0) efficiencies approaching
10% for cells on polymer substrates. Yet, many opportunities for increased efficiency in Amorphous Silicon and CIGS-based cells remain as demonstrated by NREL’s 19% (AM1.5) device. A promising approach under this topic is the development of multijunction, silicon-based or CIGS-based cells. This advance in the state-of-the-art technology will require the investigation of new material compositions and processing conditions. The new materials must be compatible with deposition processes for fabricating solar cells on flexible polymer substrates in a roll-to-roll process.

The goal for this effort is to increase the light stabilized efficiency of thin film solar cells to an AM0 efficiency of >15%. The thin film solar cell 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. AIAA S-111 solar cell standards will be used to evaluate the subject material systems throughout the course of this SBIR contract. Concentrator or organic photovoltaic systems are not considered to be feasible and will not be evaluated.

PHASE I: Develop methods for increasing the efficiency of Amorphous Silicon cells or CIGS solar cells.

PHASE II: Finalize development of all deposition processes necessary to demonstrate the viability of the design developed during Phase I (in a laboratory environment). Demonstrate the feasibility of using the resultant process for fabrication of a candidate thin film solar cell. Samples cells will be provided to the Air Force Research Laboratory for evaluation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The availability of high-efficiency, low-cost, thin film solar cells could be applied to a wide range of spacecraft, and would reduce life-cycle cost of satellite systems for military application.
Commercial Application: Commercial communications satellites and NASA interplanetary missions could use this technology.

REFERENCES:
2. Xu, Xixiang; Su, Tining; Ehlert, Scott; Pietka, Ginger; Beglau, Dave; Zhang, Jinyan; Li, Yang; DeMaggio, Greg; Worrel, Chris; Loard, Ken; Yue, Guozhen; Yan, Baojie; Beemick, Kevin; Banerjee, Arindam; Yang, Jeff; and Guha, Subhendu, “Large Area Nanocrystalline Silicon Based Multi-Junction Solar Cells with superior Light Soaking Satiability,” United Solar Ovonic LLC, Presented at the 35th IEEE Photovoltaics Specialists Conference, Honolulu, Hawaii, 20-25 June 2010.

KEYWORDS: Solar Cells, Power Generation, Thin-Film Photovoltaics, Amorphous Silicon, Microcrystalline Silicon, Multijunction, Copper Indium Gallium DiSelenide (CIGS)
TITLE: Hybrid Multi-signature Data Fusion for Remote Object Identification and Characterization

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop and demonstrate a combined analog and digital system capable of high-speed fusion of parametric target data from multiple sources for space object identification and characterization.

DESCRIPTION: Near real-time, efficient fusion of target data from different imaging and non-imaging sensors in multiple spectral domains (coherent and incoherent, visible, midwave infrared (MWIR), long-wave infrared (LWIR), etc.) to determine various aspects of a target’s state and features is required for enhanced space surveillance and protection. The incongruous nature of these data streams traditionally have stymied full exploitation of the information collected by differing sensors. Innovative fusion of heterogeneous data is therefore needed to fully exploit the complexity of the information contained in the collected data and maximize a global performance, as opposed to local optimization of each individual sensor. Much of present-day digital domain-based sensor fusion is focused on the a posteriori merger of overlapping imagery, which varies in form (spectral band, coherence, etc.) for each image. Such fusion has latency on the order of the frame rate of the sensors employed and largely relies upon a loosely-coupled set of sensors. On the other hand, a considerable volume of heterogeneous data is received from sensors observing the target (calorimetric, polarimetric, spectral, Doppler, ranging, and a priori orbital elements), which provide scalar or vector data at a much greater rate than imaging systems. The information may be fused in analog domain at near-real-time speeds to build up an overall estimate of the state-of-a-target complementary to that of the imaging components. Such approaches are commonly used in subpixel imaging and similar methods. A combined analog and digital fusion may not only be used as inputs to a posteriori image fusion, but also to prioritize and optimize the various imaging system parameters in much the same fashion as hearing and other senses augments vision in human beings. Figures of merit in assessing algorithm effectiveness include improvements in identification and characterization of a space object, enhanced detection probability, and reduced false-alarm rates.

PHASE I: Develop, analyze and down-select an optimal technique capable in multi-signature target characterization and enabling an integrated hybrid data fusion approach. Demonstrate the feasibility of the down-selected concept in a laboratory environment.

PHASE II: Refine the Phase I preliminary design to fabricate, integrate and assemble a prototype system for hybrid multi-signature target characterization with explicit control of sensor parameters. Measurements should be carried out to assess system performance such as image resolution, vibration spectrum and range under realistic application scenarios.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The hybrid processing techniques developed under this effort will have military remote sensing, active tracking of fast-moving targets including missiles, satellites and cross-communication systems.
Commercial Application: The prototype will reduce the volume of downlink data and on-board processing. Other non-military applications include medical instruments, industrial processing and product quality control.

REFERENCES:


KEYWORDS: Global and Space Situation Awareness, Situation Assessment, Information Fusion
TITLE: Concentrator Space Photovoltaic Solar Arrays

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop innovative concepts for a high-concentration-ratio Space Photovoltaic Array

DESCRIPTION: Presently, concentrating solar arrays have not seen widespread deployment on spacecraft. This is due to the tight pointing accuracy required for concentrating systems, the need to keep the solar cells at reasonable temperatures under high concentration, solar array structures designed specifically for concentrating solar arrays and premature failure of a low concentrating design flown on commercial satellites. There has been recent development of terrestrial concentrator systems, which have demonstrated 44% efficiency at concentration levels of 500 suns with a solar spectrum of Air Mass 1.5. Both point-focus and line-focus concentrators have been developed for the terrestrial market. This development has renewed interest in space concentrating solar arrays due to the increase in efficiency, potential reduction in solar array cost and increased radiation tolerance from both natural and manmade sources. The high cost of high-efficiency Inverted Metamorphic Multijunction (IMM) or other emerging solar cell technologies will ultimately have an impact on the affordability of solar array sizes in the 100 kW range. The goal for this technology development is for a solar array that is a minimum of 100 kW in power producing capability.

There is a need for concentrating optics that are capable of a concentration ratio (up to 500x) that would enable 40% efficiency of the concentrating solar array with a solar spectrum of Air Mass 0. The off-track efficiency loss for the solar array should not exceed 10% of maximum power output with off-track pointing errors of +/- 2 degrees. The thermal management system should be capable of maintaining solar cell temperatures at levels that are compatible with the 40% efficiency target with a solar spectrum of AM0. The target value for specific power rating of the concentrating solar array is 300 watts per kilogram. Considerations for volumetric specific power (W/m3) in the stowed position should be included in the proposed design.

The concentrating solar array 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: Perform preliminary analysis and conduct trade studies to validate concepts for the concentrating solar array. Acquire test results and related performance information in support payoff estimates.

PHASE II: Fabricate and deliver engineering demonstration unit. Show the flexibility of delivering reliable power with the solar array off-track errors specified. Identify radiation impacts upon components of the concentrating solar array.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Availability of high-efficiency, low-cost solar concentrating systems could be applied to a wide range of spacecraft, and would reduce life-cycle cost of satellite systems for military applications.
Commercial Application: Commercial communications satellites and NASA interplanetary missions could use this technology.

REFERENCES:

AF112-076

TITLE: Autonomous Satellite Threat Processing and Response

TECHNOLOGY AREAS: Electronics, Space Platforms

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OBJECTIVE: Research and develop technologies to enable autonomous information fusion and decision making to support reduction of timelines for missile warning and response.

DESCRIPTION: Today's Air Force satellites are not equipped to respond to real-time events, whether those are due to component failure, the environment or man-made. This has the effect of requiring ground operations to identify, characterize, and mitigate most threats or to accurately characterize evolving threats such as the launch of a missile. Without embedded flight autonomy and, more specifically, the ability to fuse disparate information sources on-board, the time to identify and respond to events can be on the order of days. Satellites and/or other entities of interest are at increased risk because of these long timelines. In addition, some surveillance missions are less than effective with increased timelines resulting in the inability of warfighters to respond to observations. As an example, monitoring missions utilizing Infrared (IR) must be able to quickly detect and accurately characterize an event in order to respond in a timely manner. Missile warning, monitoring, characterization and command and control functionality, which traditionally has relied heavily on ground operations, needs to be migrated on-board the satellite. Investments have been made in developing specialized sensors to detect specific threats. What is needed is a more robust capability to detect and isolate non-deterministic events, characterize these events, plan resulting actions and then execute activities. Each of these areas in itself is very complex with a wide array of potential solutions. The focus of this SBIR topic is to research and develop technologies to perform information fusion on board with the information sources to be considered to include telemetry, sensor data, and environmental conditions. Event characterization can be determined from the fusion of on-board processing of sensor data with other information of interest, including historical information stored on-board. This requirement leads to several challenges. Event characterization is difficult due to the range of threat signatures and backgrounds. False detections must be minimized and positive characterizations maximized. To correctly perform this function, embedded knowledge of satellite state, operating constraints and mission objectives must be very accurately maintained. The results of the information fusion system would be input into a planning or execution system, which are each very challenging areas by themselves. To properly scope this effort, the focus of this topic is on the information fusion component. This topic seeks to develop and demonstrate information fusion technologies that could serve as one component of a larger autonomous flight system.

PHASE I: For selected scenarios, develop on-board software technologies to perform autonomous information fusion and threat characterization. The research should leverage off of previous research in sensor processing, autonomous planning and task execution.
PHASE II: Build on the architecture developed in Phase I and incorporate higher fidelity components at all fusion levels. This phase will target a set of realistic scenarios and operating constraints. Phase II will culminate in a high-fidelity prototype demonstration of the system that clearly shows the utility to Space Superiority missions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This topic is addressing Space Superiority and Surveillance missions. The initial target customer for this technology is the Space and Missile Systems Center (SMC).
Commercial Application: Applicable to many NASA missions, particularly those that are in deep space where bandwidth limitations are inhibitors to responsiveness and thus requiring autonomous operations.

REFERENCES:


AF112-077 TITLE: Advanced Algorithms for Next Generation Wide Field-of-View (WFOV) EO/IR Staring Sensor Exploitation

TECHNOLOGY AREAS: Information Systems, Space Platforms

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OBJECTIVE: Develop advanced algorithms able to provide significant improvements in multiple, closely-spaced target detection and state vector estimation for wide field of view sensors viewing cluttered scenes.

DESCRIPTION: Enhanced sensors are being developed for Space-Based Infrared System (SBIRS) and other space-based sensors, for surveillance applications, to provide improvements in early launch detection and global tracking, with a wide range of secondary applications in intelligence, surveillance and reconnaissance. These next-generation, wide-field-of-view (WFOV)-electro-optic (EO) and infrared (IR) sensors will be composed of focal plane arrays with increased numbers of detector elements and improved sensitivity, combined to provide full earth hemisphere staring coverage. There is a need for development of advanced algorithms which 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 targets 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 and lower altitude maneuvering targets, that cannot be detected with current WFOV staring sensors. More specifically, a requirement is 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. Another requirement is development of algorithms to effectively 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. This topic solicits development of innovative algorithms that can be shown to be amenable for implementation 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 an innovative, algorithmic approach for providing significant improvements in low-observable, multiple, closely-spaced target detection and state vector estimation using WFOV EO/IR staring sensor data. Consider implementation in enhanced processors.

PHASE II: Develop prototype algorithms. Demonstrate potential ability to meet operational specifications, including rapid detection requirements 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.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The first use of this technology is envisioned for future enhancements of SBIRS, but could also be applied in other systems, including STSS operating in the wider-FOV target acquisition mode.
Commercial Application: Concept may be useful for monitoring launches of commercial satellites, monitoring debris in lower-earth orbits, or for aircraft and traffic monitoring from higher-altitude aircraft.

REFERENCES:

KEYWORDS: wide field-of-view sensing, next generation sensors, clutter suppression, low observable target tracking, closely-spaced objects

AF112-078 TITLE: Carbon Nanotube Radiation-Hardened Logic Device

TECHNOLOGY AREAS: Materials/Processes, Electronics, Space Platforms

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

OBJECTIVE: Develop and demonstrate a radiation-hardened logic device utilizing carbon nanotube technology.

DESCRIPTION: Digital logic is extensively utilized in communication satellite payloads for a variety of applications, and the availability of reliable, radiation-hardened logic with significantly higher density would dramatically reduce parts count, lower size, weight and power consumption, and enhance the overall reliability of the payload. Evaluation of Carbon Nanotube (CNT)-based logic suggests CNT logic is inherently radiation hard and can be scaled down to dimensions as small as 0.06 µm2. Before nanotube-based logic is viable for insertion into space, a fabrication process must be developed and proven that is both robust and can leverage CNT feature size advantages into a much higher density part. Obstacles include achieving a reliable and high-yield production process, including precision control of cross-wire patterns, spacing and tube growth. The purpose of this topic is to support the development of a radiation-hardened CNT logic device suitable for insertion into geosynchronous

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satellite applications. Goals include logic density \( >10M \) gates per device, radiation tolerance \( >100\text{krads(Si)} \) total dose, immunity from Single Event (SEE) radiation effects and operating temperature range from \(-40 \text{ to } +80 \text{ deg C.}\)

PHASE I: Survey nanotube-based logic implementations and select promising approach. Design nanotube-based memory prototype and validate design through modeling and simulation.

PHASE II: Fabricate nanotube device and characterize for access time, operating voltage, radiation characteristics and operating temperature range.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Virtually all military satellite programs could benefit from the availability of high-density, radiation-hardened logic.
Commercial Application: Commercial nanotube applications include computer memories, MP3 music players, and cell phones.

REFERENCES:

KEYWORDS: Carbon nanotube, logic, radiation hardened, logic device, ASIC, gate count, microelectronics

AF112-079 TITLE: High-Capacity Satellite Common Data Link

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: Develop an advanced Satellite Communications (SATCOM) Common Data Link (CDL) to accommodate emerging higher data rates anticipated for next generation AISR platforms.

DESCRIPTION: As the Office of the Secretary of Defense (OSD) mandated a wideband communications standard for airborne Intelligence, Surveillance and Reconnaissance (ISR) platforms, the CDL facilitates ISR communications between Unmanned Aerial Vehicles (UAVs) and battlefield theater of operations. As UAV focal planes become smaller and lighter, and multiple focal planes can be installed on a single UAV to broaden the effective field of view (FOV), Airborne Intelligence Surveillance and Reconnaissance (AISR) data rates can be expected to significantly increase. Previous technology demonstration programs have been required to compress outgoing data to accommodate the existing CDL data rate. This reduces data throughput and increases time of transfer to the end user. A high bandwidth SATCOM data link which supports beyond-line-of-sight AISR, and which is capable of supporting both existing in-theater CDL infrastructure and expanding data rates could prove a cost-effective solution for beyond-line-of-sight AISR, allowing data access to intelligence analysts located in the Continental United States (CONUS). The purpose of this topic is to support affordable hardware and software solutions meeting the demands of a next-generation, high-bandwidth SATCOM CDL link. The fundamental goal of this endeavor is to develop a high bandwidth CDL that is capable of keeping pace with current focal plane array data rate outputs, which enables the transfer of raw data at the uncompressed rate to analysis end users. An additional
requirement is compatibility with existing CDL standards, and the requisite form, fit and function to retrofit into existing applications.

PHASE I: Research viable large bandwidth CDL implementations that are compatible with existing CDL structures.

PHASE II: Develop hardware and software prototypes that have been validated through modeling and simulation. Write final report characterizing results.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Virtually all military satellite programs could benefit from the availability of high-density, radiation-hardened logic.
Commercial Application: The commercial avionics industry could utilize high capacity CDL to enhance telematics.

REFERENCES:

KEYWORDS: Common Data Link, AISR, Unmanned Aerial Vehicle, satellite communications, SATCOM
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. In meeting this requirement, the technology should be capable of passing the qualification testing outline for solar cell assemblies and solar panels in AIAA S-111 and AIAA S-112. In addition, the material must pass “Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment” outgassing tests (ASTM E-595).

PHASE I: Develop one or more candidate adhesive replacement materials. Subject them to screening testing to identify candidates with high potential for subsequent development.

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

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

REFERENCES:

KEYWORDS: solar cells, adhesives, encapsulants, space environment protection

AF112-082 TITLE: Ephemeris Update Receiver for Space Vehicle Tracking

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: The objective and goal of this research program is to develop a dual-purpose ephemeris update receiver for the Air Force Satellite Control Network (AFSCN) to be used by the AFSCN’s parabolic antennas in pseudo-monopulse scanning mode and phased array antennas in an auto tracking dithering mode.

DESCRIPTION: The Air Force Satellite Control Network (AFSCN) has need of developing an advanced Ephemeris Update Receiver (EUR) that could be used with either a (1) Remote Tracking Station (RTS) Block Change (RBC) parabolic dish antenna or (2) Geodesic Dome Phased Array Antenna (GDPAA). This dual-purpose EUR would replace the current state-of-the-art RBC tracking receiver (Maximum Likelihood Estimator), which has many design and operational issues. First, the current receiver has had limited success in acquiring and tracking suppressed carrier waveforms specified in [1] and in determining the signal and noise estimates required for tracking. Second, the current receiver requires Inter Range Operations Number (IRON) [2] manipulation that includes selection of the
low-pass filter bandwidths for signal power determination and noise bandwidth selection, plus selection of offset for noise sampling in a region free of signal power. To date, only 9 of the 1600 IRON configurations the AFSCN presently supports have been tested on the RBC project, with limited success in selecting the right receiver parameters for operational support.

This research project seeks innovative approaches to accomplish signal discrimination at low signal to noise ratios (SNRs) to enable ephemeris update and tracking and result in a dual purpose EUR that overcomes limitations of the current state-of-the-art as just described.

The key requirement for the EUR is to meet antenna tracking requirements provided in the RBC Requirements Document [1] for minimum signal levels of -195 dBm at the antenna aperture. For the parabolic dish configuration, the EUR would operate in an estimated ephemeris (enhanced ephemeris) mode synchronized with the antenna operating in the scanned mono-pulse mode. For the phased-array configuration, the EUR would work synchronously with the array in its dithering mode to provide quadrant tracking data (maximum likelihood estimates) to determine the space vehicle track. This would be the primary tracking mode of the GDPAA, since the GDPAA is not envisioned to track using a sum-to-difference null tracking technique (this technique requires doubling the beam forming network).

The key technical barrier to be overcome is improving signal and noise determination. Over 10,000 IRON configurations are possible based on the SIS502 RF interface specification to the space vehicles [3]. As a result, several digital signal processing designs have been proposed that provide signal and noise power determination robustly (no IRON manipulation). These designs have included the quadrature receiver (I2 + Q2) and the fast Fourier transform (FFT), which provide good correlation to theory.

Additional technical parameters for this research effort include carrier tracking performance and signal discrimination. Good carrier tracking performance has been achieved based on using an FFT for automatic frequency control, with either a phased-lock loop for coherent tracking of a residual carrier, or a squaring (Costas) loop for direct carrier binary phase shift keying tracking. Also, excellent signal discrimination has been obtained at low signal to noise ratios (SNRs) for either a quadrature receiver (I2 + Q2) or FFT. If the EUR can provide good signal discrimination at low SNRs, this would allow for broader beams for tracking with the GDPAA, reducing the amount of aperture required. For this reason, the EUR could be considered an enabling technology for the GDPAA, since multiple contact capability will be limited by the amount of aperture allocated for tracking.

PHASE I: Develop innovative conceptual designs for a EUR that will meet the requirements for tracking given in the RBC Requirements Document. Accomplish modeling and simulation to assess performance, cost, and risk.

PHASE II: Test key software components of the design using software radio techniques. Test against signal range and waveforms specified in RBC Requirements Document. Integrate the software design into an existing tracking receiver or develop a functional prototype. Perform testing and evaluation of the prototype device.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Virtually all military satellites and navigation data processing subsystems using both phased array systems and parabolic antenna tracking design could benefit from the EUR.
Commercial Application: Virtually all commercial satellites and navigation data processing subsystems using both phased array systems and parabolic antenna tracking design could benefit from the EUR.

REFERENCES:

2. (footnote) IRON – Inter Range Operations Number; IRON number determines the ground equipment configuration based on the capabilities allowed in [3]. To date, the AFSCN supports 1700 IRON configurations for 170+ DOD, NASA and commercial customers. An IRON load configures the ground equipment to support the SV contact.


KEYWORDS: Satellite Tracking, Ephemeris Update Receiver, Air Force Satellite Control Network, Digital Signal Processing, Remote Tracking Station

AF112-083 TITLE: Electric Field Instrument for Cube- or Nano-sized Satellites

TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop a cubesat- or nanosat-scale Direct Current (DC) Electrical Field (E-field) instrument for measuring high precision electric fields at both high and low inclination Low Earth Orbit (LEO) orbits.

DESCRIPTION: Space weather and other Space Situational Awareness (SSA) missions have become increasingly dependent on small spacecraft, in particular the cubesat of volume 10x10x10 cm, referred to as 1U, as well as the nanosat size, which is less precisely defined, but is of the order of a 10-30 kg body. The small size and low mass of the cubesat and nanosat allow sensors required for SSA to be easily proliferated in multiple orbits and buses. This in itself imposes the requirement for the next-generation sensors to be lightweight, miniaturized and flexible in terms of bus integration.

Traditionally, scientific measurements of plasma electric fields in the ionosphere-magnetosphere environment have been accomplished by either measuring the plasma velocity and combining it with the knowledge of the in situ magnetic field, or by directly measuring potential changes between two booms, directly yielding the electric field in that direction. The former type of instrument requires a 3-axis stabilized spacecraft and high enough plasma densities for precise velocity measurements. This second requirement can be difficult to satisfy at higher altitudes where densities are lower or during solar minimum conditions when the ionosphere is dominated by light ions. The latter type of instrument works best on a spinning spacecraft and requires 3 sets of double probe booms (for measuring the 3-D E-field) adding significant mass, weight and complexity to satellite integration. In both cases, precise knowledge of the spacecraft attitude and in situ magnetic field is required.

This SBIR topic seeks innovative ideas for a new, miniaturized (small size, low weight), low-power E-field instrument that can fit into a cubesat of size equivalent to a small multiple of 1U cube, or, if necessary, to a nanosat. The design should be aimed at detecting E-fields with high sensitivity and precision in either a high- or low-inclination LEO orbit, of a flexible altitude from 350-900 km. Minimum range and resolution requirements are:

-- For a high inclination LEO orbit: ±1000 mV/m with a sensitivity of 0.5 mV/m.
-- For a low inclination LEO orbit: ±600 mV/m with a sensitivity of 0.3 mV/m.

We will consider designs that require either 3-axis stabilized or spinner satellites, but preference will be given to innovative designs that offer the most flexibility for integration to various platforms without compromising sensitivity and precision in measurements. Additionally, we seek designs that use the Plug-and-Play (PnP) interface.
PHASE I: Demonstrate the feasibility of building an E-field instrument that satisfies the desired requirements on size, mass, power, precision, and interface.

PHASE II: Build a prototype E-field instrument complete with processing capability and plug-and-play interface technology that demonstrates the design.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Miniaturized sensors on small satellites are essential for future ionospheric specification and forecasting required for communication, navigation, radar ranging, and tracking of space objects.
Commercial Application: Space-qualified, low-cost sensors have many applications in advanced scientific and engineering systems.

REFERENCES:


KEYWORDS: Ion Drift Meter, Double Boom Probe, E-field probe, cubesat, nanosat

AF112-087 TITLE: Radiation-hardened, Non-volatile Memory for Aerospace and Defense Applications

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

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

OBJECTIVE: Develop and commercialize high-density and inherently radiation-hard memristor-based memory for aerospace and defense markets.

DESCRIPTION: The lack of low-cost Radiation-Hardened (RH) Non-Volatile Memory (NVM) continues to be a severely limiting factor in the design of systems for use in space environments. Present solutions rely on inefficient techniques, such as radiation hardening by design (RHBD), which are implemented either in layout or in the application architecture and not in the fabrication process. Many of these solutions are based on redundancy and result in a penalty in performance greater than one-generation of Moore’s Law. This customization has driven up costs to the point that RH NVM has completely fallen off the International Technology Roadmap for Semiconductors (ITRS) and is now 10,000 times more expensive than its commercial counterpart. Moreover, most aerospace applications preclude the use of moving parts, such as the one in a hard disk. Thus, an ultra-high density
storage solution is completely lacking. Efforts over the last two decades to develop a practical NVM solution for space have been unsuccessful. An inherently radiation-hard NVM that can achieve high density is needed.

Recently, the memristor was unveiled as a new type of memory device. Its existence was first postulated by Leon Chua in 1971. It has the potential to combine the best characteristics of the hard drive, RAM, and flash in terms of density, access speed and power. The fundamental size of a memristor memory cell is 4 F2, but can be scaled down to 0.5 F2 if stacked. This is not only superior to those of DRAM (6-8 F2), NAND flash (5 F2), and NOR flash (10 F2), it challenges the density of the hard disk, which has a density that depends on the size of the read-write head. The memristor’s simple 1R architecture greatly lowers the cost of fabrication and allows fast random access without any moving parts. The switch mechanism typically involves the forming and breaking of a conduction channel, which consumes much less power than flash memory. To the aerospace electronics field, this also can mean that memristors may be inherently immune to radiation damage. Indeed, early investigations showed that the TiO2 memristors are very radiation hard. This represents an opportunity for aerospace electronics to leverage a technology developed for the commercial market and return to the path of Moore’s Law.

There is a race to fill the gap in the commercial market for a unifying memory technology with advantages that span the hard disk, RAM, and flash memory. Even with the memristor class, multiple technologies are competing to the commercial market. This includes TiO2, with a mechanism based on the drift of oxygen vacancies (which is a mobile, n-type defect dopant) and metal-doped chalcogenides or conductive metal oxides (which involves the drift of high mobility metal atoms such as Li, Ag, or Cu). This call solicits efforts to develop and commercialize RH memristor-based NVM to serve the aerospace and defense markets.

PHASE I: Evaluate candidate memristor technologies for radiation hardness. Based on these results and other available metrics, such as device uniformity, endurance, reliability, commercial viability, and design flexibility; develop and commercialize the most promising technology.

PHASE II: The selected company will partner with an appropriate foundry to produce working prototypes that are suitable for space applications. Test and evaluate the prototypes for reliability and radiation hardening.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Currently the highest density RH memory available is 28 Mb and there is a great need for memory with a density of ~1 Gb. The memristor could be used as static RAM for military space applications. Commercial Application: Combining the advantages of the hard disk, RAM, and flash, the memristor is a strong candidate to pose as a static RAM for both commercial and military space applications.

REFERENCES:

KEYWORDS: Memristor, non-volatile memory, radiation hardened electronics, space environment, static memory drives.
TECHNOLOGY AREAS: Space Platforms

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OBJECTIVE: Develop and demonstrate novel components that enable large-deployable telescopes.

DESCRIPTION: Increasing the aperture of space telescopes enables gathering of higher-resolution images from greater distances and at larger wavelengths. Space telescopes historically have fixed cylindrical shapes with a massive, roughly disk-shaped primary mirror. Under this classic paradigm, launch vehicles impose mass and volume constraints upon the telescopes. For example, the Falcon 1 launch vehicle (SpaceX, Hawthorne, CA) is limited to 1.4 m diameter payloads. The Minotaur I and Minotaur IV launch vehicles (Orbital Sciences Corporation, Dulles, VA) are similarly limited at 1.2 m and 2.0 m diameters. To take advantage of these more affordable launch vehicles, it is desirable to have a deployable telescope.

Deployable telescopes are challenging to implement. They need a variety of opto-mechanical components. Some technologies needed to implement deployable telescopes include actuators, nanopositioners, support structures, novel mechanisms and stowage concepts, light weight optics, deployable light baffles, and large athermal structures.

We are interested in new technologies that show significant performance gains over currently available technologies. Each proposal should clearly show how their technology could help realize a successful deployable telescope. This can be a novel architecture using existing components or an existing architecture with novel components. We are interested in deployable telescopes with apertures from 0.7 m to 3.0 m in diameter that stow for launch into spaces <30% of the final size in at least two dimensions, though scaled systems are acceptable if the reduced-scale system is shown to be traceable to the larger scale.

PHASE I: Demonstrate through modeling, simulation, and other means the soundness of the prototype device or architecture.

PHASE II: Using the results from Phase I, develop, document, and demonstrate the prototype device or architecture and how it enables large deployable telescopes.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications for the needed technologies include high resolution imaging from space, including infrared wavelengths.
Commercial Application: Commercial applications for the needed technologies include astronomical observatories, cameras, precision structures and metrology systems.

REFERENCES:

KEYWORDS: lightweight optics, structures, athermal, optics, space telescopes, metrology, precision structures, space mechanisms, nano positioners, composites

AF112-091

TITLE: Advanced Solar Arrays for Small Satellite Applications

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: Develop innovative concepts for a small satellite solar array that will provide increased mission capability.

DESCRIPTION: Small satellites are playing an increasing role in meeting mission needs. As such, it is imperative to advance bus technologies to support ever-increasing payload requirements. One key bus technology that requires such advancement is the solar array. Solar arrays for small satellites have often been adaptations of standard designs for large satellites. This is primarily due to a lack of low-risk solar array options that provide optimized performance for a small satellite. Large, heritage arrays that have been adapted for small satellite applications have poor packaging efficiency and relatively high mass with a high cost relative to the rest of the spacecraft. Small satellite missions demand lower cost, mass, and volume that enable increased payload capability when launching on small launch vehicles and as secondary payloads. Therefore, innovative concepts are sought for small satellite solar arrays in the range of 60 W to 300 W that exhibit significantly lower mass, volume, and cost over a state-of-practice (SOP) honeycomb panel solar array. Proposed concepts should support integration of both currently available space-qualified multijunction solar cells and thin, inverted metamorphic solar cells. Development is sought for the complete solar array (deployment mechanisms, structure, and solar panels). Concepts will be evaluated based on risk (simplicity), specific power (W/kg), stowed volume efficiency (kW/m^3), and cost. The performance goals for this effort are 200 W/kg (vs. 50 W/kg SOP), 30 kW/m^3 (vs. 10 kW/m^3 SOP), and $500/W (vs. >$1000/W SOP). The solar array should be capable of operation in a Low Earth Orbit (LEO) for up to 5 years and in a Geosynchronous Earth Orbit (GEO) for 15 years after storage on the ground for 5 years.

PHASE I: Perform preliminary analysis and conduct trade studies to validate concepts for the small satellite solar array. Key aspects must be demonstrated during Phase I, through modeling and prototype fabrication, to warrant Phase II selection. Identify key technical challenges for Phase II.

PHASE II: Using the lessons learned from fabricating and testing of prototype in Phase I, design and fabricate a second-generation prototype concept clearly traceable to spacecraft integration.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Technology developed will be applicable to small satellites. Expected benefits include increased payload mass/volume fraction, lower spacecraft cost and improved small satellite mission capability.
Commercial Application: Commercial small satellites will benefit from this technology in support of more capable missions that include communication and earth observation.

REFERENCES:

KEYWORDS: solar arrays, small satellites

AF112-092  
TITLE: Fusion of Multiple Space Weather Data for Situational Assessment

TECHNOLOGY AREAS: Electronics, Space Platforms

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

OBJECTIVE: To develop algorithms to fuse multiple space weather data sources to perform higher level situation assessment and greater Space Situational Awareness (SSA).

DESCRIPTION: A large amount of concern is directed towards the man-made threats to our blue assets. These include direct ascent attacks, co-orbital attacks, directed energy attacks and Radio Frequency Interference (RFI). Characterization and assessment for each of these man-made threats is made difficult by the one non-man-made threat--the space environment. Understanding the space environment, and utilizing that information, is critical as we proceed towards a higher-fidelity space situational awareness. Understanding and utilizing space weather information not only gives greater insight into our satellites' state of health, but it can also help with threat characterization. Was the RFI event an equipment malfunction, intentional jamming or a product of solar RFI? There are several current space weather efforts, like Space Environmental Effects Fusion System (SEEFS) and Communication Navigation Outage Forecasting System (CNOFS), which nowcast and forecast space weather phenomena such as communication outages, GPS degradations, increased atmospheric drag, solar RFI, etc. Each of these programs predicts regions of space that will be affected by a given space weather event. None of these efforts are tightly coupled to the space order of battle, and thusly the space catalog, to predict anomalous behavior of space assets based on when they will fly through various affected regions. Today this is largely done after the fact, only after the effects are experienced and only through manual correlation. As an example, a capability is needed to notify an operator that GPS 21 is expecting anomalous behavior x due to space weather event y in T-4 hours based on the space weather forecast of z. The capability should also give the operator data traceability into what space weather forecast is driving a given predicted effect on a given asset. All of this information should be correlated and fused in an automated fashion. By fusing this information with other data sources, we can better understand satellite state-of-health, better characterize threats, mitigate false threat characterization, and nowcast/forecast communication, navigation and surveillance degradations and outages. The fusion of this data would be invaluable to operations centers and the warfighter.

PHASE I: Develop proof of concept. Characterize the different satellite anomalous effects that can be seen on a given satellite based on different space weather phenomenologies. Design an analytic engine that correlates these phenomenologies to satellites based on a satellite's current orbital path. Show the scalability & feasibility of adding more data sources in the future. Provide initial demo.

PHASE II: Develop the analytic fusion engine to predict when assets will experience space weather effects based on the now-casting and forecasting reports of the various space weather products. Develop a pub/sub alerting capability to automatically notify an operator when an object is predicted to experience a given effect. Develop visualizations for unified space weather constellation awareness. Deliver space weather fusion service capable of being ingested into service-oriented architecture. Provide demonstration of research.

PHASE III DUAL USE COMMERCIALIZATION: 
Military Application: This work should integrate various space weather products and JMS compatible web services. This information would provide a more automated predictive threat characterization and prove very valuable to the warfighter and operations facilities.
Commercial Application: These algorithms would also be very valuable to NASA or any private company that needs to communicate with their satellites or rely on communication with other satellites.

REFERENCES:


KEYWORDS: Data Fusion, Space Weather, Space Situational Awareness, Response Options, Decision Aids, Communications

AF112-093  TITLE: Nanomaterials for Lightweight Spacecraft Power Distribution and Data Transmission

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

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

OBJECTIVE: Investigate and develop nanomaterials, to include nanocomposites, for lightweight data and/or power transmission concepts for replacement of conventional copper-based components in space vehicles.

DESCRIPTION: Operationally Responsive Space (ORS) Tier-2 mid-term goals (2012-2017 timeframe) include spacecraft mass <100kg while maintaining the tech development goal of payload-to-bus mass ratio of 3:1. In order to meet these goals, innovative size and weight reduction must drive many space-based technology developments. Data and power transmission components are up to 10-20% of the overall spacecraft system weight, and are a viable target for weight reduction—however, cost and performance continues to be the primary developmental factor. For example, the push to introduce fiber optics for spacecraft cabling is primarily for increased data rates and EMI shielding, and does not reduce overall weight. For the large majority of components (<600Mb/s), we must continue to utilize common copper-based solutions, such as SpaceWire. With four shielded twisted pairs and a density up to 100g/m, bundling of several of these high bandwidth links becomes heavy.

Therefore, this topic seeks to explore innovative, affordable, advanced concepts and technologies that will result in the development of lightweight data and power transmission. Recent advancements in nanotechnologies have been investigated to replace traditional conductive transmission lines with novel nanomaterials-based solutions. Two areas of interest are listed below. This list is not exhaustive; any other highly-innovative, nano-based solution is also encouraged!

• Nanomaterials for lightweight cabling: New advances in engineered nanomaterials offer unprecedented control of electromagnetic energy that could potentially replace traditional wiring or shielding. But for this to be practically utilized, the density and conductivity must be improved/increased from that of current copper-based components. The solution should be robust enough to withstand the space environment (electron, proton, atomic oxygen, etc.), as well as the satellite build process. Attention should be given to the connection schemes, i.e., connecting the cabling to the external (payload) or internal (bus) components.

• Nanomaterials for integrated, multifunctional structures: This entails integration of the power and/or data transmission components into the spacecraft structure using solutions possibly not suitable as a stand-alone nano-based cable, as described above. Payoffs include a reduction or elimination of wiring harnesses, connectors, and electronic enclosures with a corresponding increase in payload-to-bus mass ratio. Additionally, when mated with
plug-and-play architectures, automated satellite design tools, and an integrated SHM network, these structures also offer a major reduction in electronics integration, test schedules and checkout times.

Additional requirements are as follows. Threshold reduction of weight is 50% of conventional construction, with an objective of 75%. This can involve either the total assembly or the cabling alone—wireless solutions are not to be considered for this topic. Traditional custom wiring assemblies can take up to eight months to construct, and customized electrical interfaces create additional development burdens. Therefore, in order to align with ORS initiatives for reduced integration and test times, the solution should demonstrate some overall benefit along these lines.

Key technology challenges include interconnectivity and maintaining performance levels compared to current state-of-the-art, such as bit rates, signal-to-noise ratio, voltage standing wave ratio (VSWR), attenuation and insertion loss. Other significant challenges include cost-effectiveness as a copper replacement and large-scale fabrication of these nano-sized materials.

PHASE I: Examine applicable fundamental properties of nanomaterial-based transmission concept, such as electrical/thermal conductivity, current density, etc. Model and simulate methods/designs for interconnection. Perform bench-top testing for concept demonstration.

PHASE II: Refine concepts and designs from Phase I. Conduct comprehensive testing and analysis, with focus on the transmission performance, interconnectivity, and survivability/reliability in the appropriate operating conditions. Evaluation and recommendations based on these results. Full-scale prototype will demonstrate manufacturing plan and validate technology.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Any military development for future ground, air or space systems with stringent weight requirements, including launch vehicles, small satellites, UAVs, portable communications, etc.
Commercial Application: Any commercial development for electronic-heavy systems with stringent weight requirements, including jetliners, satellites, small computers, etc.

REFERENCES:

KEYWORDS: Nanomaterials, Nanocomposites, LightweightCabling, LightweightWiring, MultifunctionalStructures, TransmissionLines, PowerDistribution

AF112-094 TITLE: Increased Data Processing Capabilities for Remotely Piloted Aircraft (RPA)

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors
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OBJECTIVE: Develop next generation of onboard data processing capabilities for RPA systems while meeting size, weight, and power (SWaP) requirements.

DESCRIPTION: The Air Force is working several upgrades to RPA platforms and sensors that will significantly challenge on-board processing capabilities. These new sensors will provide data that is several orders of magnitude higher in terms of data amounts and rates (10’s of Terabytes per sensor per mission). These sensors will function simultaneously during multi-sensor missions with each providing a high data rate output which greatly challenges existing processing and communications capacities. The challenges include data and image processing in support of new high-output sensors, multi-sensor operations, data compression supporting communications, and real-time interactive exploitation processing. The objective of this topic is to build and demonstrate the next generation of embedded multi-processing capabilities to support emerging data and multi-processing challenges while meeting SWaP constraints.

Currently ISR sensors are stove-piped. Each sensor has its own processor and signal processing/aided target acquisition (ATA) algorithms. Data link bandwidth from RPA to ground stations is limited. For real time operation, onboard processing with intelligent combination of preprocessed sensor data is needed to provide the RPA sensor operator/analyst a cohesive picture of collection operations, target cueing activities, and sensor resource management. With multiple sensors, onboard processing must move to streamed data processing with simultaneous registration and compression across all sensor modalities to meet the processing challenges.

Complex sensor and aided target acquisition processing and algorithms drive massive data processing requirements previously only available in ground based data processing systems. Data link bandwidth (and line of sight) constraints drive the need for onboard real-time local and distributed sensing algorithms and sensor fusion which will further drive processing requirements.

This topic seeks to leverage advanced switching protocols such as Infiniband and, PCI Express, or Rapid IO using low-latency and processor efficient protocols with advanced low power heterogeneous clusters of CPUs, GPUs, FPGAs, and other mission specific processors where appropriate (such as the DARPA Hyper-X) to demonstrate scalable onboard real-time processing at greater than 10GFLOPs per watt. Current computational density for onboard processing is less than 0.5 GFLOP per watt. To meet RPA multi-sensor processing requirements computational power densities of over 10 GFLOP per watt are needed in small, light-weight packages. A multi-teraflop processor would need to operate within onboard environmental constraints for over 6 hours continuously with a goal for total system power of well under 400 watts. Packaging is desired to maintain industry standards such as those accept and proposed by VITA to allow for a plug-and-play hardware infrastructure. Development based on COTS components and chipsets shall follow COTS development cycles by planning for technology insertions of COTS components to stay on the path of rapid advances in performance, power, and capability.

Industry best practice development and programming environments for scientific and signal processing libraries should be incorporated to minimize mission to mission reprogramming and sensor change out. Software abstractions and high-level languages are desired to minimize non-recurring software costs as the underlying platform or sensors change.

PHASE I: Develop & demonstrate proof of concept architectures for onboard processing HW for severe RPA operating environment to meet real time processing & aided TA requirements. Solutions will meet shortfalls in existing sensor processing & sensor fusion & demonstrate persistent surveillance algorithms.

PHASE II: Build prototype Small RPA processing systems w/interfaces & surrogate/real sensors to be evaluated & demonstrated on RPA or munitions application. Include WFOV persistent/synoptic imaging data set & HSI, SAR, and/or LADAR. Either solely or in partnership, implement, test, & verify. Through ground & flight test show transition readiness for Phase III. Integrate, field test, & qualify for use in POR.
PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Innovations developed under this topic will benefit all major DoD RPA conducting airborne operations with high-output sensors.
Commercial Application: Benefits commercial programs requiring increased processing capabilities with limited SWaP. Possible uses for this product include: commercial aerospace, automotive, and communications industries.

REFERENCES:
5. ARGUS IS, DARPA Website: http://www.darpa.mil/ipto/programs/argus/argus_approach.asp

KEYWORDS: graphics processor unit, persistent surveillance, small unmanned air system, small RPA, avionic, hyperspectral, SIGINT, image processing, mission planning, sensor fusion, pattern matching, tracking

AF112-095  TITLE: Secure/Covert Short Range Combat Wireless Personal Area Communications

TECHNOLOGY AREAS: Information Systems, Sensors

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OBJECTIVE: Develop a secure battlefield wireless personal network for battlefield airman applications that minimizes size, power consumption, and detectable electronic signature.

DESCRIPTION: This topic seeks to develop a lower power wireless personal communications link for battlefield airman applications that provides serial port compatible data rates while emphasizing security and covertness. The goal is to eliminate the USB/Ethernet/Serial cabling that connects all the gear in a combat controllers field kit. A new wireless datalink that provides enhanced security and covertness but otherwise is compatible with standard commercial wired interfaces is desired.

Commercial wireless personal communications such as Bluetooth, Zigbee, WiMax, or WiFi for example are inexpensive, but are easily detected, jammed, or exploited, making them unsuited for many military operations. Significant research in secure wireless data links has been conducted by DoD for high bandwidth wireless video, data, and communications. These modules use encryption devices, spread spectrum waveforms and coding to secure comms and lower detection. However, these result in large, expensive units and requires high operator interaction to key them and to provide physical security. The goal of this effort is short range (10 to 100meter) point to point interconnect of sensors, comms and targeting devices to replace heavy and unreliable cabling. The goal is a USB port or Ethernet port plug in module the size of a wireless mouse plug-in or memory stick that does not require physical security or external power to operate and if lost in the field is not able to reconnect.

The Battlefield Air Targeting Man-Aided Knowledge (BATMAN) intersystem communications applies human effectiveness factors to the Battlefield Airman Operations (BAO) kit system. AFRL has evaluated wearable
computers, wearable displays, mission planning software, and integrated advanced radios systems. It has also developed a Web-like special tactics reference guide and UAS checklist for the tactical computer to replace paper booklets.

BATMAN includes decision-aiding algorithms to help controllers under stress make the right decisions. Given a target close to friendly forces, the computer tells the controllers the attack is dangerously close and depicts the relative location of enemy and friendly forces. The tactical air controllers use cursor-on-target interfaces to simplify direct communications between machines. The interconnection of BATMAN equipment with Machine-to-Machine (M2M) communication is expected to eliminate errors made by tired controllers under stress. They are also expected to shorten targeting timeliness between ground controllers and aircrew.

Current approaches rely on USB and Ethernet cabling to direct cable connections for all the BATMAN sensors, radios, and other apparatus. This requires heavy and time consuming cabling that must be carried in an already overloaded operations kit.

Research should be focused on novel Personal Area Network operation in novel frequency bands with waveform modes that minimize risk of detection and/or jamming are critical. Optical methods that are outside current sensor bands are also of interest but line of sight issues must be addressed without adding size weight or power.

The data-link should support small networks of eight or more nodes at serial link data rates (115 kbs). Physically, the device should be extremely small such that it can be mounted in a laptop data port with little physical exposure similar to many wireless mice. The wireless link should provide enhanced security and covertness to minimize physical detection and electronic signature. The device should be completely plug and play with minimal setup required on the part of the user with auto-pairing to known remote equipment nodes. A good model for user setup is Bluetooth, where at worst, pairing is required on the part of the end user.

The approach should replace current hardwire USB and 802.11 approaches while providing high immunity to detection from over 100 meters away with RF detection sensors. Automatic switching and routing should be considered for connection to targeting computers, secure radios (PRC117F/G, etc.), laser targeting, and weather sensors. The long range goal is to support visible display remote operation with MPEG 4 video or equivalent. Low power consumption, omni-coverage, and auto-connection are key performance parameters.

PHASE I: Develop the architecture for the covert link and show through simulation or other means the critical operating parameters resulting in a solid plan for developing and demonstrating prototypes under a Phase II effort.

PHASE II: Develop and demonstrate several prototype wireless datalinks that can be operated under expected environmental and operational conditions. The secure/covert wireless personal area communications system should be completely plug and play with little requirement on the part of the user beyond minimal identification and connection choices.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Provide secure and covert wireless personal communications link from individual airman equipment to covertly connect battlefield airman sensors and systems. Short range UAS/UGV control. Unattended sensor networks and battlefield/airdrome weather systems.
Commercial Application: This technology will be applicable to first responders location and communications, unattended weather and security sensors, and industrial facility instrumentation.

REFERENCES:
1. IEEE 802.15.4-2006 IEEE Standard for Information Technology- Telecommunications and Information Exchange Between Systems- Local and Metropolitan Area Networks- Specific Requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)
AF - 105


5. AFSOC BAO Kit
http://www.ndiagulfcoast.com/events/archive/34th_Symposium/34_Day1/12_AFSOC%20NDIA%20Brief.pdf

KEYWORDS: Personal Area Network, Low Probability of Detection, Wireless, Secure Communications, Battlefield Airman, Covert Communications, Battlefield Airman Operations, Wearable Computer, Low Probability of Adversary Detection

AF112-096 TITLE: Compact Extended SWIR Sensor for Targeting Applications

TECHNOLOGY AREAS: Sensors

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OBJECTIVE: Develop innovative sensor materials to improve short-wave infrared (SWIR) sensors for targeting applications, and extend their operational wavelength at near room temperature.

DESCRIPTION: Current sensing systems require multiple sensors for night imaging, designator sensing, and visible sensing that take up large volumes and consume large amounts of power. The size, weight, and power of these sensors limit their use in applications such as RPA, Micro Air Vehicles (MAVs), targeting pods, combat controller ground targeting systems and airborne laser targeting systems. What is necessary is a sensor that combines the functions of laser tracking and SWIR imaging with visible response, with the ability to operate without high power or cryogenic cooling.

SWIR Detector array technologies are sought for the wavelength range over the entire range from 0.4 m and 3 m. Detector arrays that extend the SWIR sensitivity range are desirable for identifying, tracking, and targeting hostile forces and communicating covertly. Applications such as Micro air vehicle (MAV) sensors, RPA sensors, laser target tracking, laser radar, missile tracking, persistent surveillance imaging, satellite imaging, laser imaging, interceptor and require large format sensors, minimum size and weight.

Current extended wavelength InGaAs suffers from image latency of several frames and extremely large dark current which diminishes the low-light performance or requires heavy power draw electronic coolers. MCT is expensive and often nonuniform in its responsivity. New solutions are desired that are improvements over these approaches, offering room temperature performance similar to traditional low dark current InGaAs. The proposed technologies must address uniformity, performance and cost as well.

It is highly desirable to have IR detector performance at near ambient operating temperature. To ensure wide deployment of the sensors, the detectors must be manufacturable at relatively low cost. Current detector material solutions to extend imaging from the visible into the SWIR 1.6 – 3 m wavelength range are extended wavelength InGaAs and HgCdTe(MCT). Despite incredible advances, current “room temperature” sensor technologies beyond 1.6 m remain expensive or suffer from lag, noise and band gap material problems.

Development should include the necessary read-out integrated circuit development and should operate uncooled and have a dark current well below 1.5 nA/cm² at 280 K. The arrays must be scalable to large area arrays (2048 x 2048 with small pixel pitch or larger) and be butt-able to form super arrays.

The sensor should operate at user defined video (30-60Hz) frame rates and in some applications operate at frame rates upward of 400Hz. The read out integrated circuit should provide snap shot imaging and electronic gating down...
to less than 100 nanosecond exposure times with user controlled range hold off. For UAS and persistent surveillance applications, foveated and electronically gimbaled/zoom read-out-integrated circuit technologies is highly desired. The sensor package should be compatible with future tiling to larger 4x4k imagers for persistent surveillance applications. The frame rates should be at least 30 Hz for large format arrays.

PHASE I: Identify and demonstrate materials suitable for low noise, low lag, high speed, VIS-SWIR detector arrays that will result in significant improvements in performance, uniformity, and cost reduction.

PHASE II: Using the resulting materials and/or designs from Phase I, implement, test and verify these changes in prototype fashion to demonstrate the feasibility and efficacy of the material. Fabricate a large pixel count focal plane array (at least 1K by 1K) and integrate into a compact format camera with 60Hz video rate output interface electronics deliverable to government for further testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Transition into current AF UAS, targeting, PGM and persistent surveillance applications. Commercial Application: Possible uses for these products include medical imaging, surveillance, astronomy, mapping, weather monitoring and earth resource monitoring.

REFERENCES:

KEYWORDS: InGaAs, SWIR, Imaging, UAV Sensors, RPA, MAV, PGM, Laser Imaging, Ground Targeting, Day-Night Sensor

AF112-097 TITLE: Laser Designator Beam Line Stabilization

TECHNOLOGY AREAS: Sensors

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OBJECTIVE: Develop an integrated system for providing automatic low power, light weight, and small gimbal line-of-sight alignment and stabilization of laser designator beam line sensors.

DESCRIPTION: The Air Force has interest in target tracking and laser pointing over a wide field-of-view at long ranges from small unmanned air vehicles/systems (UAS/UAV). High resolution, detection and tracking are problematic for small platforms because current mechanical solutions are too heavy and require excessive power to accommodate platform dynamics. For small UAS's, platform dynamics and aerodynamic disturbances that are orders of magnitude higher than large platforms. Laser systems including illuminators, rangefinders and target
pointers/designators require precise laser and sensor(s) line of sight alignment and stabilization for use on airborne platforms. Because small UAV and micro-air vehicle (MAV) platforms are inherently less stable than larger platforms, implementing IR designator systems in these platforms is particularly challenging. The goal of this effort is to look at novel small precision pointing and tracking concepts for 4 inch to 10 inch diameter gimbals on small air/ground launched UAS’s with payload and gimbal mass of 4 pounds or less. Even smaller gimbals or beam pointing systems are desired in the future as the gimbal payloads are also miniaturized. Ideally, high precision laser pointing systems have multiple gimbal sets (i.e., two outer coarse gimbals attenuating most of the platform and aerodynamic loads and the two inner most, flexure suspended gimbals providing fine stabilization). The inertial measurement unit (IMU), IR and visible imaging sensors, and a designating/ranging laser might be located on the inner most inertially stabilized gimbal. A traditional system of this type would be prohibitively expensive, complex, and heavy for many small platforms.

For small UAS applications, complex vehicle motion due to small mass and wind effects result in large roll and pitch motion excursion that significantly affect laser systems to a higher degree than passive sensors. Novel methods of instrumenting the gimbal or using sensor data are needed for servo control to remove the engine vibration, platform aero-buffeting and flight stability jitter. Stabilizing the line-of-sight to a target or relative to a feature in the field-of-view is of primary interest. Holding less than a 25-microradian laser spot center pointing accuracy for beams of 300 microradians or less over several minutes is the goal for target marking, illumination, and optical communications. A 360 degree azimuth continuous coverage is needed with elevation angles from +40 degrees to -220 degrees minimum (Looking straight up into the vehicle for protecting the optics is a desirable feature). Retraction is also desired to minimize drag and environmental load on the gimbal optics. Slew rates of greater than 200 degrees per second are needed with novel servo stabilization to reflect small UAV dynamics near the ground (10 meters to 500 meters) in gusting conditions. Environmental considerations should include operation in desert conditions as well as cold weather conditions (125°F to -40°F ambient) which may affect platform dynamics. In particular, heat management is a key problem with current small gimbal systems. Novel techniques to minimize in-gimbal thermal load and increase heat extraction are a key to success for this topic.

PHASE I: Develop concepts for gimbal-free or very small gimbal systems with, precision stabilization of designation and tracking systems. Perform simulations to predict the resulting operations. Perform mission analysis to assess operational suitability.

PHASE II: Develop a prototype in hardware and software that will demonstrate the feasibility of the system recommended in Phase I. Develop a prototype optical and electronic system form factored for laboratory and possible flight demonstration on Air Force or other flight test platforms or contractor support aircraft platforms.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Transition the stabilization system to UAV designator and target tracking system into programs of military interest including RPAs and micro UAVs.
Commercial Application: The use of lasers alignment systems have been used in many ways such as in the construction of pipelines, nuclear particle accelerators, and many assembly jobs where precise positioning is mandatory.

REFERENCES:
KEYWORDS: target tracking, laser designator, IR Search and Track, automatic alignment, biomimetic vision, laser guided weapons, UAV, RPA

AF112-098  TITLE: Smart Bomb Rack(s) for 5th generation Fighter Aircraft

TECHNOLOGY AREAS: Air Platform, Sensors, Weapons

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

OBJECTIVE: Bomb Rack that can accommodate variable pitch angles to compensate for aircraft higher speed regime of weapon release systems.

DESCRIPTION: The next generation of Air Force fighters has the ability to carry and eject stores and/or weapons at and above supersonic as well as subsonic speeds. Current suspension and release equipment (S&RE) or bomb racks like the BRU-46 and BRU-47 have mechanical pitch settings that must be set on the ground prior to the mission. The settings are usually preset to a forward biased or slight nose-down pitch because that seems to be the best compromise setting for most bomb ejection scenarios. The ejection force is set by the use of a pyro-technique device or by a pressure vessel that is filled to a preset value. The preset pitch and force settings seem to perform well for fighter and bombers that eject stores and bombs under subsonic release conditions with weapon weights that range predominantly from 250 to 2000 lbs. However, since next generation fighters have a wide dynamic performance launch envelope or the ability to release stores under supersonic Mach numbers, the fixed or pre-programmed settings are no longer very efficient and/or practical which can limit the aircraft’s tactical operating envelope. There is an anticipated requirement for the ability to monitor and/or sense aircraft dynamic performance and environmental conditions in order to adaptively adjust the S&RE pitch and force settings for maximum safety and optimal performance. The performance requirement will be to develop algorithms suite using state-of-the art software that includes The Model Driven Architecture (MDA) and/or Unified Modeling Language (UML) that will allow S&RE to dynamically and adaptively adjust to external environmental conditions. The intended requirement is to optimize aircraft weapon delivery performance and safety by selecting, as a minimum, the optimal S&RE pitch setting and ejection force setting, based on current store properties, aircraft Mach number, attitude, maneuvering range, and environmental conditions. Due to increased computing power to handle lethality, terminal guidance accuracy, and all-weather sensor operation, it is anticipated that future trends will require smaller stores and/or bombs for increased sortie load-outs and minimal collateral damage. This innovative technology should significantly improve carriage and release performance for stores that weigh less than 250 lbs. The offeror shall consider store and/or weapon weights that vary from 10 lbs to 2000 lbs with store dimensions that ranging from 4” to 18” in diameter.

PHASE I: The Phase I effort will develop an innovative algorithm suite that will prescribe the optimum pitch and force settings based on real time environmental conditions. The Unified Modeling Language (UML) and/or The Model Driven Architecture (MDA) software technology would be preferred. A final report describing Phase I algorithm design concept along with selected software architecture should include a Phase II proposed demonstration plan which shall be submitted at the conclusion of this effort.

PHASE II: The leading algorithm design concept developed under the Phase I effort shall be modeled and simulated, prototyped and demonstrated under laboratory conditions. A final report documenting the system performance evaluation and demonstration and/or tests results shall be submitted at the conclusion of the effort. Suggestions for a proposed Phase III follow-on effort shall be included in the final report.

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 algorithms into military aerospace S&RE.
Commercial Application: Commercial benefits include industrial/commercial systems that can make use of real time environmental data for adaptive control.
REFERENCES:


KEYWORDS: Keywords: dynamic bomb rack, adaptive pitch, automatic bomb rack, automatic ejection force, dynamic pitch, adaptive bomb rack

AF112-099  TITLE: Boosted Penetrator Technology

TECHNOLOGY AREAS: Electronics, Weapons

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

OBJECTIVE: Conceptualize, design, develop, and test boosted penetrator technology for compact, internally carried weapons.

DESCRIPTION: Potential adversaries are building high value facilities deeper into the ground and/or constructing them of new generation concretes thereby making them more difficult to defeat with legacy penetrating weapons. One way to counteract this difficulty may be to boost a penetrating warhead's impact velocity by means of a tandem-mounted rocket motor. Unfortunately, the placement of the rocket motor at the end of the warhead may preclude the use of a conventional venting plate. Conventional venting plates or systems are traditionally placed at the rear of a warhead. If the warhead is subjected to an unexpectedly high temperature environment, the venting system is designed to relieve pressure caused by the rising external temperature or the build-up of internal gasses coming off the warhead's explosive fill. A properly functioning venting system allows the explosive fill to consume itself, perhaps deflagrate, without going high order and thereby causing catastrophic damage to its surroundings.

The conventional placement of a venting plate at the rear of an ordnance package may not be advisable on an envisioned boosted penetrator. The vented hot gasses could adversely impact the rocket's case, igniter assembly, or exhaust nozzle. If either a steel or a composite rocket motor case is breached, the encased propellant might be ignited with severe consequences.

Therefore, it is in the interest of insensitive munition (IM) enhancement to design, develop, and test a distributed venting system for possible employment on future boosted penetrating weapons. This distributed venting system must be able to ensure the warhead's explosive fill will not go high order in the event of an unintended heating environment. Also, its venting characteristics must not unduly damage an attached tandem rocket motor and certainly not cause a breaching in either a steel or a composite case. The venting system must be able to be activated either by an unintended severe temperature rise or by the internally generated gases coming off the warhead's explosive fill due to insult of the explosive by some other means such as a bullet or fragment strike. In all such cases the distributed venting system must prevent high order detonation.

PHASE I: Phase I activities will center around the conceptual design of a distributed venting system for a generic 2000-lb class boosted penetrating weapon whose dimensions are compatible with internal carriage on an F-35 fighter. The rocket motor will be presumed to be tandem mounted aft of the warhead. This design will be dependent on the adaptation of appropriate computational predictive tools. One such tool is a computational model that can reasonably predict the distributed venting system’s performance in the event of unintended explosive fill overheating. It is envisioned that this model can be applied to several potential designs or concepts to aid in selecting an optimum approach for a particular warhead/rocket design. All necessary assumptions and approximations that go into the predictive tool will be fully discussed. The results of this predictive tool will be
combined with existing computer-aided design software to provide a basic, generic design of a 2000lb-class rocket boosted penetrator that includes a distributed venting system. Recommendations for the future development of improved modeling techniques will be encouraged.

PHASE II: Phase II activities will center around further development of the distributed venting system described in previous sections. Computational predictive tools used under Phase I will be refined to support these activities. This development should include some proof-of-concept testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: A Phase III application would be the incorporation of a distributed venting system as part of an integrated boosted penetrator test specimen used by the Air Force for risk reduction.
Commercial Application: A distributed venting system may have commercial applicability in the design and construction of safer boilers. Applications to oil and natural gas drilling are also possible where efficient venting of high pressure gases can prevent catastrophic explosions.

REFERENCES:
2. Johnson, Joni; Kim Steve; Nolder, Matt; "Improved Insensitive Munitions Performance of an HE Rocket Warhead" AD Number: ADA394601, 2001
3. Woodall, Robert; Garcia, Felipe, Irizarry, Gilberto; "Line Charge Insensitive Munition Warhead" ADD19573, 1999
4. Graham, Kenneth; "Extremely Insensitive Detonating Substance Tests" ADA529578, 1992
5. Chizallet, Maurice; "Reduction of Hazard Zones by Uncoupling Between Munitions" ADA519534, 1992

KEYWORDS: Insensitive Munitions, Rocket Warhead, cook-off initiation, explosive venting, insensitive detonation, pyrotechnic seperation, distributed explosive venting
Recent developments have shown gyroscopes, and rate sensors and other instruments based on optically pumped rubidium and cesium using single frequency semiconductor lasers precisely tuned to the atomic resonance transition. These experiments using "cold atom" optics have shown great potential but have a long path to small system insertion. Recent experiments with “Fast Light” have shown promising results to provide nearer term insertion with small footprint and an order of magnitude accuracy improvement.

Rubidium and cesium devices have shown promise for compact microsystem applications but are a long way from transition into practical, ruggedized 3-axis flight and ground system applications. Basic research experiments as derivatives of chip scale atomic clocks have shown that hybrid integrated optical-fast light devices could potentially have large expensive laser ring gyro performance in sizes as small as 1 cubic centimeter.

Ring laser structures with anomalous dispersion (i.e., a fast-light medium) are examples of approaches in scientific literature to realize a rotation sensor with a sensitivity enhanced by a factor as high as 10E5 for experimentally accessible parameters. It may also be possible to use this approach to realize an accelerometer, with a similar enhancement in sensitivity. Given that a conventional optical accelerometer can achieve a sensitivity of less than 1 micro-G/root-Hz, it should thus be possible to reach sensitivity as high as 10 pico-g/root-Hz. Furthermore, since the enhancement is non-linear, the device can have a very high dynamic range, and should also be able to sense accelerations much larger than 100g.

Recent breakthroughs in single frequency semiconductor laser diodes and bidirectional amplifiers have enabled a conceptual integration into a single laser driven multi-axis inertial sensors with sense nodes on sub-centimeter cubed scale. These lasers are marginally available today users report long delivery times, low reliability, and frequent failure to meet published specifications.

Miniaturized, frequency-agile, robust laser systems that can operate autonomously while locked to atomic transitions with prescribed offsets up to 10 GHz are also needed and domestic suppliers must be developed to ensure stable sources of supply of these precision lasers.

The SBIR topic solicits novel concepts and technologies in design, development, and demonstration of components, subsystems, and systems for an integrated “fast light” optical device 3 axis transducers for rotational and linear inertial sensing (Inertial Measurement Units), replacement of digital compasses, and target weapon fuzing.

The sensing system should be able to withstand missile and tactical fighter aircraft temperature, acceleration, and vibration environments and not be sensitive to Electro-Magnetic Interference. The long term research goals are:

- **Navigation-grade performance:** BD (Baseline Drift): 10-5 degree/hr, ARW (Random Walk): 10-6 degree/sqrt(hr)

- **Linear Acceleration Sensing:** Performance goals include; Bias stability less than 0.01 micro-g, Scale factor less than 0.001 PPM, absolute acceleration measurement, and Noise floor less than 1x10-9 g/sqrt(hz).

- **IMU Sensor Package Size Weight and Power Goals:** less than 27 cm3 (3x3x3cm); less than 25 g; less than 10 Watts goal.

- **Size Goal:** Full IMU (3 Gyros and 3 Accelerometers and IMU sensor Processing & Data Interfaces) less than 50 Cubic inches (with objective = 34 Cubic Inches)

- **Position Accuracy Goal:** less than 0.03 m (3D 1-Sigma) in 100 seconds of inertial only flight (Assume GPS based initial alignment).

- **Multi-axis rotation and linear sensing modes within single sensor head**

- **Long term endurance for orbital environments**

- **High G sensitivity over 100’s of G’s acceleration/de-acceleration, 2 kHz vibration and high shock.**
PHASE I: Investigate enhanced laser accelerometers and gyros sensing approaches (experiments/analysis/modeling). Identify risk mitigation for electro-optic components and integration for multi-axis sensors. Address improvements to the critical single frequency laser stability, performance, and power.

PHASE II: Demonstrate proof of concept prototypes and demonstrate functionality in laboratory inertial test environments. Address engineering scale-up of proposed technology address technological hurdles. Address applicability to weapon system and aircraft/spacecraft environments (vacuum, cryogenic operation, and long term radiation exposure).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Transition demonstrations envisioned for military aircraft: UAV, weapons, other navigation requirements in severe environments, other applications in interior robotics, and training.
Commercial Application: This technology applicable to commercial aviation, emergency response in urban canyon, tunnel, and mine operations, mining and tunneling operations, commercial space, and maritime operations.

REFERENCES:

KEYWORDS: inertial navigation, attitude, MEMS, fast-light enhanced laser gyro, integrated optics, grating outcoupled single frequency laser diode, integrated optics, attitude determination, Integrated Targeting Device,
target the smallest SWaP possible. Sufficiently small SWaP concepts would be applicable to micro-air vehicles. One way to minimize SWAP is to eliminate mechanical gimbals in favor of wide-field-of-view (WFOV) sensors. This approach allows for the large field of regard enjoyed by gimbaled seekers while offering improved situational awareness by staring into a larger FOV. WFOV sensors have also been shown to provide a means of ego-motion estimation important for stability control, navigation, and guidance. This topic solicits proposals for the development and demonstration of WFOV seekers including sensors and image processing algorithms that will extract maximum useful information from the WFOV, multicolor sensor, in order to provide low SWaP high performance seeker systems, for WFOV closed loop guidance.

Prospective areas of research include sensors and image processing such as innovative adaptive FOV (e.g., optical/electronic zoom with variable acuity array) focal planes such as Variable Acuity Super-pixel Imagers (VASI) capable of resolving target features for target ID, innovative WFOV RF apertures, image processing of WFOV sensor data including target ID, state estimation of targets, and nontraditional seeker functions such as navigation aiding with active and/or passive WFOV multi-discriminants. Nature-inspired sensors are of interest. Awareness of the system implications (Avionics processing: including navigation solutions for global reference/airframe stabilization, and interaction with the control system) will help insure viable seeker concepts.

PHASE I: Identify innovative technologies for development and testing of low SWAP, WFOV multispectral seekers that will lead to meeting the described goals. Develop a conceptual design and analyze the performance and limitations of the technologies.

PHASE II: Build the design developed in phase 1, and evaluate performance to demonstrate capability of design to address mission requirements. This capability can be shown through hardware-in-the-loop testing or digital system level simulations using test results from experimental design characterization.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Small weapon/aircraft systems capable of autonomous or man-aided combat and ISR missions.
Commercial Application: Surveillance activities in law enforcement, search and rescue, border control, homeland security. Machine vision for manufacturing, robotics, or vehicle situational awareness/safety systems.

REFERENCES:
3. Robert L. Murrer Jr., Rhoe A. Thompson, and Charles F Coker, "Recent Technology Developments for the Kinetic Kill Vehicle Hardware-In-The-Loop Simulator (KHILS)," AD#: ADA355943, 1998.

KEYWORDS: autonomous guidance, strapdown seeker, Multi-spectral, Guidance, Navigation, Control, Wide Field of View,
TITLE: Advanced Solid Rocket Motor Technology for Tactical Missiles

TECHNOLOGY AREAS: Electronics, Weapons

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

OBJECTIVE: Develop advanced energy management and highly loaded grain solid rocket motor technologies for future air supremacy missiles.

DESCRIPTION: The US Air Force requires increased capabilities for next-generation, air-launched, tactical missiles to maintain air supremacy. This capability will help ensure total control of the airspace, allowing friendly air assets to operate freely without fear of attack, from either airborne or ground-launched threats. For the purposes of this topic the tactical missile may have a weight between 100 to 800 lbs, have a length between 6 to 14 feet and have a nominal diameter of 5 to 10 inches. Current inventory missiles in this class include the AIM-120 AMRAAM, AIM-9 Sidewinder and AGM-88 HARM. An overarching desire is to increase the number of missiles carried on a single sortie and increase the effectiveness of each missile. System level goals are to improve missile range and terminal maneuverability. A flow down of missile system level requirements drives the need for solid rocket motors (SRM) with increased volumetric energy capability. Areas of interest for achieving this capability include, but are not limited to, improved propellant formulations, grain configurations and packaging volume techniques (e.g. reducing inert weight/volume and replacing with energetic material). A first order metric of performance for a SRM is specific impulse (thrust/mass-flow rate of propellant). Specific impulse levels for a typical SRM with reduced-smoke, propellants range from 240 to 250 lb-s/lbm. Specific impulse levels for a typical SRM with smokey propellants range from 250 to 265 lbs-/lbm. A goal for this effort would be to achieve performance levels equal or better than smokey propellants in a reduced smoke formulation. In addition to increasing the overall energy capacity of the missile SRM, it is also important to optimize the release of that energy over the entire flight trajectory. Managing the energy release allows tailoring of the range, time-to-target and maneuvering capability of the missile. Areas of interest for achieving this capability include, but are not limited to, improved grain configurations, burn rate control methods, multiple-pulse techniques and variable nozzle throat techniques (discrete and/or continuously variable). No matter what energy management technology is developed an important goal is to have minimal impact on the overall SRM mass-fraction (Propellant weight/SRM total weight).

PHASE I: Identify and define the candidate approach for developing advanced energy management and/or highly loaded grain technologies. Demonstrate proof of principal through analysis, numerical simulation, and/or laboratory test. Establish performance goals and develop key technical milestones for Phase II.

PHASE II: Develop, characterize and demonstrate the technology through a combination of detailed analysis, simulation and laboratory tests. Depending on the specific technology pursued appropriate testing could include initial safety/hazard tests, material characterization tests, subscale motor tests, and full-scale heavyweight motor tests. Expected deliverable is a final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Air-to-air and air-to-ground tactical missiles. Ground-to-air intercept missiles.
Commercial Application: Small, suborbital rocket and sounding rocket activities.

REFERENCES:


KEYWORDS: solid propellants, energetic materials, specific impulse, pulse motors, insensitive munitions, tactical missile

AF112-106

TITLE: Multi-functional self-healing composites

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop fabrication and manufacturing techniques of multi-functional, carbon nanotube (CNT) based composites that are capable of self-healing.

DESCRIPTION: Carbon nanotubes (CNTs) are essentially elongated sheets of graphite that are arranged in one or more cylindrical layers [1]. They are recognized as unique materials because of their combination of superior mechanical, thermal, electrical, and optical properties. Due to this exceptional combination, they are attracting much attention in many areas, including aerospace applications. Current work is being done to incorporate or replace other materials with CNTs. If these new materials are successfully integrated in aerospace structures, they can theoretically provide a system with a multi-functionality that can be exploited to enhance areas of concern such as strength with weight reduction. Successful integration will address and resolve factors such as interfacial bonding and CNT alignment. In addition to enhancing the properties, extending the life and reliability of aerospace materials are imperative to both safety and cost reduction. A significant amount of effort goes into maintenance and repair, which can be reduced if a structure has the capability of repairing itself. During impact, both visible and non-visible damage occurs. While visible cracks are of less concern, it is the micro-cracks that are harder to detect and repair; thereby posing a greater risk [2]. The incorporation of self-healing materials into the composite system that are released as needed, and without manual intervention [3], to ‘heal’ the cracks as they form, can help reduce maintenance cost, increase the life span of a system, as well as reduced the potential of catastrophic failure. The intent of this SBIR topic is to explore methods of fabrication and manufacturing composite materials that incorporate both CNTs and self-healing materials into a system to produce a lighter, more thermally and electrically conductive composite that can support or replace current materials used in aerospace structures. This project should specifically address micro cracking of the wing skin due to inevitable impacts and in-service fatigue [4-5], and should take into consideration the application environments. The material must be capable of restoring its mechanical properties to near pre-impact conditions. All issues such as alignment, agglomeration, and homogenous mixing of both the CNTs and self-healing materials into the matrix as well as interfacial interactions must be addressed.

PHASE I: Develop and implement efficient techniques to fabricate multi-functional materials that are CNT based, self-healing, and that maintain or exceed current aerospace materials. Preliminary evaluation of the mechanical, thermal, and electrical properties as well as a sample must be provided.

PHASE II: Optimize fabrication methods that were developed in Phase I and demonstrate ability to scale-up process as needed. Produce a prototype airframe that can survive typical payload and environmental conditions. Evaluate the life-cycle cost to produce the composite materials.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Materials that are lighter, stronger, and more self-sustainable can help reduce the maintenance and repair needed, while also increasing the safety and life span in military air vehicles. Commercial Application: These composite materials could also be incorporated into commercial aerospace, automotive, and marine applications.

REFERENCES:

KEYWORDS: Carbon nanotubes, multi-functional, self-healing, composites, micro-cracks, self-sustainable, wing skin

AF112-108	TITLE: Structural Reactive Composites

TECHNOLOGY AREAS: Materials/Processes, Weapons

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OBJECTIVE: Develop reactive composite case technologies for high-strength, enhanced-blast, low-collateral-damage warheads.

DESCRIPTION: The Air Force desires a low collateral damage munition with increased blast effectiveness and reduced fragment footprint for military operations in urban terrain (MOUT), close control strike (CCS) missions, and/or chem-bio target defeat. These munitions might be used in open air, or in confined spaces, or both. In this conceptual warhead, the steel warhead case is replaced with a reactive material case capable of penetrating soft structures. These cases are not required to match the density of steel. There are no firm strength requirements; investigators may use the strength and toughness of aluminum alloys (~200 MPa and ~30 MPa-m**1/2, respectively) as goals, or propose and justify alternate figures of merit and standards. The reactive case might be either a single component, single material, monolithic structure or a multi-layered, multi-component, multi-material structure. These ordnance should exhibit significant increases in energy release (i.e., blast effects) versus a steel case baseline. This energy release may be immediate (i.e., detonation or fast deflagration) or delayed (i.e., post-detonation energy release or afterburn behavior similar to thermobaric formulations and inorganic reactive materials [References 1-3]).

This effort may include development of: (a) reactive materials and non-ideal explosives; (b) novel initiation techniques; (c) novel diagnostics and analysis tools for characterizing the chemistry, physics, and lethal effects of these multiphase explosive systems; (d) modeling of shock-driven reactions, dispersion of fuel-rich materials, and post-dispersion burning in atmospheric oxygen; and/or (e) low-strain-rate and high-strain-rate modeling and validation of composite materials and structures.
Although not limited to these areas, RW is interested in the following research areas:

(a) high-lethality, limited-range damage mechanisms (e.g., enhanced blast, multiphase blast effects, micro-
fragments, reactive fragments with limited range of effects);
(b) structural response of cellular metals [Reference 4] and composite materials;
(c) bio-inspired composites [References 5];
(d) generation of chemical species in the explosive reaction products to enhance chemical and biological agent
neutralization; and
(e) Particle Image Velocimetry (PIV) or other diagnostics for characterizing particle dispersion and post-dispersion
reactions, and novel, fast, in-situ spectroscopic interrogation methods for quantitative and qualitative determination
of intermediate chemical species created during detonation and/or shock events.

PHASE I: The contractor will develop the technology 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:
Used For Cased Explosives,” American Physical Society, 16th APS Topical Conference on Shock Compression of
Cellular Structures with Elastic Filler Material,” Experimental Mechanics, 49:501–509 (2009); DOI:

KEYWORDS: collateral damage, warhead, energetic materials, reactive materials, structural energetics, composites,
enhanced blast, multiphase blast

AF112-109 TITLE: Attitude Control Enhancement Using Wing Load Sensing

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

OBJECTIVE: Develop feedback control architectures for flying sensor platforms that take advantage of load sensing to enhance robustness and disturbance rejection.

DESCRIPTION: As with man-made flying systems, natural systems, e.g., birds, bats, and insects, use rate feedback to stabilize flight and damp out extraneous motion; however, natural systems achieve a level of agility, robustness and stability that exceeds that achievable with conventional rate stabilization designs. This is even more impressive given the latency associated with the optical feedback mechanisms in these systems. An important difference between the man-made systems and natural systems is the load sensing structures throughout the body that allow the animals to feel the inertial and aerodynamic forces on the wings and other control structures that influence the motion of the body. Preliminary simulation results have shown that marked improvement can be obtained in terms of aerodynamic disturbance rejection, robustness to control uncertainty, and damage tolerance if the errors in the forces influencing the body can be fed back directly into the attitude control system [1]. Other benefits of the additional sensory information include reduction or elimination of dependence on detailed control system characterization and the ability to provide compensation for rate feedback latency using estimated angular acceleration estimates. Man-made air vehicles with strap down sensors or stringent pointing stability requirements, can greatly benefit from increased disturbance rejection. In addition, load sensing techniques can be expected to improve the ability to fly robustly with power supply uncertainty, variable weather conditions, control surface damage, and through regimes of unpredictable aerodynamics.

Innovative techniques are being sought for enhanced control of air vehicles using load sensing to allow highly responsive, reflexive control reaction to disturbances and errors relative to the desired body state. Techniques that simplify control design by reducing dependence on gain scheduling and eliminate dependence on detailed characterization of aerodynamic forces are desired. Solutions that provide substantial performance improvement without requiring integration of complex or expensive sensor systems are being sought, e.g., sensing the net roll torque on the body by sensing forces at the root of the wings might prove simpler than detailed characterization of the distributed load over the wings. Approaches with a direct path to implementation and demonstration on small flying sensor platforms are desired.

PHASE I: Investigate attitude control using differential load or acceleration sensors. Demonstrate design benefits and tradeoffs using closed-loop simulation and experimentation. Design a prototype device for concept demonstration and design an experimental process for flight test validation.

PHASE II: Implement, integrate and demonstrate the software and hardware solution(s) developed in Phase I. Demonstrate solution capabilities and limitations using 6DOF simulation and prototype flight test demonstration. 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: Aerial surveillance systems with strap-down sensors are limited by platform motion. Improved flight control and sensing in complex urban and turbulent environments. Commercial Application: The requested technology will provide higher quality video in turbulent environments from aerial platforms for border security, emergency management, and general situational awareness.

REFERENCES:


KEYWORDS: Attitude, Control, UAV, MAV, Surveillance, Biomimetic, Stability, Stabilization, Surveillance

AF112-110  TITLE: Portable Laser Removal Tool

TECHNOLOGY AREAS: Materials/Processes

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

OBJECTIVE: Develop a portable laser-assisted tool for the removal of aircraft outer mold line (OML) materials.

DESCRIPTION: Maintainability continues to be a top priority for program offices and combat commands in order to increase aircraft availability and reduce nonmission capable status. The repair of OML materials, which include coatings, gap fillers, adhesives, etc., account for the majority of the maintenance hours experienced by the Air Force. The primary reasons for coating removal and replacement is flight-induced damage or facilitate other maintenance.

Technicians currently use manual and mechanical methods (hand scrapers and sanding processes) that are difficult to perform and labor intensive; work-related injuries from the repetitive action with hand tools are common. Other methods can include solvents to accelerate the removal process. These solvents are not environmentally friendly and can potentially damage the aircraft. This capability will drastically reduce the overall repair time and increase aircraft availability.

The system must demonstrate the capability to remove selectively all OML materials without damage to underlying surfaces in a field-level environment. Additionally, the tool must be able to taper coatings to proper thickness to reduce the amount of time required currently to manually sand taper into repair materials. The technology must be portable, supportable, and deployable to support deployment operations at various locations globally.

PHASE I: Identify portable laser technology capable of strip rate of less than 1 hour per square foot from start of setup to final removal. Demonstrate a small area (12 by 12 inches) repair with selective removal capability and tapering without damage to underlying substrate.

PHASE II: Develop capability to track contoured surfaces. Add programmable features such as defect size and defective material stack-up. Demonstrate a portable and deployable system capable of operation without supervision.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applicable to depot maintenance.
Commercial Application: Commercial airliners.

REFERENCES:


KEYWORDS: coating removal, laser-assisted tool, OML, outer mold line (OML), taper capability
AF112-111  TITLE: High-Temperature Ceramic Field Repair

TECHNOLOGY AREAS: Materials/Processes

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OBJECTIVE: Develop a method of repairing high-temperature ceramic materials for operational field application.

DESCRIPTION: There is a growing focus on ceramic materials being used for high-temperature structures and other applications. A method is needed to support these ceramic structures in an operational environment. Current support strategy requires parts to be removed and replaced or removed and repaired off-aircraft, affecting aircraft system availability. The ability to make on-aircraft ceramic repairs could improve aircraft availability. Current repair methods for ceramic materials include high-temperature and high-pressure cures not suitable for on-aircraft application. This influences supportability of ceramic structures/parts and ultimately affects program costs of replacing ceramic parts.

To meet operational needs, a new ceramic repair material should be suitable for application in a typical maintenance environment, e.g., flight line or aircraft hangar. The repair must return the part/component to a condition that allows it to meet structural strength requirements. In addition, the repair process shall be relatively easy to perform, not requiring engineering support, and be accomplished in a minimal amount of time, lessening aircraft downtime.

PHASE I: Identify and design a repair material/technique to mend ceramic structures in a laboratory environment, keeping in mind the end use of field installation capability. Demonstrate feasibility of repair/design concept and methodology to perform repair.

PHASE II: Using results from Phase I—(1) Fabricate and demonstrate a repair material for of ceramic parts within given guidelines for processes and strength requirements; (2) fully define repair process concept and application requirements and any unique support equipment or tools; (3) deliver a ceramic repair kit for Air Force evaluation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Ceramic repairs will be used to support an advanced high-temperature aircraft edge.
Commercial Application: An increase in ceramic materials and structures are being used on commercial aircraft engines and turbine generators along with other applications requiring high service temperature components.

REFERENCES:

KEYWORDS: aircraft maintainability, ceramic repair capability, operational field repairs

AF112-112  TITLE: Increased Infrared (IR) Sensor Angle of Regard for Conformal/Special Operations Force

TECHNOLOGY AREAS: Sensors
OBJECTIVE: Research and develop an optical sensor transparency that will provide anti-reflection properties and improve target resolution for Air Force IR sensors.

DESCRIPTION: Modeling and other data indicates that anti-reflection angle of regard can be increased for IR sensor transparencies. This would be useful for high-speed airborne platforms as well as low flying aircraft at lower speeds, enabling greater visibility under single pass conditions. The objective would be to provide robust protection against the environment while providing significantly improved IR transmission to at least 85 percent at angles of 60 degrees and beyond. Currently, serious loss of transmission occurs at 45 degrees and beyond. It is anticipated that target resolution could be improved considerably while simplifying faceted sensor design to more nearly conformal configurations. Improvement is needed for robust use in environmentally demanding settings as well as for improved and unimproved runways. Emphasis should be on a novel approach that can be easily scaled to usable sizes.

PHASE I: Develop and characterize novel anti-reflection method on laboratory-size samples with objectives of 70 percent transmission at an angle of regard of 60 degrees and minimal damage in a simulated rain environment.

PHASE II: Develop and characterize selected Phase I method on 8-inch planar and 4-inch hemispherical surfaces with objectives of 85 percent transmission at an angle of regard of 60 degrees and minimal damage in simulated blowing sand environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Faceted and conformal IR transparencies for aircraft platforms and missile domes.
Commercial Application: In-process inspection of processing for highly corrosive materials.

REFERENCES:


KEYWORDS: angle of regard, anti-reflection, infrared (IR) sensor, IR sensor transparency

AF112-113

TITLE: Measurement of Hole Depth During Automated Drilling

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a method for measuring the depth of holes drilled through stacks of material with minimal impact to the drilling process to replace manual grip measurements.

DESCRIPTION: Variability in the manufacturing process of aircraft skins and understructure components results in slight uncertainty in the thickness of material stacks. This uncertainty requires each hole across the outer surface of an aircraft to be accurately measured so that fasteners may be sized appropriately to reduce waste, excess waste, and ensure a tight fit. The current measurement process is manual and labor intensive. Mechanics use hand-operated thickness gauges, or grip gauges, to take measurements of holes individually. The measurements are stored electronically and used in selecting appropriate grip lengths for fasteners during kitting.

The goal of this program is to eliminate the use of hand-operated gauges and manual labor for acquiring grip length measurements. Significant time savings can be realized by automating the measurement process. Ideally, the automated process would be integrated into the computer numeric controlled (CNC) machines that drill each of the holes and would occur in parallel with the drilling operation, thereby eliminating manual grip measurement and adding no additional time to the manufacturing process. If an alternate solution is pursued, it should still be able to decrease significantly the time required to take these measurements over the current manual process. Additionally,
the system shall electronically record each grip measurement and associate the measurement with its respective hole identifier. For acquired grip measurements to be useable, the accuracy must be equal to or greater than +/- 0.007 inch. The system must be able to perform measurements on aerospace metal and composite materials, particularly those in use for production of the Joint Strike Fighter. If modifications are required to any production equipment, it must be proved that the modifications produce no degradation of part quality. Assuming a successful demonstration, the system may be integrated into production.

Phase I should result in a prototype system demonstrating the ability to autonomously measure holes in a bench top environment, and that it saves time over the current process. Tests for accuracy and consistency should be performed. A preliminary cost estimate along with manufacturing/transition planning should be performed. Details of a plan to integrate the system into the assembly line should be provided.

Phase II should conclude in a successful demonstration of the prototype system in a production-representative environment, utilizing a wide variety of specimens of varying thicknesses, hole diameters, and material stackups. Accuracy and consistency data should be further refined to ensure that it meets or exceeds the current manual method, and quantification of timesavings over the current method should be performed as well. A detailed cost analysis as well as manufacturing/transition planning should be performed.

PHASE I: Identify a means by which grip measurements may be acquired by nonmanual methods. Perform accuracy and consistency testing. Develop a plan for the integration of the system into manufacturing and demonstrate its compatibility with existing CNC machines and other equipment.

PHASE II: Successfully develop and demonstrate a prototype system in a mock production environment for thorough testing and analysis across a variety of hole diameters, hole thicknesses, and material stackup combinations. Provide a means by which accuracy/consistency can be confirmed. Detailed cost, transition, and manufacturing planning should be performed.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Manufacturing and depot operations of all aircraft, especially fifth-generation fighter aircraft with a significant digital thread will benefit.
Commercial Application: Applications are to the commercial aircraft industry (particularly new wide-body aircraft using material stackups) and potentially the automotive industry.

REFERENCES:

KEYWORDS: automated grip measurement, CNC, CNC hole depth, computer numeric control (CNC), material stack thickness, measurement while drilling

AF112-114 TITLE: Intelligent Wear Monitoring of Cutting Tools

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an approach to monitor machining parameters and examine individual cutting tool performance for an optimized process to remove tools from production on condition vs. tool life estimates.

DESCRIPTION: Many aerospace production machining processes, including milling and drilling, develop tool life estimates through extensive testing. To increase one’s confidence in a tool life prediction, the exercise used to generate the data must simulate as close as possible the exact process used in production. Significant resources,
including labor, machine time, and material costs, are needed to accurately document tool life estimates. Once the cutter life is established for a given process, variation in cutter materials, geometry, coolant/lubricant application, as well as changes in part composition and/or part geometry can skew the predicted cutter life estimates. While there is no standard definition of tool life, it can be documented as number of cycles, linear inches of material cut, time spent in cut, volume of material removed, flank wear measurement, etc. Once in production, variables associated with the material removal process such as tool setup, part rigidity, and programming tend to reduce the accuracy of predicting when a cutting tool has reached its end. In any material removal process, as the cutter wears, there exists many related outputs, including decreased accuracy of the finished part, increased machine power required, increased cutting forces, increased cutting temperatures, chip formation change, and tool flank wear, all of which progress toward the end of tool life. How these variables affect the geometry and finish of the machined surface is not completely understood. The ability to remove the cutter from service while still producing acceptable parts and in a state that allows for reconditioning is the common goal of the end user. We seek innovative development of concepts that uses data generated and monitored in real time to decide accurately when it is time to replace a given cutting tool based on that individual tool’s current performance while cutting typical aircraft materials.

A successful offeror will demonstrate an understanding of the types of machining equipment, cutting tools, and machining operations performed on the weapon system assembly lines.

During Phase I, define a method to relate machine part quality with a measurable output capable of being tracked on existing production machine equipment. Perform modeling and simulation as required. Explain a concept that would successfully allow a tool life monitoring system to be integrated into a computer numeric controlled (CNC) machine cell for use in a production environment. Perform a preliminary cost estimate and manufacturing/transition plans.

The output of Phase II should be the successful demonstration of a prototype system in a production representative environment, along with test data correlating cutting tool performance to machining quality. Demonstrate robustness of the system by testing it under varied machine parameters and conditions for sufficient lengths of time. Perform detailed cost estimates and manufacturing/transition plans.

PHASE I: Define methods of relating machine part quality with a measurable output(s) that can be monitored or tracked on existing machine equipment to initiate tool changes. Define a concept using this method allowing a system to be integrated into a CNC machine cell for use in a production environment.

PHASE II: Based on Phase I analysis, design and develop prototype systems that should be fabricated, demonstrated, and tested in a production-representative environment. Perform testing under various conditions to prove model accuracy and robustness of the system. Provide detailed cost estimates and manufacturing/transition plans.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Multiple applications include any manufacture of any components machined to high tolerances for air/sea/land/space applications.
Commercial Application: The commercial machining industry will significantly benefit, including commercial aircraft and automotive.

REFERENCES:
TITLE: Automate/Mechanize Current Manual Fuel Sealant Application Methodology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop methods to apply exact amounts of highly viscous sealants over pre-installed fasteners in fuel tanks using an automated direct dispensing application tool to reduce time/improve quality.

DESCRIPTION: The current method of sealant application in a fuel tank is time consuming and applicator dependent, resulting in unwanted variation in quality. The sealant is applied to avoid leakage of the fastener in the substrate. The sealant applicator apparatus comprises a pair of sealant and pre-assembled cup attachments movable to required angles into sealant applying relation with the fasteners. Each sealant applicator has an end shaped to confirm to a portion of the outer surface of the fastener. The applicators are readily removable to facilitate maintenance and replacement. This manual application of fuel seals is still highly labor dependent and time consuming. The dispense operation is currently carried out by an operator using a simple tool. The amount of sealant dispensed is completely operator dependent. The volume will vary on every hole and with each operator performing the application.

PHASE I: Identify and define a viable approach for applying fuel tank sealants that will meet quality criteria relating to thickness, porosity, and application time.

PHASE II: Develop, demonstrate, and validate a prototype tooling methodology based on the Phase I approach. Design the prototype system in a mock production environment for thorough testing and analysis. Also, the application of sealant needs to meet the quality requirements/specification. Complete Phase II with a detailed transition-to-production plan.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Scale up the Phase II technology for production robustness, maintenance, and expansion into all applicable areas of the assembly line.
Commercial Application: Commercial aircraft also utilize integral fuel tanks that require numerous sealant applications.

REFERENCES:
3. AMS 3277, Sealing Compound, Polythioether Rubber Fast Curing for Integral Fuel Tanks and General Purpose, Intermittent Use to 360 °F (182 °C).
4. AMS 3281, Sealing Compound, Polysulfide (T) Synthetic Rubber for Integral Fuel Tank and Fuel Cell Cavities Low Density for Intermittent Use to 360 °F (182 °C).

KEYWORDS: faying surface, manufacturing, porosity, sealant, viscous
TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and manufacture a prototype aircraft landing mat for high-temperature applications.

DESCRIPTION: Aluminum alloy 6061 is currently used for aircraft mat applications. Aircraft landing mats for high-temperature environments will be exposed to sustained temperatures of 450 °F and transient temperatures of 1700 °F. These two high-temperature environment performance conditions require aluminum alloys to have the following properties:

1. High-temperature tensile strength of 40 ksi at > 450 °F. The 40 ksi is estimated based on performance of current 6061 mats, which are exposed at much lower temperatures.
2. Elastic modulus values are 20 to 30 percent higher than 6061 at 450 °F. Higher modulus will reduce plastic deformation of mats from repeated takeoff and landing operations.
3. Transient exposures to 1700 °F [a temperature higher than the melting point of aluminum (Al)] by nearly 500 °F) requires that the new mat alloy have thermal conductivity that is about two times that of 6061. Such thermal conductivity values will remove heat quickly from the surface, thereby helping maintain its strength properties.

Current commercial alloys can have higher strength values than 6061 at room temperature; but at 450 °F, all of them have comparable strength values. This suggests that strengthening methods currently used for Al alloys are not stable at 450 °F. Furthermore, no improvement in modulus and thermal conductivity is known for high-strength Al alloys. Compositing Al and its alloys is one possibility to deliver the required mat properties.

During the program, testing will be required to characterize mechanical properties (yield stress, ultimate strength, and Young’s modulus) and thermal properties (coefficient of thermal expansion, specific heat capacity, and thermal conductivity/resistivity) at temperatures of 450 °F to 1700 °F.

In Phase II, further develop the material by addressing issues related to manufacturing extruded aircraft matting product. Demonstrate that the material can be extruded into panels similar in size and dimension to the current Air Force standard (AM-2 matting) and that the material can be joined to 6061 Al alloy by arc welding, stir welding, or other processes. Provide approximately 250 sq ft of matting to the Air Force Research Laboratory (AFRL) for testing under simulated aircraft trafficking and for testing under the Navy’s jet engine simulator (1700 °F at Mach 1 velocity).

PHASE I: Develop a composite aluminum material for aircraft matting exposed to high temperatures and characterize its mechanical and thermal properties at temperatures of 450 °F to 1700 °F. Define likely processing/manufacturing parameters. Perform preliminary cost analysis and transition planning.

PHASE II: Further develop the material by addressing issues related to manufacturing. Demonstrate that the material can be extruded into panels similar in size and dimension to the current Air Force standard (AM-2 matting) and that the material can be joined to 6061 aluminum alloy by arc welding, stir welding, or other processes. Provide approximately 250 sq ft of matting to AFRL for testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The material will be used for parking ramps and expeditionary landing pads for vertical takeoff and landing aircraft. Also applicable to aircraft structures.
Commercial Application: Industrial processes where a lightweight, high-strength material is required for high-temperature environments (aircraft, matting, bridges, and architectural construction).

REFERENCES:

KEYWORDS: aircraft matting, aluminum composite, high temperature
AF112-118

TITLE: Automation of Material Placement for Aircraft Radomes

TECHNOLOGY AREAS: Materials/Processes

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OBJECTIVE: Develop and demonstrate automated methods for placing material on aircraft radome surfaces.

DESCRIPTION: Aircraft radomes are complex composite structures that contain both geometric and multi-material challenges. Today's aircraft radomes are comprised of multiple stacks of material, including quartz cyanate ester fabrics, honeycomb cores, adhesives, and foam cores. The geometry challenges of pointed tips and stream-wise chines introduce production issues for radome fabrication. An automated process that can handle placement of the fabric material over the multiple materials present in the radome stack up as well as the geometric complexities of modern aircraft radomes is desired. The process must address the placement of cyanate ester quartz fabric material on complex tool surfaces and over both solid and core (honeycomb and foam) substrates. The end result will be an automated assisted work cell capable of producing aircraft radomes with reduced labor hours, flow times, and defects. The technology must be environmentally friendly and lend itself to application at the prime contractor and major composite part supplier facilities.

PHASE I: Develop automated work cell concepts. Demonstrate the ability of automated equipment to place material over radome-representative geometries and substrates. Down select to the preferred automated cell concept.

PHASE II: Fabricate and test the full-scale radome automation work cell. Fabricate multiple full-scale radomes to validate the repeatability of the automated process. Perform testing of the radome produced using automation to verify that it meets the performance targets. Prepare a cost-benefit analysis comparing the manual and automated processes.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Deploy the automated radome fabrication process. Successful completion will lead to reduced recurring and rework (cost) along with span time (schedule) during radome fabrication.
Commercial Application: The technology will be applicable to existing and future aircraft platforms that utilize modern radomes/radars, including military and commercial platforms.

REFERENCES:

KEYWORDS: automation, composites, radomes

AF112-119

TITLE: Key Characteristics Metrology Solution

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Reduce process time for measuring approximately 200 features on the center fuselage of an advanced fighter aircraft.
DESCRIPTION: The Air Force is seeking to encourage a reduction in cycle time during the production of an advanced fighter aircraft. Geometric dimensioning and tolerancing (GD&T) requirements include definition of outer mold line (OML), assembly key characteristics (KC), and interchangeable and replaceable (I/R) panel hole patterns. Current methods for measuring the center fuselage include the use of laser trackers. This process is time consuming and requires numerous set-ups due to laser line of sight. This effort seeks a solution that can measure surfaces and points against a CATIA model to accuracies of +/-0.002 inch. The proposed solution should address integration with current production tooling and processes. The data will be used to perform virtual mates for major structural components. A single technology does not need to address all measurement features; however, all of the technologies must provide real-time feedback and integrate with data systems for statistical process control analysis.

PHASE I: Review the assembly line and associated areas for GD&T data collection. Design a system(s) that measures all key features, then process the various data. System designs should include hardware, software, and external interface components; identify assembly tooling mods and high-risk technology.

PHASE II: Construct critical components of the system or systems designed in Phase I for validation of system performance. Demonstration should include a representative environment and set-up of the final product. Develop production system or systems designs and implementation plans.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Scale up the technologies and design and incorporate production robustness features, including handling, maintenance, and calibration, into all applicable areas of the assembly line.
Commercial Application: Commercial vehicles require advanced metrology solutions to verify product build quality; would reduce nonvalue added work (i.e., part inspection) and reduce cost and cycle time of aerospace products.

REFERENCES:

KEYWORDS: assembly key characteristics (KC), camera, GD&T, Geometric Dimensioning and Tolerancing (GD&T), KC, laser, metrology, OML, outer mold line (OML), tolerance
rate to specified areas in exact, but variable, amounts required by a production specification. The goal of the program is to utilize the existing liquid shim material, Hysol EA 9377, as it is too costly to qualify a new material. The material may require degassing prior to mixing and the material properties should be maintained after mixing. The unit should ensure there are no voids in the flow of the liquid shim and indicate when a material is not able to meet a flow capacity for required specifications. The unit should have the capability to variably dispense the proper amount of shim across the structure to ensure a steady bead and eliminate excess shim “squeeze out”. Therefore, the unit should have the capability to adjust the dispensing amount while moving along the flange of the aircraft. The unit should also be completely controlled so there is no need for masking of the aircraft structure and be capable of mixing the two materials to dispense the liquid shim just prior to application. In a production environment, the unit should consist of a flexible design that can be implemented with either a robotic or ergonomic assistance device.

PHASE I: Identify and define a viable approach for on demand mixing/dispensing of liquid shim that can meet quality criteria relating to thickness, porosity, and application time.

PHASE II: Develop, demonstrate, and validate a prototype dispensing system and process based on Phase I approach. Design the prototype system to be used in a production environment for thorough testing and analysis. Completion of Phase II will include a transition to production plan that details the integration of the technology into the production process.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Automated application of liquid shim is necessary for the production and maintenance of military aircraft.
Commercial Application: Commercial aircraft also utilize liquid shim processes to remove gaps between structural components. This technology allows for application of large amounts of material in a time sensitive process.

REFERENCES:
1. (Deleted 6/9/11.)
2. (Deleted 6/9/11.)

KEYWORDS: dispense on demand, liquid shim, manufacturing, mixing, viscous

AF112-121 TITLE: Advanced Power Skiver Tool

TECHNOLOGY AREAS: Materials/Processes

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OBJECTIVE: Provide a highly accurate and repeatable-powered, gap-filler skiving tool, capable of skiving/trimming gap fill materials from flush to variable positive heights as prescribed by operator.

DESCRIPTION: Military and Defense Contractors desire the manufacturing capability to better control the process of skiving various gap fill materials. Current processes generally incorporate the use of hand held razor blades or labor intensive hand sanding to bring gap fill materials flush to surrounding mold line surfaces. Studies of just one fuselage component have shown an increase of 15% in span time due to rework from low/high skiving. Mirrored effects of the study have been seen in other aircraft components. These additional manufacturing steps drive increased cycle time, and costs.
An opportunity exists for manufacturing process tools capable of achieving first time gap filler skive height requirements that meet quality goals. The process tool of interest requires the development of a pneumatic powered adjustable height skiver that is capable of cutting various gap fill materials commonly used on Low Observable platforms within both easily accessible and confined spaces where complex / compound curvature is incorporated within a height of 0.020” to flush.

PHASE I: Establish tool requirements and concepts of operation. Create initial prototype skiver and perform validations.

PHASE II: Refine prototype tool based on lessons learned in Phase I. Validate final form configuration in a production representative environment. Demonstrate suitability to production operations and develop a transition-to-production plan.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Scale up Phase II technology for all applications and materials. Design production robustness features for handling and maintaining the equipment. Commercial Application: Both commercial and military platforms would benefit equally from development of the proposed tool.

REFERENCES:
References for this particular technology are limited due to the highly specialized nature of gap filler trimming/skiving. References that are close in nature are as follows:


KEYWORDS: dimensional control, gap fill, power skiver, trimming

AF112-122 TITLE: Noncontact, Hand-Held Hole-to-Edge Distance Measurement Tool

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a tool and process for the automatic measuring of hole-to-edge distance for aircraft quality inspection.

DESCRIPTION: Hole location relative to the edge of the part is a critical aspect of ensuring aircraft structural integrity. Placing a hole too close to the edge will result in a tear-out condition and major structural failure. Future aircraft are continuing to reduce part flanges and tighten edge distance tolerances to save weight for increased performance. The current methods and tools for measuring this feature are mechanical, time consuming, and labor intensive. Current noncontact technology (cameras, lasers, etc.) offer the ability to identify and measure features accurately. The tool features should include the ability to recognize hole size and reference the engineering edge distance requirement for that particular hole size, then measure the center of the hole to the edge of part distance, and then store/report/inform the operator of the result in real time. Innovation is required to overcome the compact size (hand-held); various stand-off distances (contact to 4 inches); off-axis angles (from normal to 70°), lighting conditions; and data storage/download/formatting of data.

PHASE I: Demonstrate hardware and software algorithms capable of measuring various edge distances in a range of conditions. Develop concepts for a compact prototype and perform a cost analysis.
PHASE II: Construct a hand-held prototype system (hardware and analysis software) and validate in a production representative environment. Design features so the system can pass various reliability testing (dropping, environmental, etc.). Develop commercialization plan and market analysis.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Follow-on activities include specific application integration and creation of any customer-unique requirements, training, and operation documentation. Commercial Application: Commercial aircraft require engineered edge-distances for each hole drilled; this system has applications in both manufacturing and maintenance.

REFERENCES:
Example specification only

KEYWORDS: distance measurement, edge distance, hole-to-edge distance, noncontact inspection

AF112-124 TITLE: Heat Transfer Switching Devices

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this SBIR is to develop materials and methods for heat transfer switching (aka heat switch) to provide temperature control of DoD systems for improved thermal management.

DESCRIPTION: Many Air Force systems require temperature regulation within an allowable range. Spacecraft components must be protected from exposure to the extreme temperatures in space. Also, the ability to modulate heat transfer provides the core needed for reconfigurable thermal control systems, which will reduce design cycles from years to months or days. For aircraft, thermal control for on-station extremes is a concern, especially specialized electronics with narrow operating temperature requirements. Heat transfer switching devices currently employed utilize paraffin wax with a fixed melting point to induce mechanical motion which presses surfaces into contact to increase heat conduction. Many waxes with different melting temperatures are available, but once selected, cannot be changed for the life of the mission. This does not allow reconfiguration as mission profiles change and evolve.

Engineered materials such as MEMS, microparticle or nanoparticle composites, bimetallic cantilevers at the micro-scale, etc. have been reported as possible heat transfer switching devices. Utilizing engineered materials for heat switches offers the capability to reconfigure the switching temperature, duty cycle and other parameters to enhance the thermal management properties. It is also possible they could be actively controlled (electrical, magnetic, pneumatic, etc.) to provide dynamic temperature response. Ideally, a thermal switch approach will also be modular so that the same unit could potentially work for many applications (i.e. a thermal toolbox). There are a number of configurations and modes of operation that can be used to achieve thermal switching, but in general, they will attach between components at interfaces. The interfaces could be between component and platform structure or between platform structure and radiator, for example.

Therefore, the Air Force seeks development of a thermal switching device capable of providing an on/off heat flow switching ratio at a threshold value (minimum) of 10 and objective value (desired) of 100. The operational temperature is between -60 C and +100 C, though usability outside this range is of potential interest as well. The threshold heat flux requirement is 10 W/cm2 and the objective is up to 100 W/cm2. In addition, the heat transfer switch should operate in both micro-g and high-g environments. Also, emphasis is placed on high reliability, low power switching (if active), and light weight. Proposals should have a reasonable expectation of leading to a working device that can be included in prototype thermal management systems by the end of a Phase II SBIR.
PHASE I: Identify several possible engineered materials and/or concepts for heat transfer switch designs. Perform preliminary experiments to prove feasibility of controlling the heat flow. Perform sufficient hardware development and testing to assess feasibility to meet system requirements.

PHASE II: Develop heat transfer switch design. Optimize design to achieve system requirements. Incorporate materials developed in Phase I into a functional prototype heat switch. Test the thermal switching capability, ability to reconfigure for different heat fluxes and temperature requirements, and ability to meet requirements. Provide two working prototypes for evaluation by AFRL.

PHASE III: DUAL USE COMMERCIALIZATION:
Military Application: Many military space systems need reconfigurable thermal control to avoid cold temperatures to critical subsystems during periods of inactivity to avoid problems with reenergizing the system.
Commercial Application: Structures such as buildings experience thermal fluctuations due to periods of day and night. A heat switch would bypass insulation when advantageous and reduce dependence on HVAC systems.

REFERENCES:

KEYWORDS: heat switch, thermal toolkit, heat flux, thermal conductivity, temperature control, engineered materials, MEMS, thermal management.

AF112-125

TITLE: High-Temperature Structural Material Process for Oxidation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a surface treatment process for improving the oxidation and mechanical behavior of high-temperature aerospace structural alloys.

DESCRIPTION: Tremendous interest exists in the development of oxidation-resistant structural materials for high-temperature applications (as both thermal protective systems and hot structures). Recent advances in thermodynamic and computational modeling have provided potential new alloys for consideration in highly oxidizing environments and provided insights into the processing of currently available alloys. This project will optimize the use of surface treatments on aerospace alloys (that may include titanium, molybdenum, and nickel alloys) to improve oxidation resistance and mechanical properties at elevated temperatures. Specifically, the treatments include processing steps to impart mechanical stresses and/or microstructural modifications to the surface and subsurface regions (not development and/or application of additional coatings). The project will model and optimize the application of processing steps with oxidation and mechanical testing at elevated temperatures for proposed alloy systems. Modeling work on the mechanisms of oxidation will be used to optimize further potential new alloys using advanced computational tools coupled with experimentation. Characterization of microstructure features will be used to validate experimental results with mechanistic models.
PHASE I: In Phase I, researchers will evaluate different surface treatment procedures for improving the oxidation behavior of the proposed alloys. In addition, the phase will propose mechanistic models for oxidation behavior and the impact of the proposed surface processes.

PHASE II: In Phase II, researchers will select, develop, and optimize the surface treatment procedures for increasing the oxidation resistance of the selected alloys. Researchers will also develop and verify the mechanistic models for the process, including validation, using high-temperature experimentation and characterization.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This effort is directly applicable to high-temperature applications, including engine components, thermal protective systems, and other structures exposed to high-oxidation environments.
Commercial Application: This effort is directly applicable to hot engine and structure components, including nozzles, used in current commercial aircraft.

REFERENCES:

KEYWORDS: hot structures, oxidation, structural alloys, surface treatment

AF112-126 TITLE: High-Temperature Microsample Testing System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a testing system capable of measuring the mechanical properties of structural materials using small-sample uniaxial testing at temperatures up to 1100 °C.

DESCRIPTION: AFRL is interested in instrumentation that enables the quantitative measurement of uniaxial mechanical properties of small mechanical test samples at very high temperatures for use in current and future materials development programs. Over the past decade, there have been significant advancements in the ability to measure the mechanical properties of small volumes of material using uniaxial mechanical tests [1,2]. However, these experiments have been limited to measurements at temperatures below 600 °C, based on the capabilities of commercially available micro- and nano-mechanical testing devices.

The proposed SBIR topic shall develop a high-temperature microsample testing system that is capable of achieving sample temperatures up to 1100 °C. Here, small volumes are defined as test samples that have gage cross-sections with dimensions approximately 5 to 100 micrometers. The test system shall accommodate microsamples that are integrally fabricated and attached to a bulk substrate [1] and, preferably, can also test freestanding structures that require placement into the device using micromanipulators. The system shall be capable of either compression or tension testing and, preferably, both modes should be accessible. The system shall be capable of controlling the atmospheric environment around the microsample test volume in order to minimize or effectively eliminate oxidation of the microsamples during testing for materials of interest such as nickel superalloys, titanium alloys, and refractory metal alloys. The system shall be capable of performing uniaxial testing under quasi-static load or displacement control, and the system should allow for users to construct custom test protocols. The system shall be capable of testing multiple microsamples within a single experimental session and shall provide mechanism(s) to
minimize sample misalignment. The system shall be able to apply and sense loads up to 5 N with precision better than 0.001 mN, measure displacements over a range of 0.5 mm with a displacement resolution better than 5 nm, and control and measure sample temperature to within +/- 5 °C. The ability to visualize the sample during deformation is preferred, although this capability does not have to be built into the testing device; for example, the device could be configured to be placed within an optical or scanning electron microscope, which could be used to readily image the deformed microsample during testing.

PHASE I: Clearly define the system concept for the high-temperature microsample testing system, which includes a detailed description of system capabilities, addressing both known and anticipated issues with system development and the technical approach to mitigate said issues, and estimates system cost.

PHASE II: Build a prototype using the design developed from Phase I. Demonstrate system performance through quasi-static mechanical testing over a range of temperatures from 500 to 1100 °C of a representative high-temperature structural alloy.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The system has the potential for use at DoD Laboratories, which rely on mechanical property characterization to optimize and assess materials processes and performance. Commercial Application: The system has potential use at original equipment manufacturers and industrial materials supply base, which rely on mechanical property characterization to fabricate, develop, and utilize materials.

REFERENCES:

KEYWORDS: Keywords: high-temperature, microsample, microsample testing, microtesting, uniaxial

AF112-127 TITLE: Novel Electrochemical Couples for High Energy and Power Density

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Development of novel electrochemistries that promise practical energy densities and are approximately comparable to current lithium-ion (Li-ion) batteries to replace liquid hydrocarbon (LHC) fuels.

DESCRIPTION: In some small vehicular applications, batteries, primarily Li-ion batteries, can marginally replace LHC fuels. However, some weight and volume sensitive applications such as unmanned air vehicles (UAV) and armored vehicles still require LHC fuels because of the high energy density inherent in the internal combustion process (ca. 2700 Wh/L or 3700 Wh/kg). It is unlikely that Li-ion technologies will ever reach the energy densities required in these applications due to the fact that only one electron is transferred per reaction. Yet there are other electrochemical couples that might reach this level if they are developed sufficiently, allowing them to possibly replace LHC fuels as a power source. The ultimate goal of the United States Air Force (USAF) is to provide 24/7 autonomous operation of electrically powered small and micro UAVs in the field when coupled with energy harvesting methods with an intermediate goal of multi-day-to-indefinite service.

To support the stated goal, a higher priority has been placed on secondary batteries over primary batteries to enable their use with energy harvesting. However, a primary battery with greatly enhanced energy density is acceptable provided suitable multi-day mission times can be attained. Also, primary batteries with the ability to be recycled or refurbished in the field are of a higher priority than a primary battery that must be discarded or transported after use. The USAF seeks projects that can produce and demonstrate secondary batteries with at least one-third of the energy density of gasoline or primary batteries with at least two-thirds of the energy density of gasoline as employed in an internal combustion engine.
Power density is also a critical requirement for a battery system, as it is meaningless to have a high energy density if it can generate little power. While exceptionally high discharge rate capability would be desirable, the current state of the art is sufficient for most applications. We require any successful electrochemical system to have a demonstrable power density at least one-third of the present state of the art for Li-ion batteries (ca. 250 W/kg). Shelf life is of considerable importance, especially for primary battery systems, since there could be a long time between manufacture and use. A successful primary battery system will demonstrably retain at least 95 percent of its original charge after one year of storage. For secondary batteries, cycle life is of more importance than shelf life. Successful secondary battery systems should demonstrate at least 75 percent of the original energy density after 50 cycles. Finally, safety is also of paramount importance when dealing with such high energy densities. In many applications, one might anticipate batteries being damaged. Successful battery systems should not employ highly toxic or flammable materials that can present a hazard if battery integrity is compromised. Any systems required for thermal control or battery monitoring/control or reagent flow/control/containment should be included in determinations of system energy and power density.

PHASE I: Device modeling and design along with half-cell testing to provide proof of concept to justify further development. A button cell or similar device is a plus, but not required.

PHASE II: A minimum of a button cell or similar device along with performance data is required. Scale up to larger demonstration batteries capable of test operation in a UAV such as the RQ-11 Raven is much preferred.


REFERENCES:

KEYWORDS: autonomous power, batteries, electrochemical storage, high energy density, high power density, liquid hydrocarbon (LHC) fuel replacement, lithium-ion (Li-ion) batteries, unmanned air vehicles (UAV)

AF112-130 TITLE: Statistical Methods for Quantifying the Accuracy and Capability of Nondestructive Sensing Methods for Damage Characterization

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop augmented statistical processes and metrics to characterize the determination of location and dimensions of damage in aircraft structures with sufficient fidelity to use in risk calculations.

DESCRIPTION: The reliability and capability of detecting damage in aircraft structures can be determined through rigorous probability of detection studies; the Air Force guidance for completing such studies is given in MIL-HDBK-1823A. However, this guidance applies only to the detection of damage. To achieve the objectives of condition-based maintenance plus prognosis (CBM+), the detection of damage is not sufficient. To realize the potential of CBM+, the location and size of damage at any length scale, e.g., either a crack or a microstructural perturbation, needs to be determined with statistical metrics to feed prognostic reasoners and risk assessments.
Current damage characterization that occurs in the field and depot environments is commonly performed via an estimate obtained from the data provided by the damage sensor and occasionally from images generated from the data. However, none of these efforts addresses the determination and evaluation of statistical metrics to provide meaningful, quantitative assessment of the uncertainty and confidence of the damage characterization process. These statistical metrics are the objective of this topic. This topic does not address the improvement of damage characterization methods.

This topic seeks to develop methods for evaluating the reliability and validating the capability to characterize damage in aircraft structures, regardless of their composition. Current efforts in the Nondestructive Evaluation Branch in the Air Force Research Laboratory have initiated work in this area (as indicated in the references), and it is anticipated that these efforts be considered in the development of the approach. The use of models and model-assisted to model-based approaches is anticipated to be integrated into this development, and the approach could generate a metric of accuracy and/or other statistical metrics. In addition, it is anticipated that this approach will address the stochastic nature of variability and the geometric complexity typically found in aircraft structures and will not address simplified scenarios such as those based on plates, cylinders, or other canonical geometric configurations.

PHASE I: Develop and demonstrate the feasibility of an approach to characterize statistically with appropriate metrics the reliability and capability to provide damage characterization assessments by nondestructive sensing methods.

PHASE II: Develop the output of the feasibility product from Phase I to include further additional confounding factors and to demonstrate the statistical characterization method on a generic but representative structural aircraft component of significant complexity.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Statistical reliability assessment of nondestructive damage characterization capabilities should have extensive military applications, including aerospace, nuclear, and ground structures.
Commercial Application: Commercial initiatives aiming to use current conditions to make maintenance scheduling decisions will need these tools to assess the performance of the nondestructive damage characterization process.

REFERENCES:

KEYWORDS: damage characterization, NDE, nondestructive evaluation (DNE), nondestructive sensing statistics, validation

AF112-132 TITLE: Integrated or Fused Multi-spectral Sensor Technologies for Missile Warning Sensors (MWS), Hostile Fire Indication (HFI), and Laser Warning (LW)

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

OBJECTIVE: To identify and develop novel integrated or fused combinations of sensor technologies using complementary spectra that are synthesized to provide a high-reliability, low-cost, single sensor package.

DESCRIPTION: Current MWS, HFI, and LW are based on Infrared (IR) sensor technologies that have inherent limitations particularly as it relates to HFI. The proliferation of standalone or independent systems is impractical from a platform integration standpoint. Future sensor capabilities are required to accurately detect, identify, and track missile launches, gunfire engagements, and laser weapon attacks against aircraft operating at low altitudes. The need exists for integrated, synthesized sensor technologies that complement or replace current technologies to detect and characterize Threat engagements. Beyond the high-reliability, light-weight, and low-cost, characteristics being sought in this announcement, the minimum required mission capability being sought is missile/track, weapons caliber and direction of fire, and laser type (range finder or designator) when originating from a single discrete event. Improved program cost control and fielded sustainability is sought through the integration of commercially available components and sub-components to the maximum extent possible and practical. Integrated subsystem architectures and designs should incorporate industry standard interfaces that link the sensor components to larger assemblies for use in multiple survivability product sets from multiple suppliers.

While basic technical achievement is the initial objective, the improved sensor components should be incrementally developed to eventually meet the implementation requirements of various sizes and types of aircraft and other platforms from the smallest UAV to the largest transports. Other related characteristics include: - Determination of hostile intent: i.e., is protected platform the target of the Threat engagement? - Large field of regard - Extended range of detection - Extremely low False Alarm Rate (FAR) - High resolution imaging with compression for low/no loss data transmittal and storage - Capability to "learn" from past false alarms is also desirable - Size, Weight, and Power (SWaP) equivalent to or less than current individual sensor packages - Modular, open interface

While legacy sensor systems are passive detectors, consideration will be given to low signature, active sensor technologies where they have the potential to provide a significant tactical advantage to include pro-active detection and geo-location data regarding Threat electro-optical systems. In addition to the above characteristics, investigate the enhanced use of sensor techniques to identify specific missile characteristics that could be used in Threat identification.

PHASE I: Consider alternative technology approaches to MWS, HFI, and LW to identify Threat engagements that can be synthesized into a single sensor module.

PHASE II: Develop a working prototype module that will undergo testing with each category of Threat engagement. Develop a working prototype module that will undergo testing with each category of Threat engagement. Articulate a clear pathway forward to productization to include package design concepts that meet tactical and environmental considerations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Production development program for a sensor system to enhance or replace legacy MWS, HFI, or LW systems to be integrated with IR Countermeasure (IRCM) systems.
Commercial Application: Production development program for a sensor system to enhance or replace legacy MWS, HFI, or LW systems to be integrated with IR Countermeasure (IRCM) systems.

REFERENCES:


KEYWORDS: Sensor, Hostile Fire, Missile Warning, Laser Warning, Infra-red Countermeasures, IRCM

AF112-134

TITLE: Tracking Algorithms for Multi-Static Passive Radar Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

OBJECTIVE: Identify and define innovative techniques and algorithms for multi-static passive radar systems to generate tracks of detected aircraft and to fuse tracks from multiple receivers.

DESCRIPTION: Multi-static passive radar systems use non-cooperative emitters as illumination sources along with passive receiver sites to detect and track aircraft. These systems may have multiple channelized receivers tuned to different radio frequency emissions at multiple receiver sites. A few of these receivers will cover overlapping geographic areas, others not.

These systems, because they emit no signals, are totally passive and aircraft cannot detect that they are being tracked. A modeling/simulation capability is being created in order to develop an electronic attack capability against these passive radar systems. However, current passive radar models lack the ability to generate aircraft tracks and to fuse tracks from multiple receivers and sites to generate a complete air picture.

The USAF requires innovative techniques and algorithms to generate tracks for aircraft detected from a single passive receiver. Research is also needed to develop novel algorithms that will fuse the data from each receiver to form a single integrated track file. This fusion should address combining multiple tracks from a single receiver site as well as across multiple sites.

The Phase I efforts will include:
1. Identification of current passive coherent location radars and passive covert radars. This should include, as much as possible, the system name, system manufacturer, country of origin, operating methods, receiver types, antenna types, signal processing capabilities, frequency ranges, and tracking algorithm method.
2. Identification of methods that may be used to generate a track for detected aircraft from a single passive receiver.
3. Identification of methods that may be used to fuse the tracking data into a single integrated track picture from multiple receivers.
4. An assessment of the Electronic Combat (EC) Benchmark Tool. The EC Benchmark Tool will be made available to the vendor. The assessment should include an understanding of how the program functions in the multi-static radar mode and what variables are available to generate tracks. The analysis should also detail, as a minimum, other variables that are needed to generate tracks that are not being calculated in the EC Benchmark Tool software program.
5. An approach for enhancing the EC Benchmark Tool to use a library of fusion-tracking techniques for passive radar systems.

PHASE I: The end product for Phase I should be a final report documenting the investigation and detailing the approach for implementing a select number of fused tracking algorithms into the EC Benchmark Tool software program and required modifications to EC Benchmark Tool.
PHASE II: The end products for Phase II should include: (1) a final report detailing the description of the fused tracking algorithms, and how they function; (2) an assessment of the accuracy of the algorithms; and (3) the enhanced EC Benchmark Tool software code with fused tracking algorithms.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The product of this program could form the core of remote, unmanned sensing stations to monitor the desert southwest border of the United States or used in bi-static or multi-static radar systems.
Commercial Application: The product of this program could be used to monitor airspace or harbors in any given region of the world without needing dedicated radio frequency allocations.

REFERENCES:

KEYWORDS: Tracking algorithms, passive coherent radar, passive covert radar, single integrated track picture

AF112-135 TITLE: Readout Integrated Circuit (ROIC) Architecture Development for Remotely Piloted Aircraft (RPA) Imaging Sensors

TECHNOLOGY AREAS: Sensors

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

OBJECTIVE: Design, develop, and demonstrate innovative readout integrated circuit (ROIC) structures supporting new airborne sensor requirements.

DESCRIPTION: At the heart of virtually every airborne infrared (IR), multi-spectral (MSI) and hyperspectral (HSI) system, there is a sensor (the focal plane array) that detects and converts the incoming radiation into an electrical signal in order to form an image. This focal plane array (FPA) is comprised of two components; the detector array and the ROIC. The detector array is the optically-sensing part of the sensor and can be made from a wide variety of materials that are sensitive in the wavelength band of interest. The ROIC is the signal processing component and is generally fabricated on a silicon substrate using volume production integrated circuit processes. Once each component is fabricated and functionality is verified, they are mated physically and electrically through a hybridization process to form an FPA. Overall ROIC performance has a significant impact on the ultimate performance of the FPA and associated sensor system.

The Air Force Airborne Collection Exploitation System – Hyperspectral (ACES HY) program is producing imaging spectrometers for military aircraft RPA. The sensor in this spectrometer utilizes a single substrate-removed HgCdTe FPA design operating in the 0.4-2.5 µm region that is inherently co-registered, alleviating the need to align multiple FPAs to rigid tolerances. There are several drawbacks with the ROIC used in this system and it has been shown to introduce artifacts in the data (including electronic crosstalk) and it does not have sufficient bandwidth to characterize small, energetic, fast-moving objects. A new ROIC architecture, mated to a detector array within the band of interest and with suitable speed of response needs to be developed. This effort will establish a ROIC concept capable of performing conventional staring imaging at video frame rates, while simultaneously being able to detect
and capture the temporal profile of isolated (one to a small number of pixels on the array) energetic transients with one or more kHz bandwidth and up to a one second duration. In addition to the greatly increased frame rate, desired features include specialized functionality that will allow for windowing/binning, zoom, autonomous signal processing, programmable frame time, programmable conversion gain, and analog to digital conversion per pixel. In particular, the per-pixel selection of conversion gains adds tremendous flexibility in dealing with the wavelength-dependent scene irradiance. Similarly, on-chip A/D conversion greatly improves the noise performance of the array.

The current FPA that is employed in the ACES HY system is a 256x256 format with a 40 µm unit cell pitch. It is critical that the overall size of the array developed in this program be maintained in order allow for direct replacement of FPAs in the spectrometer. Higher resolution formats are of interest (for example 512x512 with a 20 µm pitch) and on-chip binning could be used to maintain the current 256 spectral channels to ensure backwards compatibility. These new ROICs would greatly enhance the capability of current airborne imaging spectrometers adding increased flexibility for operation across a variety of illumination conditions.

PHASE I: Conduct study of ROIC designs to determine applicability for the ACES HY spectrometer and sensing of high speed, energetic targets for persistent surveillance applications. Using this information, develop appropriate ROIC unit cells and ROIC architectures for use in Phase II development.

PHASE II: Using the design developed in Phase I (with optimization), fabricate and demonstrate a moderate-scale ROIC supporting ACES HY and high speed sensing requirements. This ROIC will then be hybridized to a detector array to form a focal plane array. Optionally, this FPA can be delivered to AFRL for independent verification of performance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Optimized FPAs that operate at high frame rates with low crosstalk have wide applications in a number of surveillance applications and could lead to significant improvements in force protection.
Commercial Application: A variety of commercial applications are possible for FPAs with the ability to sense high speed, energetic events. Included are applications in homeland security and law enforcement.

REFERENCES:

KEYWORDS: infrared, readout, photodetector, multiplexer, transient, energetic, surveillance

AF112-136  TITLE: Cryocooler for New Focal Plane Arrays

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

OBJECTIVE: Design and build a low cost and efficient cryogenic cooling system for the next generation of airborne low temperature imaging sensors requiring cooling in the 25-30 Kelvin (K) range.

DESCRIPTION: Air and space gimbaled Infrared (IR), multi-spectral (MSI) and hyperspectral (HSI) sensor systems require cryogenic cooling to operate. Current cryogenic systems are inefficient, costly, subject to vibrations, are typically the high-maintenance portion of a sensor system, and take up a considerable amount of size, weight and power (SWaP) onboard air and space platforms. The next generation of high output larger format focal plane IR, MSI, HSI sensors require parallel development of cryocooler technology.

Current cryocooler technology used by the Department of Defense generally falls into one of two categories. The first category, space cryocoolers, includes multiple candidate technologies capable of reaching an objective ~30K temperature and below, but these systems typically cost >$1M because of the low build quantities and the extreme demands of the environment. The second category, airborne tactical cryocoolers, are “affordable” at a typical cost
between $5,000 and $20,000, but they are generally designed for an operating temperature range high (>65K) for the objective mission. This topic seeks a military-grade cryocooler capable of reaching temperatures traditionally reserved for the space cryocoolers, but at a recurring price more typical of the tactical cryocooler marketplace.

The objective cryocooler system must be compatible with the airborne environment and adequately cool a silicon based large format focal plane array. The preliminary refrigeration requirement for the cryocooler is <200 mW capacity at 30K and ~4-5 W capacity at ~70K. SWAP is a major consideration. As an example the L3 Model B5000 now being used to cool a Longwave Spectrometer dewar with focal plane array operation at 45K is a balanced dual configuration, low audible noise cryocooler with a compressor 8.225inch x 3.281inch, cold finger 2.18inch x 3.6inch, weight < 10lbs, vibration < 0.75lbs, and input power < 160watts. The objective of this effort is to mature these guidelines into a set of technical requirements sufficient to fully inform the procurement of a compliant airborne cryocooler system supporting the next generation of focal plane arrays. The proposer is strongly encouraged to establish these requirements in consultation with a provider of relevant focal plane technology.

PHASE I: Establish requirements for the objective 30K airborne cryocooler by performing a trade study comparing different cryocooler technologies, develop a ranking system in consultation with the USAF Program Manager, and provide a recommendation for the cryocooler system to be fabricated in Phase II.

PHASE II: Design, build and demonstrate a low cost and efficient cryogenic cooling system in the 25-30 K range for a silicon-based, large format focal plane long wave IR sensor.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Potential airborne applications will be in a wide variety of airborne surveillance and reconnaissance sensors.
Commercial Application: Potential commercial applications include sensors used in infrared (IR) astronomical sensors, IR hyperspectral sensors, and IR vision systems.

REFERENCES:

KEYWORDS: Cryocooler, airborne, tactical, surveillance, persistent, sensors
and testing the ATC/R algorithms. Some representative moving target data is available via stored databases. If not, then the data can be gathered via pre-planned data collections or other opportunistic flight test activities. However, these moving target data collections are expensive from both a sensor platform and target range standpoint. A significant amount of synthetic aperture radar (SAR) data is already saved and available. This SAR data could be used as a data source for training a moving target ATC/R algorithm while saving the limited amount of real, measured moving target high range resolution (HRR) data for testing. A software method has been developed to extract HRR profiles from SAR data, and has proven useful to create surrogate HRR profiles to train ATC/R algorithms while retaining the limited real, or measured, HRR profiles to test the ATC/R algorithms. This method is labor intensive and does not always produce a surrogate HRR profile that is representative of the actual measured moving ground target HRR profile. New or improved techniques to capture small target components (e.g. tank barrel), remove clutter, account for multi-bounce, and create target masks are needed. Additionally, quality assurance checks throughout the process must be added to ensure the surrogate HRR data is statistically the same or similar to real measured HRR data from the actual ground target. Phase I includes the design of an improved and automated, end-to-end process with quality assurance checks that would provide a new capability to create surrogate HRR profiles from SAR data saving time and money for ongoing CID technology programs. Required deliverables include the surrogate HRR data, characterization results and the new or improved software design.

PHASE I: Determine discrepancies between surrogate and real HRR profiles preventing better matches between the two. Determine root causes of errors. Develop new or improved mathematical methods correcting these errors to include automated quality assurance checks. SAR and real HRR data will be provided by the government sponsor.

PHASE II: Implement the new design or improvements to the original method. Characterize the data from Phase I to show method improvements. Conduct tests and analyses to show ATC/R improvements and to prove automation and quality assurance checks work. Required deliverables include test results, surrogate HRR data, and final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This new or improved method is directly applicable to ongoing CID programs supporting military aircraft and all other weapons platforms requiring a moving target ATC/R capability.
Commercial Application: This new or improved method could be used for creating a family of tools for medical imaging differentiation applications or signature surrogate derivation, transformation, and validation.

REFERENCES:

KEYWORDS: sensors, automated target recognition, high range resolution, synthetic aperture radar, combat identification, ATR, HRR, SAR, CID

AF112-139 TITeL: Multi-Sensor Data Fusion Frameworks for Layered Sensing

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Develop a framework to integrate data from various air and ground sensor systems employed in an urban environment to collect data on moving/stationary vehicles and dismounts.

DESCRIPTION: The layered sensing vision, as defined in the AFRL Sensor’s directorate Layered Sensing White paper dated 6 May 2008, is to provide military and homeland security decision makers at all levels with timely, actionable, trusted, and relevant information necessary for situational awareness to ensure their decisions achieve the desired military/humanitarian effects. Layered sensing is characterized by the appropriate sensor or combination of sensors/platforms, infrastructure, and exploitation capabilities to generate situational awareness and directly support delivery of tailored effects.
A key enabler of this vision is the ability to dynamically gather and fuse relevant data from various sensors/platforms into a coherent information set that can contribute critical knowledge to the decision process and produce actionable intelligence. However, several factors complicate the design of an overall processing framework or architecture. The collected data may not be accurately registered in time and space, it may arrive out of sequence, and sensor types may span across the continuum of the phenomenological spectrum (Radar, Infra-red/Electro-Optic sensors, Hyperspectral sensors, etc.). Multiple Orient-Observe- Decide-Act (OODA) loops may exist across the Layered Sensing Enterprise and be engaged in different missions of differing priorities and time constraints. These activities may employ a large range of information sources from organic sensors (small unmanned aircraft, tower-mounted radar, building-mounted cameras, unattended ground sensors, etc.) active in smaller tactical battles and range in size up to larger standoff assets that may sense over a large area. Tasking for the numerous sensory assets must be coordinated to support automatic cross-cueing so that the right information is collected at the right time and place. In this context, centralized control may not feasible, and decentralized or distributed methods that can scale up to the combinatorics associated with the large-scale resource allocation problem are of particular interest. Further, limitations in communication bandwidth and human analyst processing requires efficient design strategies which are mindful of these constraints. There are many aspects to the overall processing framework and the goal of this work is to advance concepts which can overcome these technical challenges while serving as expandable templates for further work.

Initially, the effort will focus on a representative military surveillance or reconnaissance targeting mission, the required sensory assets used to conduct the mission, methods of collection, operational characteristics of the sensors, and associated exploitation processes.

PHASE I: Research and develop Layered Sensing processing framework concepts which advance the capability to combine information, glean meaning from the collected data, re-task sensors in a timely manner, and produce actionable intelligence. Propose a proof-of-concept demonstration on a challenging problem.

PHASE II: Continue to improve fidelity by incorporating more realistic sensor and environmental models. Develop and demonstrate algorithmic methods to validate the models and propose a method of transition to operational community.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: These techniques could be used to support military applications where reconnaissance, surveillance and tracking are necessary; overseas peacekeeping, border patrol, and counter-insurgency operations.
Commercial Application: These techniques could be used to support civilian security operations such as industrial facility control and monitoring.

REFERENCES:

KEYWORDS: data fusion, sensor resource management, visualization, target tracking

AF112-140 TITLE: Insect Vision for Sense and Avoid Applications

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop insect vision based sensor with the capability to allow Remotely Piloted Aircraft (RPA) to sense the presence of aircraft, report their location and identify those on a collision course.
DESCRIPTION: Mid-air collisions pose a significant threat for RPA. Autonomous reaction depends on a capable vision system allowing fast reaction to prevent collisions. For RPA, a wide field of view (FOV +/-110 deg AZ, +/-30 deg EL), < 50 W power consumption, collision threat declaration range > 2.5 nautical miles, and < 3 false alarms/hour is required for necessary situational awareness to fly in the National Air Space (NAS). Contemporary optical systems use cameras to capture video image sequences and then analyze the sequence of video frames to characterize objects and extract motion from the image. Video frame rates, inter-frame gaps, data transfer latency, conversion times, and computation times decrease the response time and put large computational burdens on major hardware resources. Insects accomplish similar tasks with apparent ease at speed orders of magnitude faster yet they lack a central processing architecture. Insect vision systems found in nature have unique capabilities adapted to detect motion with subpixel resolution and without numerical computation. The insect approach may provide a distinct advantage for sense and avoid applications over camera based systems, allowing real-time report generation of other aircraft locations and collision threats [Azimuth (AZ), Elevation (EL), and range if possible] at low contrast ratios (<5%), power consumption (< 50 W), operational at low contrast ratios (<5%), weight (< 5 lbs), collision threat declaration range (> 2.5 nautical miles), and < 3 false alarms/hour. Biological processing suggests smaller, efficient vision systems to accomplish sense and avoid tasks. Sensitivity profiles for each detector can be exploited to extract subpixel resolution in real-time. The goal is a paradigm shift away from video analysis to responsive survival systems employing simpler, biological information processing principles with higher processing speeds. The new paradigm must demonstrate performance improvement over camera-based systems. System processing should be compatible with infrared as well as visible spectrum sensing.

PHASE I: Define and specify architectural and algorithm design for a prototype sensor system with FOV (+/- 110 deg AZ, +/- 30 deg EL), power consumption < 50 W, operational at contrast ratios <5%, weight < 5 lbs, collision threat declaration range > 2.5 nautical miles, and < 3 false alarms/hour.

PHASE II: Design and fabricate a prototype sensor with parameters satisfying requirements stated in the Phase I description and generate outputs compatible with required interfaces of existing Air Force Research Laboratory's collision avoidance algorithms. Capable of demonstrating performance through ground and flight demonstrations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The number of hours RPA are used by the military is growing exponentially. A sense and avoid capability is required of RPA operating in the National Air Space and to improve overall safety of flight.
Commercial Application: The number of hours remotely piloted aircraft are used by commercial industry is growing rapidly. A sense and avoid capability is required of all commercial RPA operating in the National Air Space.

REFERENCES:

KEYWORDS: biomimetic vision processing, insect vision, wide field of view, low contrast ratios, high-speed processing, light weight, low power, high sensitivity, low-contrast ratios, subpixel resolution, scalable, sense and avoid.

AF112-141 TITLE: Optimization Algorithm to Enhance Antenna Array Beamforming for Radar and Early Warning (EW) Application

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

OBJECTIVE: Develop an optimization algorithm to augment antenna array beamforming for radar system and electronic warfare application.

DESCRIPTION: Advanced radar technology has provided improved capabilities as well as the implementation of sophisticated digital beamforming antenna array. As the technology evolves in beamforming antenna array panel to reduce power, weight, size, and optimally cost for next generation of radar systems. The need of controlling this complex multiple inputs and multiple output channels (multiple user objectives) in ‘near’ real-time application becomes a challenged task. Optimization algorithm has benefited from recent advances in computing power, high-speed data processing, and antenna array development in advanced radar technology. In order to capitalize the recent advanced hardware development, such as antenna array panel development and beamforming technique, a real-time control mechanism to process, execute, and generate diverse radio frequency (RF) signal waveforms and antenna patterns is of great interest to reap the system’s optimal efficiency. This research effort will focus on efficient method and accurate control of RF spectrum of multiple antennas sub-arrays. The primary focus is to develop a ‘performance algorithm’ approach under the design optimization within the input parameter constraints. Notionally, one must consider the input-output relationship which could be nonlinear and multi-dimensional with weighting function. The algorithm shall derive an optimal control function (time, frequency, and space) to augment the digital beamforming in antenna array panel development. For example, stochastic algorithm may offer an innovative computational method beyond the typical conventional approach in the development of RF waveforms in radar and electronic attack applications. The need of controlling this complex multiple inputs and multiple output channels (multiple user objectives) in ‘near’ real-time application becomes a challenging task. Optimization algorithm has benefited from recent advances in computing power, high-speed data processing, and antenna array development in advanced radar technology. In order to capitalize the recent advanced hardware development, such as antenna array panel development and beamforming technique, a real-time control mechanism to process, execute, and generate diverse radio frequency (RF) signal waveforms and antenna patterns is of great interest to reap the system’s optimal efficiency. This research effort will focus on efficient method and accurate control of RF spectrum of multiple antennas sub-arrays. The primary focus is to develop a ‘performance algorithm’ approach under the design optimization within the input parameter constraints. Notionally, one must consider the input-output relationship which could be nonlinear and multi-dimensional with weighting function. The algorithm shall derive an optimal control function (time, frequency, and space) to augment the digital beamforming in antenna array panel development. For example, stochastic algorithm may offer an innovative computational method beyond the typical conventional approach in the development of RF waveforms in radar and electronic attack applications. However, this method may offer a good solution but would also attain multiple local maximum and minimum solutions. The focus of this research is to derive a hybrid optimization performance function, a composite solution of algorithm(s) and optimization method(s) that address nonlinear programming ‘global optimization’ problems. Optimally, this research effort will augment radar system capability and advance electronic warfare technology, with the potential for scalable panel arrays, conformal radar systems, and space-based radar applications.

PHASE I: Conduct proof of concept and develop an optimum performance function coupled with controlling design parameters (scalable inputs variables) within the specified constraints while attaining an optimal solution for antenna array scaling and beam shape forming.

PHASE II: Implement and demonstrate the developed optimization algorithm model in a control environment to generating antenna beam shape from a sub-array panel, and capable of executing multiple antenna beam shapes with the “desired” power level concurrently.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The developed Optimization algorithm can be integrated in a hardware-in-the-loop radar tracking model to obtain a set of optimum solution and improve Radar capability and EW performance.
Commercial Application: Optimization algorithm would be applicable for commercial aviation to attain resource optimization and improve radar system performance concurrently.

REFERENCES:


KEYWORDS: Optimization Algorithm, Generic Algorithm, Radar, Electronic Warfare, Antenna Arrays, RF Spectrum, Beamforming, Global Optimization, Performance Algorithm

AF112-142  TITLE: Hardware Based Broadband Ultra High-speed Digital Signal Processor

TECHNOLOGY AREAS: Sensors

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OBJECTIVE: Develop a broadband ultra high-speed signal processor for real time digital signal streams representing broadband RF spectrum captures at greater than 10 GSPS for countermeasure application.

DESCRIPTION: Emerging broadband radio frequency/intermediate frequency (RF/IF) signal capture, recording and analysis systems have the capability to create, in digital form, very large segments of the RF spectrum (bandwidths up to 4 GHz or more) and in some cases record these signals for up to 60 minutes. The digitized information contains all of the RF emissions in the band including all of the modulation and signal information. This information can provide immediate identification of signal of potential interest in electronic warfare and radar system applications. However, post processing these huge data is time consuming and cost prohibits. The focus of this research is to develop a system that can perform real time digital signal analysis on digitized data streams with data rates greater than 10 Giga Samples/second. The goal is for the system to be able to, in real time, identify all signals within the data stream and be able to accurately time-tag signals of interest for immediate action or post analysis. Recent advances in high speed digital signal processing hardware, including powerful Field Programmable Gate Arrays (FPGAs) with parallel processing capabilities may now make it possible to process time-domain digital signal streams 100X faster than what was possible just a few years ago. An Ultra high-speed digital signal processing system with this capability will improve countermeasure effectiveness, including electronic warfare (EW), signal intelligence (SIGINT), and electromagnetic interference (ELINT) application. Current software based system do not have the required speed nor the processing capability. The developed ultra high-speed system must be ruggedized, small size, and low power consumption.

PHASE I: Determine the feasibility and develop a conceptual design of an ultra broadband hardware based high-speed digital signal processing system.

PHASE II: Design and fabricate a prototype hardware for proof of concept testing in a laboratory environment. Conduct preliminary testing demonstrating the system’s capabilities and performance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integrate the hardware prototype into an EW, SIGINT or ELINT system to demonstrate the ultra high-speed digital signal processing capability.
Commercial Application: The system’s capability to monitor and analyze RF spectrum in real time, including the ability to identify RF emitters for wireless, EMI regulatory compliance and homeland defense applications.

REFERENCES:

AF112-143  TITLE: Multi-Use Laser Sensors for Remotely Piloted Aircraft (RPA)

TECHNOLOGY AREAS: Air Platform, Sensors

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OBJECTIVE: Research and develop new laser sensor technologies to meet sensing requirements and size, weight, and power (SWaP) constraints for remotely piloted aircraft (RPA) and AF Combat Controller targeting.

DESCRIPTION: The Air Force currently operates a wide range of unmanned aerial vehicles (UAV) and miniature loitering Precision Guided Munitions (PGM) that could benefit from onboard multi-use laser sensors. These sensors could potentially provide guidance systems and target designation as well as detection, tracking, rangefinding and proximity detection. Because of the variety of applications and platforms, a multi-function, scalable and/or modular sensor is highly desirable. Current laser designator and rangefinder technologies are still too large and expensive to meet the requirements for practical use on small RPA and handheld targeting platforms. Moreover, operational applications are limited by optical and thermal efficiencies, the lack of multiple operation modes (low and high pulse rate) and the need for athermal performance without complicated cooling.

This solicitation seeks the development and demonstration of innovative multi-use eyesafe laser sensors which can aid navigation and also be used in targeting. These innovations should enable orders of magnitude reduction in costs, while improving optical and thermal efficiencies, and achieving significant reductions in SWaP.

Proposed technology developments should include compact and inexpensive approaches to increasing optical pumping efficiency, and improving overall thermal efficiency. Low timing jitter (with a goal of 2 ns) and pulse widths of 7 to 10 ns are desired. For miniature UAVs, a system weight of under 0.25 lbs and size under 1.5x1.5x3” for small system applications are key objectives. These small systems require functional ranges in excess of 500m, and the recurring cost goal for the short range low powered laser modules is $500 per unit for “disposable” applications. For larger RPAs, functional ranges up 10km are needed, and larger SWaP payloads could be traded for increased capability. Since future applications should be compatible with NATO coding schemes for target marking, responders are highly encouraged to partner with those experienced with laser designator and rangefinder system requirements.

Operating speeds range from 20 kts to 250kts which impact sensor scan rates, pulse repetition frequency, power and beam quality. The sensors should have the capability to perform multiple tasks such as obstacle and target detection simultaneously by rapidly changing modes. The sensors should have the ability to see through obscurants such as smoke and fog at reduced ranges. To prevent detection by hostile forces, the sensors should operate at frequencies which are not detectable by the night vision sensors and the waveforms should be eyesafe.

The unstable flight characteristics of the Small RPA environment due to turbulence and dynamics have to be considered in the concept solution. Laser sensor systems for these applications need to consider transmitter, receiver, optics, beam steering and stabilization, spot size, power storage, signal processing and downlink of the laser data. Real time interface to the autopilot, guidance controller, or remote operator should also be addressed. Output data should include range to target, size of target, discrimination and spot tracking.

PHASE I: Develop proof of concepts and design approaches that meet the described performance and functionality for lightweight ground targeting and small RPA applications. The approach should also address future cost scaling with moderate volume production in the form-factor required for deployed systems.
PHASE II: Build a breadboard system and perform laboratory testing and demonstration. Demonstrate advanced operating modes for future semi-active guidance approaches and data transfer.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Possible uses for these products include laser designators, rangefinders, machining, free-space communications and proximity fuze sensors.
Commercial Application: Products include laser machining, free-space communications, laser radar (LADAR) and light radar (LIDAR), and rangefinders.

REFERENCES:

KEYWORDS: target detection, target tracking, laser illuminator, laser designator, laser altimeter, laser rangefinder, optical proximity sensor, collision avoidance, small RPA, PGM, micro air vehicle (MAV)

AF112-144

TITLE: Advanced Radar Concepts For Small (Tier I/II) RPAs

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Research and develop advanced multi-mode radar(s) technology for use on small (Group I/II) remotely piloted aircraft (RPA).

DESCRIPTION: Ground Surveillance Radar (GSR) is a fundamental and proven component of DoD’s Battlefield Awareness. Advanced radar systems on large RPAs and strike aircraft are capable of multiple modes. These modes include high range resolution (HRR), multi-band, and multi-channel designs, which may maintain coherence for extended periods, maximize target signal return, and minimize scene clutter effects at operationally relevant altitudes. Synthetic Aperture Radar (SAR) and Ground Moving Target Indicators (GMTI) are products derived from the same GSR system; however, most U.S. systems have been designed to focus on the SAR aspect vice the GMTI. The ability to identify and track vehicles and dismounts has become a key focus, and DoD is initiating new ground surveillance radar programs with a focus on the GMTI aspect, in particular Dismount Detection Radars (DDR) for DoD RPAs. DoD is making major advances to add Dismount Detection capabilities at better than one-foot resolutions using multiple receive channels. However, many of the new GMTI features and capabilities are focused on larger DoD GSR systems.

Small (< 10 lb) radars exist for RPAs, but nearly all are limited to SAR processing vice GMTI. Adding dismount detection and tracking capabilities as part of a GMTI mode presents some very interesting challenges for small RPAs. Incorporating these same GMTI/DDR capabilities into small RPAs will improve the tactical commander’s Battlefield Awareness and is the focus of this SBIR topic.
Innovative approaches are needed to bridge the gap between advanced weapon system radars, and small Size Weight & Power (SWaP) radar systems that can operate on Group I/II RPAs. There are several advantages to pursuing small SWaP radars capabilities for enhanced small RPA capabilities. These include but are not limited to 1) dismount detection and tracking; 2) assisted target recognition of vehicles and objects; 3) detection through foliage; 4) building digital terrain models; 5) small object and wire detect; and 6) tracking through “move-stop-move”. The goals of this SBIR topic are to identify potential small SWaP radar concepts; develop new radar or radar modalities beyond the existing sub-ten pound class of SAR/GMTI systems; and demonstrate new, innovative exploitation capabilities using one of AFRL’s small RPAs.

PHASE I: Evaluate advanced multi-mode radar concepts for Group I/II RPAs. Select candidate technologies that take advantage of state of the art radar signal processing and exploitation algorithms.

PHASE II: Develop, integrate, and test hardware and software that leads to significant improvement in small SWaP radar capabilities. Support AFRL in the radar integration and flight testing of the system with AFRL’s small RPA. Development will utilize open standards to integrate radar data into an exploitation architecture for down chain processing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Application of GSR capabilities, with a focus on DDR, to small RPAs. Technology will apply to Small RPAs currently in the DoD inventory.
Commercial Application: Small Multi-Mode GSR systems have application in the airborne monitoring activities in the Police and Security sector.

REFERENCES:
1. Rihaczek, August W., personal communication indicating the possibility of signature deconstruction, 1980.

KEYWORDS: SAR, GMTI, HRR, FAT, radar, exploitation, ground motion target indicator, feature aided tracking, synthetic aperture radar

AF112-145  TITLE: High Resolution Wide Band Direct Conversion Receiver

TECHNOLOGY AREAS: Sensors, Electronics

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OBJECTIVE: Develop and demonstrate a prototype very high resolution (up to 16 bits) wide bandwidth (up to 1 GHz) direct conversion receiver capable of continuous operation in a dense signal environment.

DESCRIPTION: The Air Force requirement for rapidly identifying, receiving, and analyzing signals of interest across a very wide frequency range necessitates the development of advanced methodologies and capabilities consistent with successful high speed operation in dense signal environments across a wide frequency range.

The rapid reception and analysis of individual signals that exist in a dense signal environment across a wide frequency band has proven difficult in the past due to interference of adjacent signals that may be widely separated.
in power level. Conventional receiver approaches have typically relied on narrowband implementations to scan the subject frequency range and then to isolate individual signals from adjacent interference sources. Large differences in signal power levels have required wide dynamic range performance to detect low power signals in the presence of strong interference. The scanning receiver architecture has inherent temporal characteristics that degrade the probability of intercept for non-static signal types. The application of very wide band Digital Signal Processing techniques has been shown to provide great flexibility in separating signals out of a dense environment, and in applying modifications and upgrades as new approaches are identified. There are several aspects to this problem, including the sample rate and resolution of the signal digitizer, the signal processing algorithms to be applied to isolate the signals of interest, and the storage of large volumes of data generated by the high speed digitizer(s).

The intent of this research is to investigate and identify system architectures and algorithms consistent with real-world implementations utilizing state-of-the-art technology to provide high speed, highly selective, wide dynamic range receiving capabilities in a dense signal environment with a population of signals throughout the dynamic range. Due to the larger bandwidth and frequency agility of many of the current signal types when using complex waveforms, special consideration needs to be given to real-time implementation and wide bandwidth capabilities. Suitable architectures shall be analyzed since these are important tools in the implementation solutions. The results of these investigations will include suitable algorithms required for an assessment of the performance against a conventional receiver methodology. Hardware requirements to implement these algorithms will be identified.

PHASE I: Investigate architectural methodologies and processing algorithms to determine the feasibility of producing a high resolution (up to 16 bits) wide bandwidth (up to 1 GHz) direct conversion receiver capable of continuous operation in a dense signal environment.

PHASE II: Develop and demonstrate a prototype High Resolution Wide Band Direct Conversion Receiver capable of producing very high resolution (up to 16 bits) wide instantaneous bandwidth (up to 1 GHz) to be used in providing continuous direct down conversion of complex signals for capture/demodulation/analysis purposes in a dense signal environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integrate the prototype unit to demonstrate its capability to provide continuous direct down conversion of complex signals for capture/demodulation/analysis purposes in a dense signal environment.
Commercial Application: This research will ultimately find utilization within the general communications segment. It will be suitable for direct sampling and conversion applications adjacent to receiving apertures.

REFERENCES:

KEYWORDS: Very Wide Bandwidth, Direct Conversion

AF112-146 TITLE: Ultra-Wideband Radio Frequency (RF) Vector Signal Generator for Early Warning (EW) Applications

TECHNOLOGY AREAS: Sensors, Electronics

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OBJECTIVE: Develop an Ultra-Wideband Vector Signal Generator to convert captured and digitally stored, modified or created high-speed digital signal streams greater than 10 GSPS into complex wideband RF signals
DESCRIPTION: Current high-speed RF signal capture and analysis systems have the ability to record, in digital form, limited segments of the RF spectrum for only several minutes. Modern and emerging RF systems have increasingly large signal bandwidths and use complex waveforms, which must be able to be recreated for analysis, testing, and other applications. High-speed digital signal processing and signal creation system are emerging that can create precise digital representations of very complex broadband waveforms, with the capability to store and recreate in digital form ultra wideband modulated RF waveforms of any duration. To allow this emerging capability to be used to recreate the signals at RF, a Vector Signal Generator is needed to convert the high-speed digital data streams (greater than 10 Giga Samples/Second) into a high quality modulated RF signal with low spurious sidelobes and noise output. A system with this capability will have a wide range of applications in electronic warfare and radar systems, including countermeasure development and vulnerability assessment. The focus of this research is to develop a RF Vector Signal Generator that can (a) Reproduce signals with a RF instantaneous bandwidth greater than 3 GHz; (b) RF center frequency up to 20 GHz, with a goal of 26 GHz; (c) Capable of accepting either digital I&Q (Complex Signal representation of a Polar form where I/Q Data is the Cartesian (X,Y) coordinated system) or sampled real RF input data; (d) Can accept digital data with a resolution of 8 bits, with 16 bit as the goal; (e) Data sample rate at least 10 Giga samples/second; and (f) An analog I & Q input capability. The developed ultra wideband RF Vector Signal Generator must be ruggedized, small size, and low power consumption.

PHASE I: Determine the feasibility of a conceptual design for an ultra-wideband RF Vector Signal Generator with the desired characteristics.

PHASE II: Develop detailed design and fabricate a prototype for proof of concept testing in a laboratory environment. Conduct preliminary testing demonstrating the system’s capabilities and performance.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Integrate the prototype unit to demonstrate its capability to record and playback with high fidelity live broadband signals, and emulate known waveforms for use in a test and evaluation environment. Commercial Application: The capability to recreate complex broadband signal in a “real-world” environment to assess wireless communication devices development and for design validation and testing.

REFERENCES:


KEYWORDS: Vector Signal Generator, Ultra Wideband, Electronic Warfare, Radio Frequency, RF Signal, Complex I & Q, Broadband Waveform, Modulator

AF112-147 TITLE: 3L (Lightweight, Low-Cost, Low-light) Focal Plane for Persistent Surveillance

TECHNOLOGY AREAS: Information Systems, Sensors

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OBJECTIVE: Develop a Visible-Near Infrared-Short Wave Infrared (VNIR-SWIR) 16 Megapixel Mosaic Imaging System for night passive persistent surveillance.
DESCRIPTION: Use of cooled thermal imagers for wide-area nighttime passive persistent surveillance results in a prohibitive cost for the sensor, outweighing the small remotely-piloted aircraft’s cost. VNIR-SWIR detectors could provide a lower cost option in urban areas with residual man-made illumination or in rural areas with some moon illumination. Past solid-state low-light focal plane array (FPA) efforts have developed charge coupled device (CCD)/complementary metal-oxide semiconductor (CMOS) hybrids, low-light CMOS and electron-multiplied CCDs as well as short-wave infrared in small formats but cost and chip yield issues prevent scaling to extremely large formats. Wide area coverage would be possible with a system comprised of a number of cameras, with each camera comprised of a sparse array of lower format (one to few megapixel) sensor chips on a common substrate with sufficient space between each chip to allow for interconnecting signal and power leads. Such a sparse array has been referred to as a Composite Focal Plane Array (CFPA). A contiguous mosaic covering an area of persistence on the ground is assured using a system of multiple cameras each with a different offset pattern of the CFPA and overlap between adjacent CPFAs in the multiple cameras.

Innovative technology is needed to build a non-thermal mosaic imaging system with day/night capability. At a minimum, the system requires spectral response from 0.55 - 1.0 microns with 0.55 – 1.7 microns as an objective. The system must have sufficient signal-to-noise ratio, dynamic range, high uniformity, low blooming and low residual image defects to allow detection, tracking and resolving of targets in urban and rural areas and provide overwatch imagery to dispersed ground parties. The system must provide these capabilities from full sunlight down to moonlit (1/4 moon), clear night sky (threshold), clear starlight (objective) illumination. The final system must comprise at least 16 megapixels (threshold) using multiple cameras and provide at least a 10 hertz frame rate (i.e. imaging at 160 megapixels/second). The ground sample distance (GSD) shall be sufficient to track humans in urban environments from 10,000 ft altitude above ground level and 60 degree (threshold) 45 degree (objective) depression angle. Detector pitch and fill factor trades shall be accomplished to balance charge well capacity, dynamic range, focal plane availability, and size of the optics. CFPA assemblies shall have sufficient overlap to allow image stitching and target tracking in a downstream processor (such processors and associated algorithms shall not be developed under this program however). The resulting data rate shall consider the use of fiber-optic vs copper transmission off of a gimbal to the downstream processor. Array flatness shall allow sufficient depth of field for the imaging tasks described above with optics no slower than f/1.4.

PHASE I: Phase I will develop candidate architectures for a complete camera and lens including the CFPA, read-out, signal conditioning and image pre-processing (i.e. NUC and dead pixels). Motion smear at the image corners during long integration times and proper shuttering will be considered. Key aspects of this phase include preliminary design of a wide-field of view optical system suitable for low-light imaging over militarily useful temperature/altitude ranges, designing a layout of the sparse array that maximizes contiguous ground coverage and investigating techniques to maintain flatness of the CFPA assembly to allow for adequate depth of field. Size, weight and power (SWAP) of the full system comprising the several cameras, lenses and associated electronics shall be estimated.

PHASE II: A single prototype camera and lens using an approach determined by the Phase I effort shall be designed, fabricated, tested and delivered. A full system comprising several cameras each with a different offset CFPA is not required. An analysis of productability and affordability shall also be included. The Phase II prototype will be robust enough to undergo laboratory and limited environmental testing with the goal of producing a full ruggedized system with complete and contiguous coverage under a future effort. SWAP of the full system shall be demonstrated via analysis.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Lightweight focal plane single array or composite array assemblies would support camera systems with persistent surveillance capability.
Commercial Application: Such cameras would have dual-use applications in law enforcement and home land security.

REFERENCES:

KEYWORDS: imaging systems, low-light imaging, focal plane arrays

AF112-149

TITLE: Integrated Optical Thresholder Function for Use in Optical Analog to Digital Converters (OADCs)

TECHNOLOGY AREAS: Sensors, Electronics

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OBJECTIVE: Develop an innovative optical thresholder design that can be integrated into a Photonic Integrated Circuit (PIC) structure enabling Optical Analog to Digital Converters (OADCs).

DESCRIPTION: Because of the ability to effectively move large amounts of digital information on fiber optic networks there is a push to digitize information that would normally be transported in its native analog form. Once an analog signal is converted into a digital form it can be transported to multiple destinations and retransmitted without any degradation in the analog signal characteristics. Once the analog signal is captured into the digital domain its analog properties of dynamic range, frequency response, noise figure, etc. are no longer impacted. At this point digital networks based on commercial protocols can be used to transport this digitized analog information to various sensor processing systems.

The ability to digitize a number of analog signals is currently limited by the performance of the current electrical ADC components. Also, if many of the analog signals are being transported in an optical form an Optical Analog to Digital Converter (OADC) design has the potential to operate at significantly higher sampling rates than Electrical Analog to Digital Converter (EADC) designs due to the ability to perform the conversion in the optical domain.

A critical function needed to perform Optical Analog to Digital Converter (OADC) is an optical thresholder. An optical thresholder would provide a binary output as the result of comparing an optical input against a threshold level. In order for this function to fit into an OADC design it is desired to have the following features:

1. All optical – no conversion to electrical within the thresholder function
2. Integrated – monolithic design using Photonic Integrated Circuit (PIC) technology (SiON, InP, Silica, SOI, etc.)
3. 10uW resolution – 10uW increments will enable 60 dB of dynamic range from 0 to 10mW input power
4. 10GHz – ability to sample threshold output at 10GHz rate
5. 0/1 output – either optical or electrical

Additional considerations are size (die area), thermal (athermal approach is preferred), electrical power, and scalability to higher sample rates and number of bits.

PHASE I: Develop a integrated optical thresholder concept and demonstrate via modeling and simulation. Prove baseline features and physical implementation concept

PHASE II: Develop, build, test, and demonstrate a prototype optical thresholder concept as integrated into a scaled down Optical Analog to Digital Converter (OADC) based on features and additional considerations listed. Test and validate.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military radar, surveillance, electronic-warfare and communication receivers require efficient ADCs to enable digital signal processing that improves system multi-functionality and performance.
Commercial Application: Commercial high-speed instrumentation, including test and measurement equipment, as well as wideband communications, sensors and imaging benefit from improved analog to digital conversion techniques.

REFERENCES:

KEYWORDS: Avionics; Analog to Digital Converter (ADC) Fiber Optics; Optoelectronic Packaging; Optical Threshold

AF112-150  TITLE: 20 Gigahertz (GHz) Radiation Hardened Solid State Power Amplifier (SSPA) for Satellite Communications (SATCOM) Downlinks

TECHNOLOGY AREAS: Electronics, Space Platforms

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OBJECTIVE: Development of a new generation of ultra-linear K-band high-performance power amplifiers to address future military satcom high data rate requirements.

DESCRIPTION: A new generation of high power amplifiers (HPAs) is required to support high data rate battlefield communications at K-band. Future Military Satellite Communications Systems have the potential of achieving much-needed higher signal capacities by employing complex modulation schemes in channels that are closely spaced in frequency. Current state-of-art HPAs in the K-band show relatively low power (< 2 watts total) and/or power-added efficiency (PAE). In addition, nonlinearities in terminal electronics, particularly power amplifiers, cause spectral regrowth, wherein extraneous power from one channel interferes with signals from adjacent channels. Adjacent channel interference adversely affects communications data rates. This SBIR effort will focus on innovative approaches towards realizing ultra-linear 20 GHz HPAs with minimized adjacent channel interference. The proposed approaches should address both the selected high-performance power transistor process and the innovative ultra-linear HPA, towards demonstrating K-band HPAs with breakthrough linear-power performance. The HPA should address the following challenging performance goals. Linearity should support an adjacent channel power ratio better than -40 dBc for typical quadrature phase shift key modulation (and 64 quadrature amplitude modulation) when operating with output power greater than 1 watt and PAE greater than 35%. The 20.2–21.2 GHz performance should be accompanied by radio frequency (RF) output greater than 2 watts with an RF input of 100 milliwatts, spurious harmonics less than -80 dBc, voltage standing wave ratios of 1.5:1 (input), 2.0:1 (output), and reliability that supports a 15-year mean mission duration. The selected power transistor and power amplifier approaches should further support space application and a total dose radiation tolerance greater than 1 Million Radiation Absorbed Dose (Mrad) (Si).
PHASE I: The Phase I effort should address concept design and circuit simulations for the innovative, ultra-linear K-band high power amplifier. The designs should be based on a suitable, high-performance power transistor processes.

PHASE II: The Phase II effort should include the fabrication and assembly of the ultra-linear K-band power amplifiers that were designed in Phase I. Characterization of the developed high power amplifiers’ linearity, output power, gain and efficiency (under typical signal and environmental conditions) should also be addressed in Phase II.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The amplifier is proposed for terminals to support the high data rates of the future transformational satellites.
Commercial Application: Technologies and methodologies under this effort will directly benefit commercial communication networks in nearby frequency bands.

REFERENCES:

KEYWORDS: Solid State Power Amplifier, super high frequency (SHF), satellite communications, downlink, Power Added Efficiency
software tools are a concern even when integrated circuits are manufactured/field-programmable gate arrays (FPGA) programmed in a “trusted” environment; (5) In many cases, “gold standards” for integrated circuits do not exist or are not readily available, particularly for COTS parts; (6) Destructive statistical sampling-based techniques are not always practical from a cost and/or schedule perspective. As a result, these tradeoffs and limitations should be addressed in the proposed solution.

This topic seeks innovative solutions to the above problems that can include, but are not limited to, developing countermeasures to malicious hardware alteration and tampering, hardware Trojan triggering mechanism disruption, behavior-based hardware/firmware monitoring and response techniques, and covert tagging techniques.

PHASE I: (1) Research microelectronic device protection solutions, provide an analysis of alternatives, and select the most promising approach for implementation in Phase II; (2) Where appropriate, validate a limited prototype through modeling and simulation.

PHASE II: Based on the results in Phase I, design and implement a fully functioning prototype solution; (2) Demonstrate the effectiveness of the device or circuit anti-tamper, protection, or verification solution using a compromised microelectronics device and/or maliciously altered wafer fabrication process; (3) Develop a final report that describes the attack vectors mitigated by the solution.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military space programs, such as the EHF program, Wideband Global SATCOM will benefit from this research. Other applications include anti-tamper sensors and military communication systems.
Commercial Application: Commercial applications including financial systems, satellite communication systems, such as DirecTV, and supervisory control and data acquisition (SCADA) systems will benefit from this research.

REFERENCES:

KEYWORDS: supply chain risk management, malicious hardware, hardware Trojans, firmware Trojans, FPGA viruses, microelectronics, sabotage, trapdoor, product assurance, counterfeiting, reliability impairment, anti-tampering
through improving the robustness of DoD GPS receivers against interference signals while denying enemy use of GPS through blue force electronic attack (BFEA). Current military GPS receivers are large, heavy, consume excessive battery power, have cumbersome menu structures and are costly compared to commercial receivers. As a result, many military applications utilize commercial GPS receivers that are not compatible with emerging NAVWAR strategies and may limit NAVWAR effectiveness. Eventual modernized Military code (M-code) receiver designs will greatly enhance US and its allies’ ability to wage NAVWAR. However, if current trends continue, M-code receivers may also fall short of desired Size, Weight and Power-Cost (SWaP-C) goals for resource limited applications. This may result in the continued use of commercial receivers that are not NAVWAR compatible. This topic seeks to design a small SWAP-C NAVWAR compatible GPS receiver that incorporates protection technology against BFEA and enemy jamming as well as providing situational awareness of the radio frequency (RF) environment. The SWAP-C goals for this effort include; less than 3/4 size of current military handheld units, less than 8 ounces with batteries, battery life of up to an objective of 120hrs per the MGUE Capabilities Development Document (CDD) and cost of less than $500 per unit in large quantities. These estimates include a robust antenna design required to provide anti-jam protection. The use of Course/Acquisition (C/A) code as the primary means of providing GPS PNT may be acceptable to meet SWAP-C goals however designs must provide PNT robustness against jamming and be compatible with NAVWAR BFEA strategies. This effort requires the identification SWaP-C drivers for current military GPS receivers, a review of current Modernized GPS User Equipment (MGUE) and Common GPS Module (CGM) requirements, an understanding of the latest threats to GPS and an evaluation of emerging NAVWAR strategies in order to develop small SWaP-C GPS receiver and protection designs. The effort will ultimately design and demonstrate a small SWaP-C NAVWAR compatible GPS receiver with protection technology applicable to resource limited applications specifically, disadvantaged user and UAVs. For this effort, NAVWAR compatibility is defined as addressing the following: the GPS receiver must be able to provide accurate navigation using GPS in the presence of BFEA signals that deny the use of GPS C/A code and other GNSS signals potentially utilized by enemy forces. To further clarify, the NAVWAR compatible GPS receiver design must minimize the use of C/A code or protect the C/A code signal from electronic attack. Situational awareness of the RF environment is defined as providing the GPS user with information on the presence of interference signals including enemy jamming and BFEA as well as indicating the effect on current GPS performance.

PHASE I: Review current MGUE/CGM requirements and NAVWAR strategies. Identify SWaP-C requirements and develop prelim design for NAVWAR compatible GPS receiver for resource limited applications.

PHASE II: Finalize design of NAVWAR compatible GPS receiver. Build prototype components of the receiver to demonstrate feasibility of the design. Demonstrate prototype in laboratory and field test trials. Prepare final report.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Build NAVWAR compatible GPS receiver based on Phase II prototype. Use of state of the art technologies that shrink SWaP-C may help control cost of future receivers operating in NAVWAR environments. Commercial Application: Technology developed will help to expand current commercial application of Global Positioning System technology for the Air Force.

REFERENCES:

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

OBJECTIVE: Develop a research asset that can perform autonomous analysis on Positioning, Navigation, and Timing (PNT) systems to analyze thousands of interference types and their effects on PNT Systems/networks.

DESCRIPTION: An ongoing challenge for the DoD and commercial PNT users in general is the inability to fully comprehend the impacts of interference sources (intentional or unintentional) on their PNT equipment. Today, we have historically attacked this problem from a reactive posture, in the future, we need to address this from a predictive perspective based upon quantitative and qualitative analysis. Past research has focused exclusively upon a specific waveform against a specific global positioning system (GPS) receiver – with no comprehensive database being developed, cataloged and referenced because of its cost prohibitive nature and excessive time required for completing such a feat. An autonomous analysis asset is required to quickly, accurately, and comprehensively perform detailed analysis and arrive at beneficial effectiveness-based data that can be utilized across the PNT community.

The primary purpose of this SBIR is to create such an asset and algorithms to parametrically perform autonomous hardware-in-the-loop (HITL) analysis for both DoD and commercial PNT systems. The outputs will be automatically analyzed and quantitative and qualitative database generated. The system will also be developed with the flexibility and responsiveness to provide timely and accurate analysis as the global navigation satellite system (GNSS) architecture matures and new interference types that are conceptualized. The ability to create the test scenarios, perform the analysis autonomously, simplify post test research while developing a comprehensive effects-based database is the result of this SBIR.

The integrated test asset developed with this SBIR will be the first of its kind and enable the simplification of the complex PNT system compliance and interference analysis that the DoD and commercial markets desires. The simplification and autonomy of PNT analysis achieved under this effort will not sacrifice performance metrics such as accuracy, validity, and usability of the overall database. The resulting individual cost savings will vary depending on the number of PNT systems tested, interference types analyzed, and findings resulting from the analysis. However, the overall cost savings will be significant for DoD and the commercial sector by being able to reduce the operational risk of the PNT system in a challenged environment since the counter capabilities will already be resident in the user equipment.

PHASE I: Design the HITL test asset, algorithms for parametric setup and autonomous analysis across numerous interference types and PNT systems. This will demo a clear path to development of an advanced test asset, algorithms to create the needed compliance, integration and interference types/interfaces.

PHASE II: In Phase II a complete PANACIA system will be developed and demonstrated with the existing GNSS architecture and current jammer/interference systems. The database built will reflect both current commercial PNT receivers (compliance testing and unclassified data) and DoD receivers (compliance testing and classified data) against the latest known threat systems and projected technologies.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This system will establish the DoD standard for assessing military systems and the seventeen critical commercial architectures identified by DHS as vulnerable to PNT information disruption or loss. Commercial Application: This system will also establish the standardized compliance testing metric for commercial systems that support US critical national infrastructure will fill the void that exists today.

REFERENCES:
1. Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System. (29 August 2001)

2. BIENNIAL REPORT TO CONGRESS ON THE GLOBAL POSITIONING SYSTEM 1998.
AF112-155

TITLE: Anti-jam (AJ) GPS Technology Development for Precise Global Positioning System (GPS) Positioning Applications

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

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OBJECTIVE: Develop/Demonstrate algorithms/technology that address challenges associated with the use of AJ techniques such as Space Time Adaptive Processing (STAP) in precise GPS positioning (<30cm) applications

DESCRIPTION: The use of anti-jam (AJ) techniques, such as Space Time Adaptive Processing (STAP), that protect traditional GPS receivers, produce pseudo-range biases that affect the overall position, velocity and time (PVT) accuracy of precise positioning Global Positioning System (GPS) receivers. Studies have shown promising techniques to reduce, or possibly eliminate, these pseudo-range/carrier phase biases. This topic will seek to further understand the degraded accuracy issues associated with the use of anti-jam GPS techniques such as STAP. The effort is targeted for precise positioning GPS receivers that use Carrier Phase Differential (CPD) and Real Time Kinematic (RTK) techniques. Algorithms and techniques will be developed and integrated into prototype hardware. Hardware in the loop simulations and field trials will be used to demonstrate algorithm performance of the prototype hardware. The overall goal of the effort is to demonstrate precise positioning accuracy (less than 30cm from truth) using the prototype hardware in an interference environment. An additional goal of this effort is to demonstrate high timing precision using GPS tracking in an interference environment. Results from this effort will show the effects of jamming/interference on precise positioning for protected and unprotected systems.

PHASE I: Produce simulation illustrating degradation in PVT due to STAP and other AJ GPS antenna solutions. Develop technique to minimize error for precise GPS applications (<30cm). Design prototype to demonstrate precise GPS position/time in greater than 80dB interference to GPS signal ratio environment.

PHASE II: Build prototype hardware system designed in Phase I. Demonstrate prototype in laboratory and field test trials. Demonstrations should show precise positioning (<30cm) and time in the presence of wideband (>20MHz) and narrow band interference. Design more robust precise positioning GPS receiver system from prototype lessons learned.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military GPS requiring high accuracy in jamming such as Joint Precision Approach Landing System and Automated Aerial Refueling. Technology also enables new sensor capabilities to operate in jamming. Commercial Application: Technology provides high accuracy GPS to be implemented where the potential for interference exists. Surveying, aircraft landing, and high accuracy timing receivers are potential applications.

REFERENCES:


OBJECTIVE: Develop/Demonstrate a multifunction, multi-beam X-band subarray simultaneously supporting communications for satellite operations and radar for air/space surveillance.

DESCRIPTION: Currently DoD requirements for X-band satellite communications operations (SATOPS) and X-band radar for space situational awareness (SSA) are met using separate ground sites each with different antennas. To reduce the cost and complexity of dual installations it would be highly desirable to develop an X-band antenna capable of supporting both communications for tracking, telemetry, and commanding (TT&C) of multiple space vehicles as well as radar for surveillance of air/space objects. Multiple beam phased arrays exist; however, a multiple beam phased array capable of simultaneous X-band communication and X-band radar operations does not exist. Building a phased array that supports both communications and radar presents many new challenges, the most important is the isolation between simultaneous transmit and receive signals. Specifically, high power transmit signals (comm and radar) couple into receive channels (comm and radar) and may saturate the front-end LNAs and also produce unwanted interference. Achieving over a 100 dB of isolation between transmit and receive channels is extremely difficult and will require creative solutions. Thus, this topic will require innovative R&D to explore the technical feasibility of combining both communications and radar in the same phased array.

This topic supports both DoD X-band communication and radar systems by the development of a single multi-function Electronically Scanned Array (ESA). It is envisioned that the basic building block of such an ESA could be a multilayer tile subarray which can operate with either two X-band communication beams or one communication beam and one X-band radar beam [1,2,3].

The design of the subarray is an important first step. Innovative approaches are encouraged; each should include but are not limited to addressing the following topics: the different X-band frequencies for communications and radar, the isolation needed between transmitted and received signals for simultaneous full-duplex communication and radar operation, thermal management, and the size, weight and power (SWAP). Follow-on fabrication and testing of the subarray would validate the readiness to develop a multiple subarray ESA.

PHASE I: Investigate possible X-band ESA concepts and architectures that can achieve simultaneous multiple-beam communication and radar operations. The design of a multi-layer tile subarray with 2 X 2 elements can be considered as a viable option.

PHASE II: Perform detail numerical simulation and refine the design trade-offs in terms of communication and radar operation and performance, as well as fabrication, reliability, and cost. Fabricate a 2 X 2 element subarray and test in a far-field range.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The subarray would be the basic building block of an ESA antenna for the air and space traffic control, homeland defense, cruise missile defense for both military and commercial users.
Commercial Application: The Civilian application would include satellite communication and surveillance for air traffic control.
REFERENCES:


KEYWORDS: Electronic scanned array, multi-beam phased array, communications, satellite operations and
control, radar, space situational awareness (SSA)

AF112-157  TITLE: Synthetic Aperture Radar (SAR) Aided Navigation

TECHNOLOGY AREAS: Sensors, Weapons

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

OBJECTIVE: Research and development of a navigation system where measurements derived from synthetic
aperture radar (SAR) data are used to aid an integrated GPS/INS navigator.

DESCRIPTION: Future sensing systems are being designed to work in an integrated fashion. One key challenge in
developing these disparate sensing concepts is the assurance of a robust common coordinate frame among the
sensing platforms. This common coordinate frame is necessary for the fusion of data from the disparate platforms.
Currently, integrated global positioning system/ inertial navigation system (GPS/INS) navigation systems provide
this common coordinate frame; however, GPS susceptible to jamming. One approach to overcome this challenge is
to perform research on the integration of measurements derived from a synthetic aperture radar (SAR) sensor with a
GPS/INS system. An optimal approach to tightly integrate these derived SAR measurements with GPS and INS is
desired. Specifically the research needed includes derivation of both position update from SAR images as well as
velocity updates which may be able to be obtained from the processing of SAR data.

In performing this research, of interest is not only the accuracy of the measurements derived from SAR, but methods
to determine measurement integrity. Given the measurements derived from SAR are dependent on the environment,
the SAR data is collected from (i.e. measurements derived from SAR data collected over water may be of limited
value as compared to SAR data collected over land) a framework to quantify the system performance based on the
environment sensed by the SAR sensor is also of interest.

PHASE I: Consider alternative approaches for the extraction of information from SAR data including motion
estimates from focusing information as well as SAR image feature matching. Design and develop an approach to
optimally integrate these measurements in a tightly coupled GPS/INS navigation system.

PHASE II: Development and build of a proof of concept device where measurements from SAR data are extracted
and combined with a tightly couple GPS/INS navigation system. Characterize the performance of the system with
full GPS and degraded GPS (< 4 satellites).

PHASE III DUAL USE COMMERCIALIZATION:
Military Application:Production development program for a system which processes and extracts measurement from
a SAR system and integrates them with GPS and INS measurements.
Commercial Application: Customers performing Layered Sensing tasks have a strong need for this to ensure a
robust relative navigation solution.

REFERENCES:


KEYWORDS: Inertial Navigation System (INS), Global Positioning System (GPS), Synthetic Aperture Radar (SAR), Integrated Navigation

AF112-158 TITLE: High Spatial Resolution Hyperspectral Sensor

TECHNOLOGY AREAS: Sensors

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OBJECTIVE: Design and build a hyperspectral sensor that maintains high spatial resolution information.

DESCRIPTION: Current hyperspectral sensor systems sacrifice spatial resolution for area coverage based on the premise that target detection and material identification can be accomplished on small, possibly sub-pixel targets, solely on the spectral content in the imagery. However, these sensor systems are not utilized for target identification with shape-based algorithms or human-in-the-loop exploitation due to the limited spatial content. Further, there have been a number of applications where smaller, pure pixels can benefit target detection, identification and tracking. The challenge of this effort is to design and build a long wave infrared (LWIR) hyperspectral sensor system that is capable of placing enough pixels on target for shape-based target identification, while maintaining the ability to detect and identify the target material based on its spectral signature. The candidate technology transition platform is a mid-altitude reconnaissance aircraft, flying at 15,000 ft. (possibly up to 45° off-nadir). The sensor should be able to maintain 0.3m (threshold) ground resolution distance (GRD) in both nadir and oblique flight geometries with a target GRD of 0.15m (objective). The minimum nadir ground area of coverage for the specified flight geometries should be at least 40m x 40m (threshold) with a desired nadir coverage of 80m x 80m (objective).

For sufficient spectral processing and nighttime imaging capability, the LWIR hyperspectral imaging (HSI) sensor should cover 8-11 micrometers (threshold) with a desired spectral coverage of 7.5-12.5 micrometers (objective). The spectral resolution of the sensor should be 50 nanometers (threshold) with a target spectral resolution of 25 nanometers (objective). The system shall minimize smile and keystone distortions to less than 0.1 pixels in both dimensions. In order to adequately utilize the spectral content of the imagery, the noise equivalent spectral radiance (NESR) of the system shall be less than or equal to 1 W/sr cm2 m and the system shall capture the entire image cube in less than 0.3 seconds (threshold) with a target image acquisition time of 0.1 seconds (objective). Because the sensor system will most likely be utilized in dynamic environments, it will most likely be queued to the target location. Balancing both spatial and spectral fidelity by reducing aliasing and distortion in both dimensions will be the aspect of the sensor design that carries the most risk.

To adequately integrate this system onto an airborne platform carrying other sensor payloads, minimal size, weight and power should be in the forefront of the system design. Designs should promote possible integration into a small, manned aircraft (threshold) and ideally, into a Tier II unmanned aerial vehicle (UAV) (objective).

While software for sensor operability will be an integral part of the system, the solution to this solicitation shall be a hardware deliverable. This is not a target identification or target detection algorithm effort. Software only solutions will not be considered.
PHASE I: Start with analysis of alternatives for achieving listed requirements, including trades in Modulation transfer function (MTF), spectral ranges, bandwidths & addressing HSI inter-band registration, spatial/spectral aberrations & aliasing. A preliminary design for the system will also be developed.

PHASE II: The Phase II of this effort will begin with the refinement of the preliminary design(s) developed under the Phase I effort. The goal of the Phase II effort will be to produce a working prototype instrument that addresses the solicitation requirements with the appropriate analysis of alternatives referenced during the Phase I.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Further refinement for miniaturization, ruggedization for flight testing on chosen aircraft. The technology will also be applicable to other reconnaissance platforms, as well as extending the CONOPs.
Commercial Application: Commercial applications of this technology include law enforcement, border patrol and search and rescue.

REFERENCES:

KEYWORDS: hyperspectral, long wave infrared, LWIR, high resolution

AF112-159

TITLE: Static Systematical Assessment for Dynamic Reputation Management

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: Develop a tractable off-line methodology for calculating the initial trustworthiness of nodes within a wireless sensor network.

DESCRIPTION: Distributed sensing systems, especially wireless sensor networks (WSN), are highly vulnerable to compromise due to the adversary’s access to the device, constrained computing resources, and limited mission availability. While anti-tamper mechanisms can be deployed on each device, this may become cost prohibitive. This is true for large-scale ubiquitous sensor networks where the physical security requirements for each node exceed the utility that an individual node provides to the system. An alternative and potentially more efficient approach is to deploy a reputation management service over the entire WSN. A reputation management service provides the capacity for each node to track which peers are cooperative and non-cooperative by evaluating the outcome of historical interactions (i.e., sensor reports, packet forwarding, topology dissemination, etc.). Such a service permits nodes to develop relationships between cooperative peers while learning to avoid non-cooperative and potentially malicious peers. The adaptive response at the node level permits the system to recover from degradation. There is considerable research in the field of reputation management systems such as [1],[2],[3],[4] with the emphasis mainly on the measurement and propagation of peer-level reputation. Since reputation is based on historical interactions, a reputation service is initially useless when there are little or no available histories on neighboring nodes. During a “warm-up” period a node does not have enough information to reach valid conclusions about a neighborhood's expected behavior and may avoid truly cooperative nodes or naively interact with malicious nodes. Most reputation management services assign a homogeneous initial value to all system components (such assuming all peers start
with good or bad reputation). This is problematic, since a given initialization strategy 1) is not guaranteed to provide a starting condition that a WSN can initially perform its mission and 2) may severely deviate from the actual conditions and therefore require an excessive warm-up period. An improvement to the initialization strategy should minimize the warm-up period of the reputation system. Specifically, the initialization strategy should provide a valid initial condition that is more sensitive to the invariant contextual parameters of a WSN node (such as position within topology, role in WSN application, software architecture, radio, exposure level, threat model, deployed protections, etc.).

This effort will address the initialization problem for dynamic reputation management services deployed on distributed systems such as wireless sensor networks by developing an automated evaluation technique that can estimate the initial reputation of nodes within a system. Since reputation is based on learned interaction histories, other assessment techniques must be explored to evaluate each component on its inherent trustworthiness or risk with respect to the system. One such example would be the trustworthiness metric proposed in [5]; however, other techniques that exploit available information from the sensing architecture are highly encouraged.

The evaluation technique should take into consideration the intrinsic security properties of a given system component and the external dependencies it shares with other nodes within the system. Additionally, the results of the evaluation technique should have composability, akin to overlapping subproblems, such that higher echelon system constructs can be evaluated as a function of the evaluations for each of its components. For example, a wireless sensor network cluster is comprised of several sensor motes. Composability would allow the initial reputation of the cluster to be related to the initial reputation of each mote within the cluster. This would allow the assessment of hierarchical systems complex distributed systems including, but not limited to wireless sensor networks.

PHASE I: 1) Develop a tractable way to evaluate the initial reputation of nodes within a WSN or similar distributed system; 2) Explore the transitivity of a node’s evaluation and its effect on other node evaluations; 3) Demonstrate the proof of feasibility by showing warm-up period is minimized using evaluation technique for distributed systems while under attack and normal conditions.

PHASE II: 1) Extend the evaluation method to incorporate evaluations of related nodes within a WSN or equivalent system; 2) Extend the methodology such that it can combine subcomponent assessments to generate composite, higher-level system component assessments; and 3) Develop a demonstrable prototype that can be incorporated into an existing or experimental reputation management service within a realistic distributed system application, such as a people tracking using a wireless sensor network.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This technique will minimize the warm-up period for reputation services over WSN systems, which reduces the period of time that the system is vulnerable to mischief. In addition, this evaluation technique can used to assess the impact of design, deployment strategy, or environmental changes on initial reputation for WSN or similar distributed systems.

Commercial Application: Ubiquitous computing is an emerging area of commercial potential that operates within similar scale and exposure risk as military sensing systems. Therefore, this capability can be applied to large-scale networked devices for ubiquitous computing applications that use reputation services to identify and isolate misbehaving nodes. By seeding the initial reputation for all nodes within the system in regard to things such as deployment, environment, and design properties, the warm-up time can be reduced. Likewise, the effects of design, deployment, and environmental changes can be explored as a maximizing search optimization over the evaluation technique.

REFERENCES:


KEYWORDS: reputation, wireless sensor networks, trustworthiness, risk assessment, distributed sensing architectures, static analysis

AF112-160

TITLE: Holographic Optical Elements for Coherent and Spectral Laser Beam Combining

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Identify, develop, and demonstrate innovative optical components for coherent and spectral laser beam combining in multichannel mid-wavelength infrared (3-8 micron) laser systems.

DESCRIPTION: Laser systems are widely used for remote sensing, laser detection and ranging, free space optical communication, micromachining, medical surgery, chemical spectroscopy, infrared countermeasures. Many rugged sensors systems requiring high quality photon radiation for mobile platforms are currently based on solid state and fiber lasers, and ideally these systems would be based on integrated semiconductor lasers solutions. A number of applications require increased power of laser sources. The approach enabling power increase beyond limits of single aperture sources is beam combining. There are two types of laser beam combining. The first one is a spectral beam combining where the use of spectral dispersive elements or spectral filters allows spatial and angular combining of several sources with different wavelengths. The second one is a coherent beam combining where different laser sources are phase locked in such manner that they provide constructive interference at semitransparent optical components (beam splitters-combiners). Those optical components are mainly based on different types of diffractive gratings which are produced by surface profiling of by volume hologram recording. The highest spectral density in combined beams was demonstrated with the use of volume Bragg gratings which demonstrate high spectral selectivity, high tolerance to laser radiation and high robustness. However, these volume Bragg gratings were recorded in a silica glass which is spectrally limited to visible and near-infrared bands no greater than about 2 micron optical wavelength. There were some successful attempts to fabricate holographic optical elements in Gallium Arsenide and Zink Selenide materials that are transparent in Mid-Wavelength Infrared (MWIR) region of 3-8 micron optical wavelength.

There is a strong demand for laser sources operating in MWIR because of eye safety, transparency window in atmosphere, a number of important chemical components having absorption bands in this region, and also it is the region of thermal radiation. However, most of available diffractive optical elements are fabricated from silica or silicate compounds which are not transparent in MWIR region. Thus, new materials, which enable fabrication of diffractive optical elements for spectral and coherent beam combining in MWIR, need to be developed. Alternatively, these new optical materials can be used for recording advanced holographic optical elements for laser modes tuning and laser beam control.

There are several known technologies to produce surface profiles, e.g. surface etching or epitaxial growth. Alternatively, the spatial modulation of refractive index can be produced by direct laser writing, photo-thermo-induced or optical filed-induced structural transformations. There are several chalcogenide glass forming systems which are transparent in MWIR, e.g. tellurides, selenides, germanates, antimonides etc. However, there are no commercially available materials and technologies enabling fabrication of diffractive optical elements with high spectral selectivity in MWIR. Thus, there is a need to establish a technology of fabrication of diffractive optical elements which enable efficient spectral and coherent combining of MWIR laser beams.
PHASE I: Determine and demonstrate materials and fabrication techniques for manufacturing diffractive optical elements applicable for spectral and coherent combining of laser beams in MWIR (3-8 micron). Provide samples of diffractive optical elements to the Air Force for testing and evaluation.

PHASE II: Using results from Phase I, fabricate and validate prototypes of diffractive optical elements for efficient splitting and combining of laser beams in MWIR (3-8 micron). Provide practical implementation of coherent and spectral laser beam combining of up to 10 channels and predict what would be the practical limit. Identify other limitations of developed materials and fabrication techniques.

PHASE III: DUAL USE COMMERCIALIZATION:
Military Application: Multichannel single aperture laser systems for remote sensing, target detection, free space optical communication, infrared countermeasures, chemicals detection.
Commercial Application: Micromachining, chemical analysis, optical memory, laser modes tuning, laser applications with reduced heat affected zone for medical surgery.

REFERENCES:

KEYWORDS: mid-wavelength infrared, laser, Bragg grating, chalcogenide glass, beam combining, holographic optical elements

AF112-163

TITLE: Layered Target Reacquisition and Prosecution from Wide Area Motion Imagery (WAMI) Cues

TECHNOLOGY AREAS: Information Systems, Sensors

OBJECTIVE: Handoff of target tracks & labels from WAMI to sensors on weapon & small unmanned aircraft systems (SUAS) platforms to integrate close-in sensing layer with persistent surveillance to perform continuous tracking of civilian vehicles and/or dismounts.

DESCRIPTION: The technical community has made significant progress in developing wide area motion imagery sensors and preliminary tools for exploitation, including ground object tracking. This capability allows observation over large areas and extended periods of time, but provides (a) only limited phenomenology and (b) only observation of objects. This effort addresses both of these shortcomings by integrating cues (tracks, locations, labels and other parameters) from WAMI with lower, closer systems such as munitions and small unmanned systems. Both provide additional phenomenology (resolution, mode, geometry) to improve target labeling, and munitions reacquisition supports target engagement. Challenges include location estimation and projection for moving targets; object feature and label association across platforms, viewpoints, and modes; and resource management to support these functions.

State of the art moving target tracking for civilian vehicles and dismounts provides very short term tracks and breaks track easily based on poor geolocation, limited motion or obscuration. WAMI sensing supports only limited feature aiding for kinematic trackers to mitigate these challenges. Sensors with additional spatial/spectral/temporal resolution (such as those potentially deployed on SUAS or munitions) observe only a limited area but high quality
association has been observed (though not demonstrated across conditions). Parametric understanding of association quality and its dependence on geolocation accuracy do not currently exist and would be valuable contributions of this effort.

This parametric understanding also serves as the model support for resource management that would determine platform route for the munition or SUAS, sensor and mode utilization, and information combination. Current state of the art has only very limited model support for resource management.

PHASE I: Develop initial cueing algorithm approaches for moving targets in WAMI data and perform system trades to identify critical operating condition variability and its impact on target handoff from WAMI sensing to the lower tier. Develop initial WAMI to close-in cue association approaches for moving targets.

PHASE II: Implement tracking, association, resource management and handoff algorithms from the Phase I approaches and parametric models developed. Validate anticipated performance through parametric experimentation.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Persistent target tracking and engagement in challenging scenarios
Commercial Application: Border surveillance

REFERENCES:

KEYWORDS: tracking, wide area motion imagery, registration, munition, SUAS
Situations arise with structural testing or structural health monitoring of aerospace components operating in extreme environments (jet engine fan and compressor blades, aircraft propellers, helicopter blades, transmission parts) where a conformal sensor capable of transmitting high-bandwidth sensor data is needed. A common method of structural testing or structural health monitoring is to install sensors and wire them to a data collection system. For example, strain and shear are sensed with this technique. However, wired sensors are generally limited to temperate environments and stationary structures. New types of miniaturized wireless sensors are being developed to address these deficiencies but conformal, high-temperature packaging and installation methods are not yet available to support these emerging sensors. As the sensor technology evolves to meet the requirements of the environment, new packaging materials and in situ installation methods are needed to facilitate the application of these new sensing capabilities in harsh environments.

PHASE I: Determine technical feasibility and identify viable approaches for packaging conformal, high temperature sensors in harsh environments. Feasibility must be addressed for operating temperature, high acceleration levels, low mass, aerodynamics, ease of installation, and variable sensor size.

PHASE II: Fabricate and demonstrate the operation of a number of packages and install them conformally on a high speed, high-temperature aerospace component. The operating environment includes temperatures up to +600°C and acceleration forces up to 56600g.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Conformal high-temperature packages are being developed for use in aerospace applications in all military platforms.
Commercial Application: This device technology could be used in a wide variety of industrial testing and structural health monitoring applications.

REFERENCES:


KEYWORDS: strain sensor, wireless sensor, passive sensor, conformal sensor
foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and apply high-accuracy sensor and algorithm technology to ground based production balancing and diagnostics for a wide variety of turbo-machinery applications.

DESCRIPTION: Mass balancing of turbine machinery is a critical capability that compensates for variability of manufacturing processes and material systems. It also compensates for material systems that have less than ideal characteristics or unique characteristics. Mass balancing is critical for components and fixtures that operate at high speeds, require long bearing life, and must have freedom from vibration induced effects including failure. Current techniques employed in the turbine manufacturing (factory) environment use specialized equipment and tooling that provides capability that is unavailable in the field due to reasons of difficulty to employ or required performance. These techniques are often based on an iterative process that results in a high expenditure of labor to meet specifications, yet could result in less accuracy and repeatability (low process/tolerance ratio) than desired. They are also based on sensors, actuators and fixtures which provide limited accuracy (amplitude, phase angle) when measuring small imbalance and vibration. Development of highly accurate new sensors and algorithms are required to improve the current state of the art employed in component production and development applications. The sensors will be considered for employment in existing machinery and tooling applications to significantly enhance the quality of the data (provide high confidence and repeatability) in balancing rotor systems. A highly accurate measurement system will make a significant contribution toward eliminating rework, test anomalies, field problems and reducing overall cost. Current research in sensor and actuator technology for active vibration control (including balancing) has resulted in sensors and actuators that are more compact, higher performing, and versatile over the last decades. Piezo-ceramic and silicon nanotechnology devices are becoming mature for high performance measurement and active control applications. Self-powered sensors are now a possibility in many difficult to instrument applications. The combination of improved sensing devices and active control techniques offer significantly capability enhancements compared to the state of the art vibration reduction and balance techniques used in the production (factory) environment. In the Phase I effort the proposed technology must demonstrate the ability to achieve balance within (0.1” ounce-inches) for 95 percent of the time without iterations. A high confidence level of the procedure is the ultimate goal.

Phase I: Demonstrate the feasibility of a high accuracy and high confidence sensor system for turbine balance applications that can be used in both a production environment as well as in a depot or laboratory environment based on the requirements set forth in the description.

Phase II: Fully develop and refine the Phase I concept into a prototype system consisting of sensor hardware and measurement electronics for the proposed turbine balancing system. Demonstrate the system capability by conducting tests on a relevant engine compressor or turbine rig and compare results with state-of-the-art balancing methods. Provide a concept of operations for both production application and field use with a list of required utilities/equipment for operation. It is desired that the prototype be delivered to the AF for further testing and validation on turbine engine rigs and rotating components.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: Legacy and advanced engine component technology, rotor system, compressor, and turbine are target military applications. Commercial Application: The technology developed is applicable to commercial rotating machinery balancing and vibration applications including, tooling, electric motors, and gas turbines.

REFERENCES:


AF112-167  TITLE: Spatially and Temporally Resolved Imaging of Dense Sprays

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: To design and demonstrate advanced measurement techniques for imaging optically dense sprays with high spatial and temporal resolution.

DESCRIPTION: The development of modern propulsion systems depends on computational fluid dynamics (CFD) simulations. However, spray dynamics represent a weak link in CFD models, especially the dynamics of the so-called primary breakup processes near the injector: the breakup of the liquid jet into primary droplets. The efficient and stable combustion of fuel strongly depends on this breakup and the subsequent atomization process. Though various approaches have been devised to model these processes, the experimental data available to validate these models remain sparse. There is a critical need for new spray measurement techniques, not only to provide experimental data to validate existing models, but also to resolve spray dynamics and inspire new models.

The fundamental challenge in understanding such dynamics is that the sprays, being optically thick, scatter probing photons multiple times, and each scattering event redirects the photons randomly. Consequently, the structural information of the target spray is lost in the image generated. Because of such strong multiple-scattering, dense sprays preclude the use of various established laser diagnostics, including Fraunhofer diffraction, Doppler anemometry, and the combined use of laser-induced fluorescence (LIF) and Mie scattering. Hence, innovative techniques are to be developed to resolve the structure of dense sprays. The proposed technique should overcome the limitations of established techniques to resolve the three-dimensional (3D) structure of practical sprays with adequate temporal resolution. The proposed technique should also enable measurements with sufficient signal-to-noise ratio so that it can be applied on practical sprays under realistic conditions. Furthermore, it would be advantageous if the proposed technique only involves portable equipment so that it can be packaged for transportation to in-situ field applications.

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 US 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 include the Combustion and Laser Diagnostics Research Complex (CLDRC) and certain amplified ultrafast laser systems therein.

PHASE I: Design imaging diagnostics for dense sprays, and conduct proof-of-concept computations/experiments to demonstrate the spatial resolution, temporal resolution, and signal level of the proposed technique.

PHASE II: Further develop the proposed technique for optimal performance. Obtain diagnostic measurements in dense sprays under both laboratory conditions and realistic operating conditions characteristic of dense sprays in combustors and/or augmentors. It is desired that the prototype system be delivered to the government for further evaluation and testing.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Build and deliver a functional imaging system to use with optically dense sprays in real combustor and augmentor development programs.
Commercial Application: Successful development of this technology will pay off in designing next-generation injectors for commercial aviation engines, power generation, transport vehicles, and prognostics/health management.

REFERENCES:


KEYWORDS: dense sprays; laser diagnostics; 3D imaging; spray diagnostics; fuel-oxidant mixing; combustion, propulsion

AF112-168  TITLE: Revolutionary Technologies for the Reduction of Aircraft Jet Noise

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and evaluate revolutionary integrated technologies for 10 dB reduction of jet noise from gas turbine engines.

DESCRIPTION: The noise from current commercial and military aircraft continues to be an environmental concern. Noise from aircraft continues to grow as the need for engines with higher thrust and lower fuel consumption drives turbine engine technology development. High noise levels from aircraft impact residential communities around commercial airports and military bases. Aircraft noise also has a more acute effect on airport ground crews, and military aircraft carrier launch/recovery crews.

Noise regulations proposed by the International Civil Aviation Organization over the last two decades have continued to require source reduction of the allowable noise from aircraft. Also proposed are solutions for community noise such as land-use planning and management, and operational restrictions. These solutions applied over the long term, without source reductions, will be very costly to federal, state, and local governments. While the latter may mitigate community noise issues, only source reductions will reduce noise to commercial and military flight line and military aircraft carrier launch and recovery crews.

Research is ongoing in the area of jet noise reduction. Various treatments to the nozzle of the aircraft such as chevrons, blowing and suction, or plasma actuators which can produce 3 to 5 dB reductions to the jet noise. Chevron technologies are relatively mature and could be retrofit to existing engines relatively easily. Other technologies under development may require significant bleed air or power from the propulsion system to function. These bleeds are a debit to the performance of the propulsion system. For the next generation of commercial, fighter, transport or bomber aircraft systems, significant reductions to jet noise will only be realized by an integrated airframe and propulsion system approach.

Desired is a revolutionary smart noise reduction technology or suite of technologies that reduce jet noise from aircraft by up to 10 dB as compared to untreated jets at the same condition. Smart technologies take advantage of key physical properties to allow for passive control of suppression without significant use of external power or bleeds. An example would be, but is not limited to, the shape memory effect in certain alloys. Smart technologies should also be developed with advanced propulsion system concepts and cycles in mind. Exploration of the trade space between noise reduction, thrust, and fuel consumption is a key. An evaluation of the trade space between noise suppression and performance of candidate noise suppression technology to maximize the payoff of propulsion system noise suppression technologies is essential to the further development of smart noise suppression technologies.

The new smart technology should be demonstrated to a Technology Readiness Level (TRL) of 4 in an appropriate environment at the end of the Phase II program. Close collaboration with an original equipment manufacturer (OEM) of aircraft or gas turbine engines is highly recommended to aid transition of technology concepts.

PHASE I: Demonstrate the feasibility of revolutionary smart noise suppression concepts to a TRL of 3. Perform analysis to determine the potential benefit and impact of the concept on the engine cycle, thrust, and fuel consumption.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Noise suppression technologies for future fighter, tanker, transport, and bombers with significant noise reduction and minimal impact on aircraft performance.
Commercial Application: Demonstrated revolutionary integrated technology concept will allow for significant reductions in commercial jet noise sources.

REFERENCES:

KEYWORDS: jet noise, noise suppression, smart technologies

AF112-169
TITLE: Thermoacoustic Instabilities in High-Pressure Combustors for Aerospace Fuels and Emerging Alternatives

TECHNOLOGY AREAS: Air Platform, Electronics

OBJECTIVE: Develop and apply state-of-the-art high-bandwidth noninvasive technology for measurements of key performance parameters in alternative fuel-based high-pressure combustors.

DESCRIPTION: In chemically reacting flows, the instability modes that affect the performance of combustors evolve both spatially and temporally. The presence of heat release due to chemical reactions complicates the spatiotemporally evolving Kelvin-Helmholtz instabilities generally associated with jet flows or mixing layers. The instabilities associated with the combustion and flow processes in turn significantly affect the combustor performance. Thermoacoustic instabilities are prevalent in many practical combustion systems. They occur due to the in-phase relationship of the acoustic pressure and unsteady heat release and can lead to catastrophic combustor damage. Since the heat-release rates of various alternative fuels differ, they will exhibit various modes and degrees of thermoacoustic instabilities. A noninvasive measurement technology capable of measuring key performance parameters at multiple spatial points with a data rate of 10 kHz or greater is required to address the instability issues related to high-pressure combustors for various alternative fuels. The performance parameters of interest are temperature, major species concentrations such as H2O, CO, or CO2, and minor species concentrations such as OH or CH.

Current state-of-the-art invasive technology is limited to providing pressure and temperature data at the surface of the combustor, and noninvasive technology is limited either to spatially averaged chemiluminescence imaging or concentration measurements for one species, generally at rates lower than 10 kHz. These measurements are insufficient to provide in-situ 2D and 3D quantitative data regarding temperature and/or the local heat release at higher data rates. Devising control strategies for thermoacoustic instabilities associated with alternative fuel-based high-pressure combustion requires real-time measurement of temperature and heat-release rates in two- or three-dimensional configurations. These data acquisition capabilities must be complemented by essential software tools for identifying the instability modes, their interactions, their impact on combustor performance, and their influence on real-time control strategies.

Understanding the causes of combustion instabilities requires information on local flame-front phenomena, global heat release, and acoustic feedback at frequencies greater than 10 kHz. There is a short- and long-term need, therefore, to develop practical experimental tools that will enable researchers and engine manufacturers to capture local variations of temperature and species concentrations as a function of time to track the mechanisms that lead to
and help sustain combustion instabilities. Furthermore, interpretation of measured signals acquired using existing continuous wave, nanosecond, and picosecond laser-based technologies requires detailed understanding of the effects of molecular collisions, which generally depend on local temperatures and species concentrations. There is no unique way of modeling the effects of collisions, which generally requires an empirical approach, and the interpretation of collisional dynamics differs among research groups. An ideal noninvasive measurement technique in practical combustors is expected to be independent of the local effects of molecular collisions. Even though collision-free measurement is desired, it is not essential for addressing the instability issues related to alternative fuel-based high-pressure combustors.

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 US 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 Combustion and Laser Diagnostics Research Complex (CLDRC) and certain amplified ultrafast laser systems therein.

**PHASE I:** Perform research to demonstrate the feasibility of the measurement approach in laboratory turbulent flames for various hydrocarbon fuels.

**PHASE II:** Fully develop and fabricate a measurement system capable of tracking combustion instabilities in alternative-fueled high-pressure combustors. Demonstrate the capabilities in a model high-pressure combustor.

**PHASE III DUAL USE COMMERCIALIZATION:**
Military Application: Measurement technologies demonstrated herein can be used in development and procurement programs for the collection of high-quality data for validation of design, performance, and robustness. It is desired that the prototype system be delivered to the government for further evaluation and testing at an AFRL facility.
Commercial Application: A high-bandwidth measurement system will have a broad range of applications, making this technology applicable to turbine combustors, turbine test facilities, and biological imaging, for example.

**REFERENCES:**

**KEYWORDS:** laser diagnostics, fluid dynamics measurement, combustion instability, high-bandwidth measurement, high-pressure combustion, alternative fuels
TITLE: Extended Endurance System Integration in an Air-launched Expendable Small Remotely Piloted Aircraft (RPA)

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop and demonstrate an integrated Group 1 air-launched RPA platform weighing <10 lb capable of operation on an air-breathing electric power system for extended endurance applications (>2+ hours).

DESCRIPTION: As the Air Force lead command for small RPA, the Air Force Special Operations Command (AFSOC) intends the air-launched RPA to extend range of onboard sensors, see below the weather, track multiple targets, increase target acquisition accuracy and provide direct support to ground teams. Today, state of the art technology for Group 1 (<20 lb), provides approximately 30 minutes endurance with conventional batteries. However, to make air-launched expendable RPAs viable for multiple mission scenarios, technology must be developed to allow for a mission endurance of a minimum of 4 hours. Complicating this challenge is requirement to integrate a power solution that does not produce or utilize potential explosive or environmental hazards while system is onboard aircraft or in storage.

Typical employment of an air-launched RPA would include launching the aircraft via a common launch tube in support of a surface team. The common launch tube is 6- to 8-inch diameter, where the RPA is stowed initially for an extended time (up to 6 months) with no initial air flow. Therefore, shelf life of any fueling solution is a consideration of the integrated RPA. It is the intention that Group 1 RPA shall perform its mission functions under low acoustic and thermal detection, minimal hazard waste and fumes, requires low user maintenance, in environments that contain dust and sand, at least 90 percent humidity, one inch per hour of precipitation, wind speeds <30 knots, temperature ranging from -20 °F to 131 °F. Proper consideration must be made in the design of the platform for proper ventilation and/or air filtration for the air breathing electric power system. Since the air-launched RPA utilizes a fuel source, the transportation, storage, and handling requirements must be consistent with existing logistics (e.g., battery, hazmat, etc). This effort will focus on the system integration effects of incorporating a air breathing electric power system on an air-launched RPA. The system integration should require the platform to be designed/modified around the power system. This effort shall focus on RPA platform requirements such as system integration and design for maximum efficiency, tube launch capability (internal pressure, minimum air flow, internal heat dissipation, handling opening shock (G-loads), safety of fuel during storage/compressed tube launch, remote start/standby of power system components prior to/during employment, effects of pressure drop from compressed tube launch on power system, ease of use (accessibility to fuel cartridge), etc. Given the 2-hour threshold/4-hour objective flight time, it is assumed the power system will provide >200 W/kg average, with >300 W/kg during 10 percent of mission to meet peak power demands. The overall power system energy density would be ~400 W-hr/kg to meet the 2-hour mission endurance (800 W-hr/kg for the 4-hour objective). An appropriate fueling solution shall be proposed in Phase I with sufficient energy density to achieve design metrics and a thorough study shall be performed on safety, storability/transportability while integrated into the RPA platform. The safety/storability of the fueling solution shall be demonstrated in Phase II under simulated operational conditions.

PHASE I: Design air-launched RPA and define performance parameters/interface constraints based upon integration of air-breathing electric power system. Key tech challenges/performance limitations shall be outlined. Plan shall outline how tech challenges can be overcome/requirements met to achieve 4hr flight.

PHASE II: The offeror shall demonstrate air-launched RPA (<10 lb) based upon Phase I design (tube launch, flight in min 30kt wind, 1+lb payload). Fuel safety/storability shall be demonstrated under simulated flight conditions. RPA shall demonstrate flight ops on conventional battery with onboard fuel and simulated power system weight/volume. Demonstrate integration path of power system via follow-on.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Follow-on efforts are expected to be aggressively pursued by offeror, seeking opportunities to integrate power system into RPA platforms. Application includes ISR, target tracking and acquisition.
Commercial Application: Commercial applications include long endurance tube-launched RPA for border patrol and emergency responders.
REFERENCES:
1. Defense Technology Area Plan for 2005; DoD Key Technology Areas (#1); AFSOC/A5ZU Key Technology Areas – Increased Power.


KEYWORDS: hybrid power systems, fuel cells, batteries, RPA, air-launched SUAS

AF112-175 TITLE: Smart, High-Temperature Pressure Sensor

TECHNOLOGY AREAS: Air Platform, Sensors

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

OBJECTIVE: Develop a smart pressure sensor capable of measuring combustor as well as exhaust pressures inside/outside a turbine engine.

DESCRIPTION: There is a growing demand for high-temperature (HT) pressure sensors (PSs) for use in extreme temperature environments such as aircraft gas turbine combustion control. These demands contribute to the long-term development of an intelligent engine by providing information on engine conditions even in HT, harsh environments. Realization of a future intelligent engine depends on the development of both hardware and software including electronics and sensors to make smart components. Recently, many efforts have been focused on the design of a robust piezoresistive sensor for harsh environment applications based on wideband-gap semiconductors such as SiC, diamond, and GaN [1–6]. However, micro-fabrication technology of wide band-gap sensor materials is far less mature than silicon micromachining technology. There is still some distance to go for these wideband-gap sensors to become cost-effective products. Therefore, development of HT low-cost micromachined silicon piezoresistive transducers based on silicon-on-insulator (SOI) technology is still attractive. Several companies and NASA manufacture PSs for use in harsh environments such as internal combustion and turbine engines. Microelectromechanical Systems (MEMS)-based HT pressure transducer technology will improve fuel efficiency and reduce the emissions of turbine engines. The design of a high-temperature PS has remained one of the toughest aspects of fiber-optic sensing. Many of the significant challenges are related to the materials’ performance, including finding a way to create hermetic bonding that can survive HTs. Researchers have found that adhesive-free direct bonding between similar materials can be an excellent approach for avoiding a possible thermal expansion mismatch, which can break the seal. For fiber sensors, this is often reduced to how to directly bond silica to silica or a single crystal to the same material with the same crystal axis orientations. What is needed is a reliable smart PS capable of measuring combustor/exhaust pressures. It should tolerate 1250 <sup>°</sup> F sensed air temperature, survive in a 400 <sup>°</sup> F ambient environment and have a range of 0 to 700 psia. The steady-state accuracy should be +/-.75% of point or +/- 0.5 psi, whichever is greater, and have a dynamic range of 100 Hz. The device should communicate over a data bus to the full authority digital engine control and will be provided with conditioned 28 VDC power.

PHASE I: Conduct research leading to the development of very small, inexpensive intelligent HT PS showing the feasibility of detecting at extreme temperature environments such as aircraft gas turbine combustion control and exhaust systems.
PHASE II: Develop, test, and validation a prototype system consisting of sensor and software/algorithms. Demonstrate the capability of the prototype system under simulated laboratory conditions. Determine approach for integrating sensor in gas turbine combustion control and exhaust nozzles.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: The technology could be used on military and commercial aircraft to detect pressure at high temperature in the combustor and exhaust regions. Commercial Application: The technology should be applicable to any type of engine requiring HT PS.

REFERENCES:

KEYWORDS: smart sensor, pressure sensor, SiC on SOI Technology, MEMS-based high temperature pressure transducer, Silicon carbide on insulator (SiCOIN) technology, silicon on insulator (SOI), SiC high temperature sensor.

AF112-177 TITLE: High Thrust Electric Propulsion

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop high power, long lifetime thrusters for emerging critical Department of Defense (DoD) missions.

DESCRIPTION: A need exists for additional research on innovative, high power, inherently long lifetime thrusters in support of DoD missions. Electric propulsion has the capability to greatly enhance the maneuverability and payload capacity of spacecraft, however, current Electric Propulsion devices do not provide enough thrust to perform some time critical maneuvers. For example, advanced military communications satellites use high power Hall Thrusters for much of their orbit raising, but these thrusters cannot complete the entire maneuver in a timely manner. The use of lightweight, higher-powered Electric Thrusters and advanced power generation systems may enable the elimination of chemical thrusters and propellant systems on many missions.

Traditional Hall Thrusters have a specific power of roughly 3 kg/kw when scaled to the power levels of interest. This solicitation seeks research on thrusters capable of achieving a goal specific power of 1.5 kg/kw or less. This goal must be met while achieving thrust efficiencies equal to or greater than the current state of the art (>60%) at specific impulses of 1400-3500 sec. with constant power input. Proposal solutions may be either ideas for improving existing thruster technology or the development of new concepts. A representative power level for this technology is
50 to 100 kW per thruster, though demonstrations may be conducted at different power levels to accommodate cost-effective research activities.

The thruster 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 ground storage of 5 years.

PHASE I: Perform proof-of-concept analysis and/or experiments that demonstrate the feasibility of the compact low mass high-power propulsion concept.

PHASE II: Measure performance of breadboard hardware, which demonstrate program goals for compact low mass thruster.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The high power thruster will be useful for maneuvering geosynchronous orbit transfer for large communications satellites and large military spacecraft that will perform a variety of critical missions. Commercial Application: It will be useful for commercial space tug and communications satellite geosynchronous orbit transfer operations.

REFERENCES:


KEYWORDS: Electric Propulsion, High Power, High Delta-V, Responsive, Maneuver
It is envisioned that the methods developed in this effort will transition to the next generation Air Force booster and upper stage engines. Booster engines will use high performance closed-cycles such as oxygen risk staged combustion, fuel-rich staged combustion, or other closed cycles. Propellants being considered include liquid oxygen as the oxidizer and liquid methane or kerosene as a fuel. Upper stage engines will use gas generator, staged combustion, or expander cycles and will use liquid oxygen as the oxidizer and will potentially use liquid hydrogen, liquid methane or kerosene as the fuel.

Some of the aspects that need to be assessed are; material compatibilities, coolant characteristics that must be compensated for in the design, identification of possible shortcomings (design limitations) and further benefits stemming from the different types of cooling methods. Cooling techniques must be able to successfully operate in the extreme conditions of rocket engine combustion chambers where the chamber pressure will potentially exceed 2000 psi for boosters and 1000 psi for upper stage engines. Depending upon the cycle configuration, coolant pressure will be between 10% and 500% of chamber pressure. Heat flux to the propellant can be up to 100 btu/in²/s in the combustion chamber throat section. Temperatures are dependent upon the propellant and cycle selection.

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

The demonstration effort should be closely linked to the modeling and simulation activities and help to validate the data. The testing effort should be set in such a way that test results and data are useful to the modeling and simulation efforts.

PHASE I: Demonstrate the feasibility of a cooling method which enables high performance, highly operable rocket engine systems. Perform initial modeling and simulation studies to demonstrate the applicability of the proposed technology to future Air Force booster or upper stage engines.

PHASE II: Develop and test the novel cooling method in an environment that is simulative of future Air Force booster or upper stage engines. Assess instrumentation effectiveness in gathering the data for comparison with the modeling and simulation efforts. Utilize the modeling and simulation tools to show the applicability of the cooling technology to full-scale applications.

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

REFERENCES:

KEYWORDS: cooling methods, thrust chambers, reusable rocket engine, verification and validation, responsive space access
AF112-179

TITLE: Fluid/Structural Interaction Tools for Liquid Rocket Engines

TECHNOLOGY AREAS: Ground/Sea Vehicles, Space Platforms

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

OBJECTIVE: Develop modeling and simulation tools that are capable of solving the complex fluid/structural interactions in liquid rocket engines, particularly in turbomachinery

DESCRIPTION: The coupled fluid structural interaction within liquid rocket engines is an extremely complex problem that is difficult to model. In the case of rocket engine turbomachinery, the turbines are rotating at very high velocities and in an extremely harsh environment that is very high pressure and can be at either temperature extreme. However, fluid/structural interaction issues are prevalent in many places in liquid rocket engines.

The purpose of this research topic is to develop modeling and simulation tools that can examine the fluid/structural interaction problem. Improving the capability in this area is key to improving the understanding of the phenomena occurring inside these devices and better understanding the design trades necessary to improve the life of these devices.

PHASE I: Demonstrate the feasibility of tools and models to study the fluid/structural interactions in liquid rocket engines. Identify potential verification and validation cases relevant to liquid rocket engine conditions.

PHASE II: Integrate the fluid/structural interaction tools into a stand-alone or existing modeling tool. Utilize the verification and validation cases with the code to determine the applicability of the code.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Developing innovative tools to model the interactions between fluids and structures in rocket engines is critical to long-life, reusable systems which will increase operational tempo and reduce cost.
Commercial Application: Civilian power generation systems operate in similar regimes and suffer fluid-structural interaction which can be life limiting—these tools would have direct application to these types of systems.

REFERENCES:

KEYWORDS: Keywords: Turbomachinery, aeroelasticity, fluid structural interaction, verification and validation

AF112-180

TITLE: Satellite Disposal Technologies
TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop spacecraft disposal technologies that minimize requirements for additional propellant mass.

DESCRIPTION: All new spacecraft must now be launched with the ability to move to a disposal orbit. This is to prevent the population of spacecraft in a particular orbit from growing to the point that collisions become likely.

The design considerations for end-of-life propulsion are different for each operational orbit. Low Earth orbiting spacecraft may be disposed of by re-entry into the atmosphere. Geosynchronous Earth Orbit (GEO) spacecraft will typically raise orbit a few hundred kilometers at end-of-life. An intermediate orbit can be changed to reenter or to stay out of the way depending on the particulars of that orbit. The impact of retirement may be more severe for small spacecraft than large. The length of time before retirement may also place heavy demands on a propulsion system needed initially for orbit insertion. Restarting a propulsion system after a long wait is uncertain. Small attitude control system thrusters and station keeping thrusters can also be used to place the satellite in its disposal orbit. However, this will require the addition of significant propellant mass beyond what is needed for the operational mission. The time required for an orbit change is probably the only commodity not in short supply for a spacecraft after its useful life has ended. This incomplete list of considerations should be addressed and expanded in a successful Phase I SBIR proposal and effort.

One example, a Low Earth Orbit (LEO) spacecraft could be lowered gradually into the atmosphere by using existing torque rods operated at maximum field strength to produce plasma drag.

In summary, we are looking for approaches to satellite end-of-life orbit removal that utilize in-situ spacecraft resources, the space environment, and perhaps a minimal amount of additional hardware. Successful approaches should save weight and improve reliability over current approaches without making operations more difficult. A successful proposal and Phase I effort should demonstrate increased useful payload mass and reduced development and operational cost.

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 ground storage of 5 years.

PHASE I: Perform proof-of-concept analysis and/or experiments that demonstrate the feasibility of the end-of-life spacecraft orbit retirement concept.

PHASE II: Develop breadboard hardware to demonstrate performance of selected technology, which demonstrates program goals.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Removal of spacecraft from orbit at end-of-life is very important to open space for new spacecraft, to meet requirements of international agreements, and to reduce the risk of orbital collisions.
Commercial Application: This technology applies to Commercial and NASA spacecraft in the same way as it does to Military spacecraft.

REFERENCES:
AF112-181  TITLE: Deep Throttle Enabling Nozzle Technology

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop concepts for dramatically reducing the thrust of a liquid rocket engine while maintaining the turbomachinery flow-rate and output pressure at or above the typical minimum throttle condition.

DESCRIPTION: Future military and commercial spacelift systems will utilize reusable systems in order to increase the military utility by both enhancing current missions, enabling new missions and reducing cost. These highly operable, high performance rocket engine systems must be able to throttle as much as possible. Current engine research and development efforts are only targeting a 3:1 throttle setting. However an even lower throttle setting (6:1 or greater) is desirable for use in specific operations. It is desirable to achieve this lower throttle setting without having an effect on the turbomachinery of the engines.

It is envisioned that the methods developed in this effort will transition to the next generation Air Force booster. The booster engines will likely be liquid oxygen/kerosene oxygen-rich staged combustion cycle engine or other closed-cycle liquid oxygen/hydrocarbon (kerosene or methane) engine capable of generating booster-class (500,000 lbf+) thrust levels. The applications of this technology will be in enabling a significantly lower thrust during stage separation in a reusable booster application. The capabilities are also applicable to smaller engines that have an extreme deep throttle requirement. A potential application of this technology is during a stage separation of an upper stage from a reusable booster system, it is desirable to reduce the thrust as much as possible to minimize load transfer. However, turning the engine completely off, would require a restart event which could potentially increase the risk of catastrophic failure.

In order to meet these requirements, new approaches are desired to reduce the effective thrust of the engine as a whole. These approaches should not require the turbomachinery to operate below the 33% power level setting; however, it should be capable of reducing thrust to at least less than ½ of the 33% power level setting.

Some of the aspects that need to be assessed are; control mechanism, actuation, material compatibilities (high temperature), nozzle characteristics that must be compensated for in the design, identification of possible shortcomings (design limitations) and further benefits stemming from the different type throttling.

The result of this effort will be highly operable, highly reusable, highly reliable throttling methods that can potentially transition into future systems. Since the cost of testing full-scale engine systems is prohibitive under a SBIR program, it is expected that demonstration of these activities will be performed on sub-scale or lab-scale hardware which may not be fully representative of the actual application. In order to insure that the applicability of the system, modeling and simulation will likely need to be used to simulate the flow characteristics in larger scale devices. These modeling and simulation activities will be a key part of this effort.
The demonstration effort should be closely linked to the modeling and simulation activities and help to validate the data. The testing effort should be set in such a way that test results and data are useful to the modeling and simulation efforts.

PHASE I: Identify novel throttling methods which will enable very low thrust, highly operable rocket engine systems. Perform initial modeling and simulation studies to demonstrate the applicability of the system to future closed cycle engines.

PHASE II: Develop and test the novel throttling method in an environment that is simulative of future high performance closed cycle booster engines. Assess instrumentation effectiveness in gathering the data for comparison with the modeling and simulation efforts. Perform proof of concept testing. Utilize the modeling and simulation tools to show the applicability of the system to full-scale applications.

PHASE III DUAL USE COMMERCIALIZATION:
Military application: Future military spacelift missions will use reusable launch vehicles to reduce cost and increase utility. These systems will require significant throttle capability to meet mission requirements. Commercial application: Future commercial spacelift missions will utilize reusable launch vehicles in order to reduce cost. These systems may require new throttling methods to enable this capability.

REFERENCES:


KEYWORDS: Throttling Methods, Thrust Chambers, Reusable Rocket Engine, Verification and Validation, Responsive Space Access, Deep Throttle

AF112-182 TITLE: Hypersonic Propulsion: Improvements in Controls and Instrumentation

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop technologies for enhancing the robustness of mid-scale scramjet engines through improvements in fast response control schemes and instrumentation.

DESCRIPTION: The Air Force is currently pursuing advanced mid-scale scramjet systems that push the state-of-the-art in terms of speed of air-breathing flight systems. Hydrocarbon fueled supersonic combustion ramjets (scramjets) are expected to operate from Mach 3.5 up to Mach 7-8. Scramjet engines are categorized into three general sizes based on air flowrate: small-scale (10 lbm/s), mid-scale (100 lbm/s), and large-scale (1000 lbm/s).

The X-51 program represents the current state-of-the-art for scramjet technology and is used as a reference point for this topic. It is a small-scale system that uses JP-7 fuel, has a takeover Mach number of 4.5 and an overall contraction ratio of approximately 5.

Moving from small-scale systems to mid-scale systems has exposed various technical challenges. This topic seeks new technologies that will enhance robustness of mid-scale scramjet systems through innovations in fast-response
control schemes and instrumentation. It is also advantageous if these systems are applicable to small- and large-scale systems as well.

Scramjet vehicle performance is currently restricted because the engine is not actively controlled. High-priority items for control system development include: a) isolator unstart margin, b) fuel flow response to both engine and vehicle transients or throttling of thrust, and c) overall engine thermal management. There is a need to be able to quickly and accurately detect the flight parameters, determine if corrective action is necessary, and then actuate systems to counter any impacts. Proposals may address any of these issues individually or collectively.

Sensors and actuators are important to scramjet control systems and at this time fundamental issues such as sensor type, sensor placement, and temporal response are critical areas of research. Similar issues exist for actuators. Presently, there is little scramjet engine transient data available which makes it difficult to formulate the relevant time scales that are needed to guide sensor/actuator placement and performance requirements.

Proposals in response to this topic may either be computational or experimentally focused and may work in either cold or reacting flows. Note that there is not expected to be any Government Furnished Equipment (GFE) required to perform a Phase I effort and proposals should not assume equipment or facility is to be furnished at no cost.

PHASE I: Design innovative concepts for one of the high-priority items listed in the description. Perform detailed numerical analyses or subscale testing of the proposed concepts. Demonstrate the feasibility of the innovative concept to respond to one of the high-priority items listed in the description.

PHASE II: Fabricate and fully develop a prototypical device or hardware to confirm improvements to the high priority area chosen for Phase I. Provide engineering systems analyses on one or more of the high-priority items for developing larger and broader operating ranges for scramjet systems. Fabricate and evaluate prototypical devices or hardware to confirm predictions at an acceptable scale.

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 designs is needed for access to space applications. It allows physical testing at smaller scales to save costs while upholding confidence of applicability to larger systems.

REFERENCES:


KEYWORDS: hypersonic, scramjet, propulsion, high speed, space access, controls, instrumentation
OBJECTIVE: Develop a semi-ruggedized, medium-pressure (>400 psi) hydrogen generation system that is capable of providing high-purity hydrogen for use in portable fuel-cell-based power systems.

DESCRIPTION: Fuel-cell-based power systems can offer the significant advantage to the DoD Warfighters for many applications including medical transport, austere environment radio stations, and forward operating locations wherein high quality, low-signature power is of critical importance. One such example includes the support of critical-care patients wherein continuous power is required to support the patient monitoring and life-support systems during an entire airlift operation which might last 12 hours or more.

To meet this need, the Air Force Research Laboratory has teamed with contractor partners to develop a portable fuel cell system, based on metal hydride hydrogen storage, which provides uninterrupted power to meet the medical equipment support needs of the Aeromedical Evacuation mission. However, recharge of the metal hydride hydrogen storage canisters presents additional logistic burdens. To mitigate this, a field-capable hydrogen generation system is desired which can provide a continuous flow of high-purity hydrogen at 400 to 500 psi. The canister recharge system must be capable of refilling up to six metal hydride canisters per hour (~2000 ml/hr @ 400 psi) and must fit in a semi-ruggedized, rollable case for transport and storage. The solutions can include, but are not limited to, water electrolyzers, logistic fuel processors, and hydrogen generation by primary hydrides. Safety and reliability are of paramount concern. While the primary power for this system is expected to be 120VAC, solutions which integrate the hydrogen generation systems with optional solar power or related renewable technologies are favored. The maximum weight of the hydrogen generator system is desired to be < 50 lb.

The Phase I will focus on producing a detailed design of the hydrogen generation system leveraging commercial technologies to the greatest extent possible. The offeror must define clear functional tolerance levels in terms of water quality, power input/quality, hydrogen output, input/output couplings, and other related factors. The offeror should also attempt to demonstrate that the candidate technology can be readily integrated into a functional system that can be qualified for use in a battlefield setting. The Phase II will develop a fully functional prototype and will demonstrate its operation in a relevant setting.

PHASE I: Demonstrate the feasibility of the proposed design to meet the requirements as stated above

PHASE II: Develop a functional prototype which meets the Phase I goals in terms of device weight/size, hydrogen generation rate, and runtime hours. The offeror must demonstrate the functionality of the system in a relevant environment in conjunction with existing Aeromedical Evacuation Operations and present a manufacturing plan that shows the device is readily producible and viable for these operations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military applications include supply of hydrogen for portable power systems including critical-care patient support, radio listening stations, and other silent watch applications.
Commercial Application: Potential applications could include hydrogen generation to support first responder needs and other purposes including laboratory equipment (commercial and academic).

REFERENCES:

KEYWORDS: electrolyzer, hydrogen generator, hydrogen storage, fuel cells, solar energy
TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Improve volcanic ash detection/forecasting models by developing an airborne-capable aerosol detection system used to make measurements of ash concentration, size, and composition in an ash plume.

DESCRIPTION: Volcanic ash plumes may not be visually detectable by the pilot, and yet present a serious risk to aircraft flight safety and systems. Numerous ash encounters have caused serious incidents including multiple in-flight engine failure events. In high concentration levels of volcanic ash, a potential for loss of aircraft is extremely serious. In lower concentration levels, volcanic ash impacts engine lifetime, electronics, and other aircraft systems causing mission failure, decreased mission readiness, increased aircraft vulnerability, and significant increase in aircraft maintenance cost. The volcanic ash problem is broken into two major technical areas; a) Detection, forecasting, and modeling the concentration levels and dispersion of the volcanic ash clouds, and b) Weapon system vulnerability: determining the effects of ash on airframe and engine safety, performance, and maintenance.

Before weapon system vulnerabilities can be efficiently evaluated the ash cloud concentration, size, composition, and position must be determined. These variables are required to: 1) validate volcanic ash dispersion models, 2) determine the threshold ash concentrations for satellite ash detection, 3) quantify the immediate risk to aircraft, 4) assess the need for enhanced aircraft maintenance, and 5) confirm airspace near key USAF assets is safe for flight operation. This SBIR topic will focus on the development and demonstration of real time detection technology, data transmission, and data fusion technologies into an approved AF volcanic ash dispersion model or models. The AF approved volcanic ash dispersion models include Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT), Weather Research and Forecasting Chemistry (WRF-CHEM), and ASH3D. These models were developed and supported by the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS). Model downloads and other related information can be obtained from their web sites http://ready.arl.noaa.gov/HYSPLIT.php; http://www.noaa.gov/; http://ruc.noaa.gov/wrf/WG11/; and http://www.usgs.gov/.

Current models can forecast concentration levels with an accuracy of 2 orders of magnitude with 4 orders of magnitude range. The goal of this effort is to forecast concentration levels at 75 percent accuracy. Furthermore, the capability to collect in situ measurements of concentration, size, and composition of volcanic ash clouds does not exist along with feeding these measurements “real-time” into models. This effort will develop this technology.

This technology possesses strong multi-use capability. It may be used for CBRNE detection, visibility and dust lofting determinations, and human health assessments, in addition to volcanic ash quantification. The multi-use capability makes the detection system ideal for use by our UK and other European allies. The commonality in detection systems would reduce the distrust of the foreign technology being used to clear airspace and allow the USAF to operate in Europe under potential volcanic ash conditions.

PHASE I: Demonstrate concept feasibility of portable, deployable impactor/sensor capable of gathering real time information (composition, size, and concentration) from volcanic ash clouds for data integration into AF approved volcanic ash dispersion forecasting models supported by the government.

PHASE II: Fully develop and fabricate prototype impactor/sensor. Demonstrate overall sensor accuracy and data fusion performance through benchmark tests while using an AF approved volcanic ash dispersion models and quantify improvements in dispersion modeling accuracy. Demonstration will require flying sensor in ash cloud while relaying sensor information to dispersion models.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This program will ensure mission access, safe flight operations, and reduced maintenance costs for flights in proximity to volcanic ash plumes by identifying safe passage ways for USAF aircraft.
Commercial Application: Every airline company and DoD agency uses the information from the volcanic observatories and the official Volcanic Ash Advisory Centers to develop operation plans for their fleet. These companies and agencies are the market for purchase or lease of the detection technology and software products to use in their meteorology and operations centers to produce more accurate plans for reroute and fly/no fly decisions. This technology has world-wide applications for every aircraft fleet.
REFERENCES:

2. Army Research Laboratory, RDECOM: W911NF-07-1-0346, W911NF-08-1-0318 and W911NF-09-01-0543

KEYWORDS: gas turbine engine, volcanic ash, puff model, plume sensor, aerosol, impactor, lidar, Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT), WRF-Chem, volcanic ash dispersion

AF112-185 TITLe: Methods For Measuring Coke Buildup in the Cooling Channels of Liquid Rocket Engines

TECHNOLOGY AREAS: Space Platforms

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

OBJECTIVE: Develop novel non-intrusive methods for determining coke buildup in the narrow cooling passages of a liquid rocket engine.

DESCRIPTION: Future military and commercial spacelift systems will utilize reusable systems in order to increase the military utility by both enhancing current missions, enabling new missions and reducing cost. These highly operable, high performance rocket engine systems must be able to be quickly prepared for new missions within a minimum amount of time and with a minimum of effort. To gain the required high performance, the system losses associated with coke deposits, which can cause undesirable hot spots on chamber walls, must be eliminated. This topic seeks to develop methods to determine if there is any coke remaining in the coolant passage after the reusable system returns to its base of operations. Methods to determine the coke build-up must be able to be utilized in an operational environment.

Many of the engine systems under consideration for this mission utilize the high performance, oxygen-rich staged combustion cycle and use liquid oxygen as the oxidizer and kerosene as the fuel. In this cycle, the kerosene fuel is used to cool the main combustion chamber. As it cools the chamber, it has the potential to form coke deposits. The coolant channels are integral to the combustion chamber and nozzle and have a typical length of more than 60” and a typical cross-section of 0.25”x0.25”. Engines typically have a large number of cooling channels that are fed from a common manifold.

In order to meet the turn-around-time requirements, new approaches are required to identify the build-up of coke deposits within these rocket engine cooling channels. Not that it will be necessary to perform the measurements without the disassembly of the engine. Non-intrusive diagnostics are preferred, but intrusive diagnostics can be considered if there is an acceptable means to ensure that no debris will remain in the channels. This debris can potentially damage other engine components.

Some of the aspects that need to be assessed within any proposed solution are the ability to measure the buildup of coke deposits, the accuracy of the measurements, the time required to make the measurement and process the data, and the ability to make the required measurement in a field environment.

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

The demonstration effort should be closely linked to the modeling and simulation activities and help to validate the data. The testing effort should be set in such a way that test results and data are useful to the modeling and simulation efforts.

PHASE I: Identify novel non-intrusive measurement methods to determine the amount of coke deposits within the cooling channels of a liquid rocket engine. Perform initial verification of the technique and its applicability to future Air Force rocket systems.

PHASE II: Develop and test the novel measurement method in an environment that is simulative of future Air Force booster engines. Assess instrumentation effectiveness in gathering the required validation data. Show applicability to full-scale applications.

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

REFERENCES:

KEYWORDS: Coking, Thrust Chambers, Cooling Channels, Reusable Rocket Engine, Non-Destructive Evaluation, Responsive Space Access
that the balance be instrumented with a suite of sensors, a structural motion calibration procedure be devised and a supporting computational model be developed. However, innovative solutions are encouraged and all approaches will be considered. And, importantly, the solution should not compromise the ability to extract useful aerodynamic data from each and every data sample at a test condition. The structural motion that interferes with the aerodynamic data is typically bounded by accelerations up to 10 gee at a frequency of up to 300 Hz. The ability to retrofit a solution to existing wind tunnel balances is highly desirable. The Phase II effort should perform a wind-off test of balance and inertial system installed on a supporting sting with independent measurement of motion to demonstrate the prototype system performance.

PHASE I: Develop system design concept and demonstrate measurement and processing pitch plane motion to remove inertial effects for first and second structural modal motion.

PHASE II: Develop and demonstrate a prototype wind tunnel internal balance and associated inertial sensing system for pitch, yaw, and roll acceleration.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Product development of military vehicles that are range-critical need highly accurate wind tunnel test results for risk management.
Commercial Application: The benefits to NASA research and commercial applications are the same as for military applications.

REFERENCES:

KEYWORDS: Inertial Compensation, Wind Tunnel Balance Measurement
and maximum off-axis solar/lunar angles. Cryo-vacuum simulation chambers are limited volume and crowded with optical benches and test equipment. The close proximity of mirrors needed to provide incident radiation causes significant optical scattering and stray radiation. The sensor system under test (SUT) can be fixed, or placed on a gimbal mount or turning mirror to change the angle of light entering the SUT. There are significant configuration issues that would require Size, Weight, and Power (SWAP) assessment. A modular antechamber (nominally 2 m diameter and 3 m long) could be used to integrate this capability into existing facilities. The SLE technology must measure sensor performance to nominally 1E-09/sr (ratio of sensor response at an off-axis angle to normal incidence per solid angle) with a dynamic range goal of 14 orders of magnitude. This demands high-level collimated source irradiance with known polarization characteristics and extremely low levels of stray radiation. Broadband infrared spectral output (1 to 20 µm) and a uniform intensity profile are desired, although approaches using lasers for necessary power levels will be considered. The full solar irradiance level is desirable, as is the spectral radiation shape manifested by the sun or moon (or other defined target). Generic sensor parameters are 10-in. apertures and up to 12 deg off-axis angles. The Phase I should demonstrate operation in the 1 to 14 µm range with nominal 0.1 solar irradiance (over system aperture) at a dynamic range of 6. The Phase II should demonstrate operation in the 1 to 20 µm range with nominal 1.0 solar irradiance (over system aperture) at a dynamic range of 14. Preference will be given to innovation in the optical configuration rather than exactly meeting the spectral range or power specifications.

PHASE I: Demonstrate a proof of concept optical design for a reduced path length exclusion test configuration operating in an 80 K and 1E-6 Torr cryo-vacuum environment.

PHASE II: Develop and demonstrate a prototype optical design for reduced path length exclusion test configuration operating in a 30 K and 1E-6 Torr cryo-vacuum environment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Such optical configurations would be applicable to on-board spacecraft systems and military space simulation test facilities.
Commercial Application: Such optical configurations would be applicable to on-board spacecraft systems and commercial space simulation test facilities.

REFERENCES:

KEYWORDS: Cryo-vacuum, Off-axis Rejection, Solar Exclusion, Optical Design, Optical Scattering, Infrared Radiation
DESCRIPTION: An innovative time synchronization capability is needed for data acquisition sources, processing software and human operator displays for test data acquisition and analysis when external time references are not accessible. Today, time stamps for data sources without access to external time reference signals are extrapolated and can result in mis-interpretation of critical test events from synchronization errors. With data acquisition systems composed of one or more networks, the possibility exists to create a novel exploitation of network communications and existing network components’ internal clocks to achieve time synchronization of all data collected and flowing over the network. Currently, external time references such as IRIG (Inter Range Instrumentation Group) or Global Positioning System (GPS) are connected to each data source or close to each data source. IRIG requires connectivity to an external IRIG reference source for each and every source or element for which timer synchronization is desired. GPS signals are not always available at data collection points. GPS signals may be blocked or intermittent, causing data synchronization loss. Both IRIG and GPS require additional, costly hardware associated operations and maintenance overhead. For some important DoD applications, space, power and environmental constraints and conditions make the use of IRIG and GPS impossible. The use of the ‘IEEE 1588 Precision Time Protocol (PTP)’ and Internet protocol suite ‘Request For Comment (RFC) 5905, Network Time Protocol (NTP)’ are examples of the desired characteristics. The desired solution should have no additional hardware, no external reference source and no external reference source connectivity. The desired solution should be completely standards based with no additional implementation or O&M cost. The performance need is for time synchronization to a level of 0.5 millisecond (ms) or less with jitter of less than 0.2 ms. Desired solution characteristics are to provide the time synchronization function and the performance on Ethernet LANs with at least 20 COTS computers and COTS network interface cards (NICs), using only Internet standard RFC protocols and COTS Ethernet switches without the need for external time references. Achieving these performance parameters within the solution constraint goals would assure adoption all of DoD and the commercial world as a lowest life cycle cost solution.

PHASE I: Develop and demonstrate a concept validation using an Ethernet network with a number of PCs with simulated data acquisition instrumentation and data communication to a single data recorder.

PHASE II: Develop software application program interface (API) and demonstrate for a generic Ethernet, COTS based data acquisition system with no external time reference.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applications include DoD ground and flight test facilities, data acquisition systems, data fusion, internal aircraft or weapon system networks.
Commercial Application: Applications include all data acquisition systems, LANs, WANs, cloud computing and distributed processing applications.

REFERENCES:


KEYWORDS: time synchronization, NTP, IEEE 1588, precision time protocol
TECHNOLOGY AREAS: Sensors

OBJECTIVE: Research and develop a system that uses a ruggedized field-portable unit to detect, identify and track desert fauna in remote areas.

DESCRIPTION: The primary purpose of this system is a drastic reduction of costs/manpower and field time required to determine the presence/absence of sensitive species. A secondary purpose is to produce species specific activity maps (similar to lightning strike maps) with frequency and location (+/- 2 meters), thereby enabling researchers to develop follow-up studies in an efficient manner.

Most animals have at least two calls or songs, many have more and may have other detectable marks. Because of this known phenomenon, acoustic sensors may prove useful in the identification of the fauna. If acoustic sensors are chosen, then the Activity map should document at least “alert or danger” calls and “mating” signals.

Every year the Natural Resource Branch spends thousands of dollars documenting the presence/absence of the various sensitive and listed species on base. This is costly in terms of time, materials, manpower and impacts to study results. A new system is needed to enable effective detection and tracking of sensitive and listed species at a significantly reduced in all these costs.

The technological challenge is detection and tracking of secretive, primarily nocturnal, animals that spend a large amount of their time underground or flying through the area. The sensor must be rugged, able to withstand temperatures ranging from 0 to 120 degrees Fahrenheit and wind gust up to 50 miles per hour in a desert environment. Species specific, digital “Acoustic Fingerprints” or other marks are available for most birds, and small mammal barks or chippers are well known if not readily available. The system should be able to record data for a minimum of two weeks prior to downloading, and produce species activity maps from the data.

The Endangered Species Act (ESA) 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 the 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 and administer the base’s natural resources in concert with the military mission. Preventing sensitive species from becoming listed species greatly lessens the impacts to the mission. The only way to convince the US Fish and Wildlife Service (FWS) that listing is not necessary under the ESA is to have good data.

PHASE I: Develop and produce a conceptual system design that includes all component technologies. Provide a detailed analysis of predicted performance, including details of expected range, longevity, sensitivity and tracking parameters which are substantiated with simulations or other means.

PHASE II: Develop and successfully demonstrate a working prototype system based upon the Phase I results. System will be tested to demonstrate capabilities in a real world remote desert location.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Provide DOD installations and other federal agencies the tools to better understand the demography of sensitive species to prevent listing and lessen the controls and restrictions on the mission.
Commercial Application: Many users of public and private land face the same requirements and have a vested interest in studying fauna in their natural habitat and in showing the listing of various fauna is not necessary.

REFERENCES:
OBJECTIVE: Develop an air launched rawinsonde and dropsonde system compatible with an F-16 aircraft equipped with an AN/ALE-40 or AN/ALE-47 countermeasures dispensing system and MJU-12 flare magazine.

DESCRIPTION: The goal of this effort is to develop a miniature air launched rawinsonde and dropsonde (MALRD) system that can be deployed from a standard countermeasures dispensing system. The MALRD is to be compatible with the F-16 aircraft that are typically used for test or safety chase at the Air Force Flight Test Center and include a ground data recorder or be compatible with existing weather data systems.

Accurate measurement of ambient air pressure, temperature, humidity, wind speed and wind direction (PTU+wind) data in specific volumes of airspace is a typical flight test requirement; however, existing technology is not capable of measuring specific medium to high altitude air masses. The inability to measure specific air masses results in data uncertainty and requires technical expertise and data extrapolation and correction to approximate the actual atmospheric conditions in the area of primary interest.

Typical flight techniques to determine PTU + wind data can be inefficient and time consuming. These techniques include ground launched radiosondes or rawinsondes attached to weather balloons, air launched dropsondes attached to parachutes, calibrated pacer air vehicles, and specialized flight profiles such as a cloverleaf flight pattern flown in the test area.

These typical techniques have limitations that adversely affect data accuracy. For example, a ground launched rawinsonde attached to a weather balloon may be carried by the prevailing winds to areas outside the test area. An air launched dropsonde is typically deployed via an open door or special launch tube which negates their use by most fixed or rotary wing air vehicles and limits their ease of use at high altitude. For both of these examples, the atmospheric conditions above the launch site or launch vehicle cannot be directly determined.

The MALRD system will provide accurate PTU+wind data in specific volumes of airspace. This new in-situ, real time measurement will provide accurate, quick, and cost effective measurement of ambient atmospheric conditions. A significant improvement in the state of the art is the MALRDs ability to measure extended air volumes by deploying rawinsondes or dropsondes along the predicted or actual flight path of air vehicles and along the projected or actual beam path for directed energy weapons.

Although the MALRD should be compatible with the thousands of electronic countermeasure dispensers deployed by the Department of Defense and in foreign service, the test air vehicle and dispenser for this effort is a F-16 series aircraft equipped with an AN/ALE-40 or AN/ALE-47 countermeasures dispensing system and a MJU-12 flare magazine.

PHASE I: Demonstrate the feasibility of a basic design for an air launched rawinsonde and dropsonde compatible with an F-16 aircraft equipped with an AN/ALE-40 or AN/ALE-47 countermeasures dispensing system and MJU-12 flare magazine.
PHASE II: Develop and demonstrate a prototype dropsonde and rawinsonde, based on the Phase I results, suitable for measuring ambient air pressure, temperature, humidity, wind speed and wind direction (PTU+wind) data in specific volumes of airspace.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The system has a wide variety of potential applications including flight testing of aircraft, munitions and directed energy weapons. It may have applications in weather data collection and combat.
Commercial Application: The system would be of interest to government and civilian weather forecasting activities and civilian flight test organizations. The National Weather Service has expressed interest in the concept.

REFERENCES:
6. MJU-7A/B Flare Dimensions.

KEYWORDS: air launched, rawinsonde, dropsonde, electronic countermeasure dispenser

AF112-195 TITLE: Ultra High Performance Radar Absorbing Material

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop radar absorbing material which provides improved attenuation of specular power over a frequency range from 0.5 to 18 GHz and capable of absorbing energy density of 2 watts per square inch.

DESCRIPTION: The Benefield Anechoic Facility uses a large anechoic chamber to support aircraft-level testing of installed avionic and electronic warfare (EW) systems in an electromagnetically quiet environment. It is also used for making installed antenna pattern and gain measurements, antenna-to-antenna isolation measurements, and electromagnetic interference/electromagnetic compatibility (EMI/EMC) measurements. New aircraft systems require improved electromagnetically quiet environments to accurately verify system performance.

The BAF produces an electromagnetically quiet environment by attaching radar absorbing material (RAM) to the ceiling, walls, and floor. Radiated signals produced during the test that reflect off the surfaces of the BAF chamber are greatly attenuated and until recently provided significant absorption resulting in acceptable measurement error. The performance of the existing RAM used in the BAF reduces the specular signal by 50 dB from X- through Ku-band, and is capable of operating safely at a power level of 0.5 Watts per square inch. It also produces non-specular signal scattering, which can be characterized as scattering noise, and is now causing significant measurement error for tests conducted from 2 to 18 GHz, with a more prominent error from 8 to 18 GHz. For a receiver system requiring a test environment in excess of 120 dB of dynamic range current RAM used in the BAF does not provide the necessary performance.
The current RAM is made of pyramidal shaped polyurethane material loaded with a carbon-salt solution. For high frequency applications, specular absorption is accomplished by three different mechanisms; 1) direct absorption, 2) diffuse scattering off the tips of the pyramidal shaped RAM, and 3) local specular reflection off the faceted surfaces of the RAM. Each of these mechanisms work together to provide lower forward specular scattering but also results in non-specular scattering that increases the noise level of the EM environment.

The development of an ultra high performance RAM that reduces forward scattering to 65 dB from 10 to 18 GHz, 55 dB from 3 to 10 GHz, 50 dB from 1 to 3 GHz, 45 dB from 0.5 to 1 GHz and non-specular scattering to 90 dB would provide a test environment capable of accurately testing current and future high frequency aircraft avionic and EW systems. The RAM should exhibit this level of performance over an angle of incidence of 0 to 50 degrees relative to the normal angel of incidence to the RAM face. In addition, the new RAM would need to operate safely at 2.0 Watts per square inch to handle RADAR, electronic attack, and other high power transmitting systems. The RAM would be applied to the BAF chamber walls, ceiling, and floor in large enough areas to support these tests and perform from 0.5 GHz. to 18 GHz. The RAM cannot exceed the dimensions of 24”X24” square X 18” high. The UHP RAM must meet the NRL 8093 1, 2, and 3 fire retardant test and specifications.

PHASE I: Analytically demonstrate an initial design which provides the required levels of attenuation across the required broadband of frequencies and the required energy density absorption, angle of incidence, specular and non-specular scattering performance.

PHASE II: Develop and demonstrate prototype ultra high performance RAM which provides the required levels of attenuation across the required broadband of frequencies and the required energy density absorption, angle of incidence, specular and non-specular scattering performance.

PHASE III DUAL USE COMMERCIALIZATION: Military Application: The RAM will find application at any DoD installation that uses an anechoic chamber or a semi-anechoic chamber for testing and evaluating high performance avionic, EW, ECM and other systems. Commercial Application: The RAM will find application at commercial facilities that use anechoic chambers to test any RF system, such as cell phone, GPS, Blue Tooth, and Wi-Fi, requiring isolation levels below -110 dB.

REFERENCES:
2. Morphology of EM Field Scattered by Absorber Material and Walls of Absorber Lined Chambers, Dr. S.R. Mishra, National Research Council, Ottawa, Canada, Prof. T.J.F. Pavlasek, McGill University, Montreal, Canada.
4. Specular and Non-Specular Scattering Studies of RADAR Absorbing Materials at 200-600 GHz, J. Saily, J. Mallat, P. Eskelinen, A. V. Raisanen, Radio Laboratory, Helsinki University of Technology, P.O. Box 3000, FIN-02015 HUT, Finland, Email: Jussi.Saily@hut.fi

KEYWORDS: Radar Absorbing Material, RAM, Anechoic Chamber, Specular Scattering, Non-Specular Scattering

AF112-199 
TITLE: Airborne High Speed Video

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a high speed video system that will fit in a small unmanned aerial vehicle. Demonstrate functionality over a warhead blast field. Demonstrate phenomena extensions not otherwise possible.
DESCRIPTION: No current capability exists to collect up close high speed video directly above the blast field. Imagery is currently collected at ground level and from towers. Airborne high speed video (AHSV) collection provides a new perspective for 3D warhead performance estimation and model development. In addition, prediction of high pressure blasts and low particle densities is currently conducted post detonation and using labor intensive verification techniques. Overhead AHSV will allow significantly faster pattern and pressure measurements. Overhead AHSV will also improve prediction of low collateral damage warhead fireball and blast phenomena not currently measured due to limitations of current techniques. Overhead AHSV will also allow physical model development and verification by increasing the accuracy and processing speed of collected data. Current technology calculates impact scoring via labor intensive measurements and quickly deteriorating fiber board techniques. AHSV can expand into particle impact scoring and reducing or removing the need for existing techniques.

PHASE I: Study micro HSV products. Make concept for micro AHSV that fit the Pointer and the MLB BAT3 CC UAV, with optics. Fit Sony block camera. Design has 2,000 fps, a resolution of 1920x1080, 500 lux, and 24 bit color bit depth. Have a MATLAB based AHSV camera algorithm. Camera stores 16 secs of AHSV.

PHASE II: Design and fabricate a bench level AHSV prototype based on the results of Phase I. The AHSV camera must be fit small UAV platforms. Demonstrate AHSV performance against ground based high speed events. Recommend updates to algorithm. Deliver prototype AHSV and MATLAB algorithm(s).

PHASE III DUAL USE COMMERCIALIZATION: Incorporate lessons learned from Phase II into design. If required fabricate updated ASHV. Design, fabricate, and integrate the AHSV on GFE UAV. Demonstrate AHSV airborne performance against relevant high speed events.


Commercial Application: Crash test from new perspectives. Natural phenomena, such as inside hurricane/tornados, volcanoes and earthquakes. AHSV positioned within lethal zones of catastrophes. Academic research. Sports events. Sports medicine research. Nuclear Sciences

REFERENCES:
2. Feasibility of a High-Speed Gamma-Camera Design Using the High-Yield-Pileup-Event-Recovery Method, Department of Nuclear Medicine, The University of Texas M.D.
3. Shock wave analysis in medicine, Kazuyoshi Takayama Professor Emeritus, Tohoku University Japan.

KEYWORDS: Miniature Airborne High Speed Video, Low Lux High Speed Video, High Definition High Speed Videod video, miniaturized cameras, UAV sensors, natural phenomena data collection
spatially and spectrally combined the input images. Each of the combined spectral band images that are produced from the prototype must spatially compare with the image for each of the input sources (UV and IR). For example, if an IR image is input into the prototype and a spatially identical UV image is input into the prototype the resulting output image shall consist of a co-aligned image identical to the size and shape of both input images and include both spectral characteristics.

The prototype must not exceed a dimension of 1’X1’X1’ and a weight of 10 lbs. Other specifications include an output IR bandwidth of 1 to 5um and an output UV bandwidth of 0.25 to 0.4um. The output image shall have a minimum UV and IR spectral throughput of 50%, spectral uniformity of 20%, and have minimal-to no ghosting. The input and output apertures of the prototype device shall be no less than 6 inches. Additionally, the resultant collimated output image shall resolve an image of size 10 microradians from a distance of 60cm.

PHASE I: Develop initial design/model key elements that will yield a spatially and spectrally combined image from separate IR&UV input sources. Modeled parameters include the layout of the optical design. The design should discuss properties & theory behind materials, coatings, etc. used for the concept.

PHASE II: Develop and demonstrate a full scale prototype device. Validate spectral and spatial goals defined in the description. The prototype, at a minimum, must combine one UV image and one IR image into a single spectrally and spatially co-aligned image. The prototype device must include a minimum input and output aperture of 1 inch.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Systems requiring the testing of multiband UV/IR sensors and multi or hyper spectral scene rendering for target detection, identifying, and sensor tracking characterization.
Commercial Application: Ranging from the removal of sub-micrometer-thick layers of material laser eye surgery, to Differential Absorption LIDAR (DIAL) that measures ozone and simultaneously measures aerosols and clouds.

REFERENCES:
4. BLOOMFIELD, J R; PRATT, P D; HUGHES, R J; WILLIAMS, L G, “Feasibility of multi-sensor combined displays”, Aerospace & High Technology Database

KEYWORDS: UV and IR Image combiner, Spectral Ultraviolet and Infrared Alignment, UV and IR image combining, Spectral Co-alignment, Dual Wavelength co-alignment, Spatial Registration, multispectral image overlay, Image Combiner

AF112-203  TITLE: Laser Material Survivability Model

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Develop a validated model that predicts ignition of composite aircraft fuel tanks under airflow conditions when impacted by a laser.
DESCRIPTION: High Energy Lasers (HEL) have been identified as an emerging threat with a potential to increase the probability of kill beyond that of KE threats. Rapid headway is desired for development and validation of corresponding predictive fire models for laser threats. One such code that has lead the way in this particular lethality/vulnerability realm is the Laser Effects Weapons Analysis Toolkit (LEWAT) developed by Physical Sciences Inc., which has sophisticated modeling abilities such as the incorporation of laser characteristics, environmental conditions, and material effects. However, there continues to be capability gaps even within LEWAT, particularly in the area of fuel backed composites within a high velocity airstream. This capability gap in LEWAT is substantial, as a proper understanding of laser material effects against composite fuel tanks under realistic conditions is a necessity for hardening blue systems against HEL threats during operations. A specialized subroutine is needed that can assess air-vehicle-specific issues concerning laser engagements of composite materials with a fuel backing within an airstream. This subroutine must be capable of linking to LEWAT as well as recognized aircraft vulnerability assessment codes (primarily COVART and AJEM) used within government and industry. Particular attention needs to be given to air flow velocities in range of 100-500 knots, composite materials such as graphite/epoxy and graphite bismaleimide, and various jet fuels (JP-8 and well as emerging biofuels). The subroutine must be capable of assessing the potential for a fuel fire (both an external fire and a dry bay fire). Model parameters of interest include: laser wavelengths, standoff power-densities, beam profiles, dwell times, laser power incident on the target, thermal losses due to the speed and turbulence of the adjacent flow passing over the laser illuminated surface, and the aero-optic state of flow. A laser fire prediction model will provide improvement in assessing the vulnerability of blue systems against HEL threat, provide tool for live fire pretest predictions, and provide understanding of potential hardening methods to counteract HEL threats.

PHASE I: Initiate development of a predictive fire module suitable for HEL engagements of fueled composite aircraft systems within an airstream.

PHASE II: Complete the development and credibility assessment of a predictive fire module suitable for HEL engagements of fueled composite aircraft systems within an airstream. Ensure the module interfaces with recognized codes for aircraft vulnerability assessment.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: High fidelity model will increase overall survivability of blue aircraft and increase effectiveness of test predictions.
Commercial Application: High fidelity model will increase overall understanding of industrial laser interactions with materials during fabrication and repair processes.

REFERENCES:

KEYWORDS: laser, HEL, engagement, aircraft, survivability, vulnerability, fuel, fire, threat, airflow, airstream, damage, composite, material, model
development and deployment of more energy efficient networking equipment worldwide. This is equivalent to $5 billion in energy cost savings. Servers are typically on-line 24 hours a day, 7 days a week, handling e-mails, processing internet requests, safeguarding classified data, handling financial transactions, and storing video and medical records. The use of the internet will only increase as more and more applications are developed and expanded. It is estimated from Google that only 20% (1.5 billion) of the world population is currently on-line. As these needs have progressed, the capacity of the servers has increased. This increased capacity has led to an increase in the heat output per server and increased the overall energy needs. The US government is interested in decreasing overall energy usage. Data servers present a concentrated area for energy efficiency. If the general population can reduce the overall amount of energy that network-supporting equipment uses this would help businesses and consumers save money by lowering their energy costs. The average data center uses half the energy to run its processors, and the other half is used to cool the facility. Areas to be improved include computing software, computing, storage and network hardware, the power conversion chain, heat removal, and controls.

There are several long term opportunities to improve data center energy efficiency through the development of new technologies and practices. This topic would research and develop improved methods of dealing with data center energy usage, focusing on either one area or a combination of several areas.

PHASE I: Research and develop concepts to reduce overall energy usage. Estimate energy savings for each concept suggested. Show how the technology could be easily adapted to industry.

PHASE II: Further develop most promising energy reduction strategies from phase I. Provide a final report that will document validated results, measured metrics and benefits.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Applications would apply to any improved energy usage such as data centers in military areas.
Commercial Application: Any large data centers would use this improved technology to decrease their costs. This could include internet servers, large companies, or even small governments.

REFERENCES:

KEYWORDS: energy reduction, data centers, net servers, conservation

AF112-206 TITLE: Machining Parameters for Direct Digital Manufacturing (DDM) of Aerospace Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop methodology, processes, and analytical tools required for final machining of metallic aircraft components produced using Direct Digital Manufacturing to reduce qualification cost and times.

DESCRIPTION: Direct Digital Manufacturing (DDM) process is an additive metal fabrication technology where parts are built up layer by layer. This process allows for highly complex geometries to be created directly from the 3D Computer Aided Design (CAD) data, automatically, in hours and without any tooling. In contrast the same part produced using conventional methods can take several months for manufacture or require long procurement times to obtain materials to manufacture. If a part cannot be procured in a timely manner, this often leads to a decision between using a condemned part past its life limits, or not having the end item part available for use that could result in weapon system downtime. For conventional materials, machining processes and material irregularities they cause are well known and any potential failure points or induced stress points that could result in failures have corrective
actions to take (e.g. Heat treat). But the newer technologies of additive metal fabrication materials are unknown. Research of the required machining processes (Turning, milling, grinding) for final machining of DDM parts and the standardization of these processes to eliminate stress build up or failure points need to be established.

DDM is a near net-shape process, producing parts with high accuracy and detail resolution, good surface quality and excellent mechanical properties. Typically, DDM parts must go through a machining process to obtain the surface finish and tolerances required to meet final form, fit, and function design. Tight tolerance fit-ups regularly require component features +/- .0005”. While DMLS machines have been demonstrated +/- .002” capability, better accuracies are required.

This process works well to create production tooling. However, since some machining processes (e.g. grinding) generate heat that may alter the microstructure of the material, the process renders DDM parts nonfunctional for use in safety of flight applications or will require extensive testing. Development of a greater understanding of how best to machine parts during finishing processes will increase operational safety, suitability, and effectiveness engineering acceptance of DDM produced parts for maintenance repair and manufacturing of aging aircraft parts. A plan is required to identify and define safe machining parameters for the DDM process. To support the accelerated qualification process, development of robust, validated, structure-property-processing models are needed in order to enable accurate material performance predictions. Currently, the aerospace industry utilizes DDM parts for non-safety of flight applications (e.g. production tooling, test cell environments and ground support). But a more thorough understanding of safe machining parameters will assist in standardization of acceptable finishing processes and increase the usage of DDM parts for safety of flight applications (such as vanes, valves, brackets and other aircraft components). Screening of materials for suitability for DDM is an expensive and time-consuming activity so the methodology should include screening methodologies for identifying acceptable advanced manufacturing materials for the final machining of DDM produced parts for operational safety, suitability, and effectiveness (OSS&E) validation and acceptance for airworthiness.

It is anticipated that DDM can, and will, be a viable process to produce aging aircraft parts and obsolete production tooling but requires more research and manufacturing data to attest to flight worthiness of parts produced using DDM processes. As a result of this project, a full parameter set should be established for approved standards on the safe and qualified accepted machining of DDM components. Variables such as material/construction, spindle Revolutions Per Minute (RPM), depth of cut, table speed, and coolant flow are anticipated. Additional variables will need to be identified and shown as key parameters in performing the analytical analysis. This information will increase the production readiness level of DDM and will specifically help expedite the use of DDM in the support of the war fighter through more rapid delivery of aging aircraft replacement parts.

PHASE I: Demonstrate the viability of the DDM process by developing machining parameters that will not alter the DDM part microstructures. Define metrics for measuring the effectiveness of implementation of the machining parameters and proposed standards, the methodology used, and concept analytical tools produced.

PHASE II: Develop, demonstrate, and perform the necessary validation of the methodology on produced prototype parts required to rapidly produce metallic DDM components through the utilization of developed standard machining processes. A final report will be provided to the government that documents the results of the Phase II demonstrations and qualifications.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This technology could be used across all areas of the government, from all aircraft engines, and expanded to other transportation types (vehicles, ships, etc).
Commercial Application: Technology would apply to commercial aircraft builds and maintenance. It anticipated that medical equipment manufacturers could also benefit.

REFERENCES:

KEYWORDS: Direct Digital Manufacturing, Machining Parameters, Additive, Microstructure

AF112-208 TITLE: Proactive Methodology for Identifying Problem Aerospace Parts

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a methodology to accurately predict/evaluate parts performance/reliability with compounding problem criteria factors for early corrective actions and acquisition of aerospace parts.

DESCRIPTION: In today’s Department of Defense (DoD) aging aircraft fleet environment, the acquisition process for replacement parts are increasing in longer lead times that result in higher acquisition costs, costly repair adjustments with shorter service life while awaiting acquisition of replacements, and longer depot flow days. DoD recognizes the need to improve acquisition processes by developing a gated processes with criteria to support improved funding, risk, and alternative options for the acquisition process. One approach is the development to better predict “Bad Actor” parts before acquisition begins. A Bad Actor is a serial-numbered item that has lower life cycle service life resulting in decreased reliability, repair processes, or field maintenance activities. The development of an analysis tool is needed with the necessary methodology that can accurately identify and rank bad actors so that System Engineering best practices can be applied for corrective action before replacement acquisition is performed. This will aid in preventing common mode failures and to more accurately rank problem components. Currently, methods for ranking failing system/component (bad actors) are based either on failures or antiquated maintenance indicators (established by the Original Equipment Manufacturer (OEM)) that if considered cumulatively could produce a projected unacceptable level of false risk. Additionally, benefits of implementing this concept can also lead to replacement of the defective part with an improved design replacement with higher service life, enhanced repair performed, or identifying the need to change the processes used in determining field inspection/repair procedures.

PHASE I: Develop concepts to provide a methodology to identify bad actors and demonstrate examples utilizing existing sample parts. Provide details for methodology and criteria developed, any processes utilized and information systems required, and the concept analytical tools produced.

PHASE II: Further develop a prototype methodology from phase I. Provide a final report that will document validated results, measured metrics and final criteria, and benefits based on demonstration of provided requirements. A final report will be provided to the government that documents the results of the Phase II demonstrations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: The improved processes would apply to all military aging aircraft components and systems where components have to periodically be replaced.
Commercial Application: Applications should apply to various commercial aging aircraft components where components have to periodically be replaced.

REFERENCES:

KEYWORDS: Product Improvement, Cost reduction

AF112-212 TITLE: Landing Gear Fatigue Inspection
OBJECTIVE: To obtain technology that has the capability of inspecting high strength steel landing gear components for fatigue damage.

DESCRIPTION: There is a critical current need for landing gear inspections that go beyond the current standard of crack identification and focus more on fatigue life or fatigue damage. Landing gear systems are designed utilizing the safe-life methodology, meaning that the system was evaluated and laboratory fatigue tested to last a statistical approximation of approximately 4 life-times with a safe operation limit of one lifetime. However, there are multiple platforms which are reaching and exceeding their designed-to-life limit. Additionally, aircraft operational weights and capacity have increased over time and metal fatigue is becoming more and more of a concern. Metal fatigue is a phenomenon resulting from cyclic stresses, these stresses being either in the elastic or plastic zone, which eventually nucleates and propagates surface cracks. Once cracks reach a critical size, sudden fracture will occur with minimal or no warning. Critical structural members of landing gear utilize low-alloy, high strength steel. For these types of high strength materials, critical crack sizes are extremely small and any cracking found must be removed, either by polishing or grinding, if cracking is still present the component is condemned. For landing gear materials, once cracking has propagated enough to allow inspection to identify its existence, it is often beyond the critical crack size limit and therefore at a high risk of failure. Current inspections center on macro aspects of fatigue in that they are only applicable during the crack propagation phase. In order to identify damage due to fatigue in landing gear components, inspection of micro effects focused on crack nucleation need be identified. One such is the existence of Persistent Slip Bands (PSB). PSB’s are a surface phenomenon due to fatigue owing to dislocation movement. The PSB’s are generated on the maximum shear plane at the 45 degree angle. These PSB’s form edges on the surface and therefore generates stress concentrations at which cracks will nucleate and eventually propagate. An inspection which measures micro fatigue effects would be utilized to remove suspect components from operation prior to failure.

PHASE I: Determine the feasibility of inspecting landing gear components for fatigue damage. The potential technology is targeted to be utilized during the repair and overhaul process.

PHASE II: The prototype device is expected to show, through laboratory testing on representative landing gear components, fatigue damage prior to cracking.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: All military platforms are expected to benefit from technology. Fatigue inspection will result in removing damaged landing gear components prior to failure.
Commercial Application: Technology will be beneficial to commercial industry by allowing components to safely extend their service life or be removed prior to receiving detrimental damage.

REFERENCES:

KEYWORDS: High Strength Steel, Micro, Macro, Inspection, Landing Gear, Critical Crack Size, Safe-Life, Low-Alloy, Nucleate, Propagate
DESCRIPTION: There is a current need to gather in-service fatigue data on landing gear components. As with other aircraft systems, landing gear has its own unique problems. It is one of the few which are not redundant and failure usually results in catastrophe. The entire structural load bearing members of landing gear utilize high strength steel and aluminum materials. These materials exhibit high fracture toughness but are brittle in nature, making them damage intolerant. This means that critical crack sizes are very small and any members which are showing cracks must be removed from service. The design of landing gear systems is that of “safe-life”. This philosophy means that the system was designed and laboratory fatigue tested to four (4) lifetimes. This ensures that all scatter inherent to fatigue and other material properties and manufacturing defects is safely taken into account. However, due to government economical decisions, USAF weapon system platforms are being required to operate up to and at times, beyond their original life limit. Due to this, landing gear structures are becoming more and more a safety risk. There are multiple weapon system platforms which utilize periodic maintenance for their respective landing gear systems. As this practice dictates, the entire landing gear is removed from the aircraft and sent to the overhaul facility for inspection and repair. Non-Destructive Inspection (NDI) techniques such as Fluorescent Magnetic Particle Inspection (FMPI) and Fluorescent Penetrate Inspection (FPI) are among the most common methods for locating and condemning landing gear parts which have irreversible damage. However, these inspection methods are limited to locating visible cracks which have already propagated beyond the materials critical size limitations. Component fatigue is a unique phenomenon which, at this time, cannot be measured or determined. The only known method of quantifying fatigue is to record in-service loads data. Since the fatigue limit is known through material properties and design, this data can be used to remove landing gear components prior to their reaching the fatigue limit and therefore reducing the safety risk of component failure.

PHASE I: Determine the feasibility of gathering load magnitude and cycles on in-service landing gear components. The potential technology is expected to be robust enough to remain on aircraft gathering data for an indeterminate amount of time.

PHASE II: The prototype device is expected to show, through laboratory testing on representative landing gear coupons, load magnitude and cycle count.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: To be used on DOD aircraft landing gear structural members.
Commercial Application: Can be utilized by commercial aircraft for determining fatigue of landing gear structural members and removing suspect components prior to failure.

REFERENCES:

KEYWORDS: Fatigue, Steel, Aluminum, High Strength. Damage Intolerant, Safe Life
well-established processes and procedures with conventional Aluminum Oxide grinding wheels. EHC also provides a good sealing surface for hydraulic fluid as well as nitrogen. Due to its widely accepted use and long history, there exists a large plating base with highly experienced and skilled personnel. Numerous landing gear components such as axles, pins, pistons and cylinder bores have benefited from the EHC process. However, there is a down side to using EHC. One such is that the process induces hydrogen into the component substrate which, if not baked out properly, will cause operational failure. Due to High Strength Steel (HSS) usage in landing gear components, hydrogen embrittling is always a concern. Additionally, EHC is now targeted for replacement due to its environmental and health hazard risks. The Under Secretary of Defense has directed all DOD Military Departments to invest in appropriate research and development on substitutes and approve the use of alternatives where they can perform adequately for the intended application. In the late 90’s, a Hard Chrome Alternatives Team (HCAT) was assembled which consisted of DOD and Industry representatives. Through testing and evaluation, HCAT developed/qualified the High Velocity Oxygen Fuel (HVOF) process as an alternative to EHC. It was proven that thermal sprayed coatings applied through the use of HVOF were as good as or better than EHC. The HVOF process is used typically to provide coatings of lower porosity and higher adhesive/cohesive strength than generally attainable with conventional plasma spray. This process is particularly suited for applications requiring wear, heat and corrosion resistance or dimensional restoration that traditionally utilized EHC. An additional benefit is that no hydrogen is introduced into the component and therefore no post-baking operation is required and the risk of hydrogen embrittling failure is removed. For this reason, the USAF is currently executing a large scale, multi-year effort implementing HVOF thermal spray coatings on HSS landing gear line of sight applications. However, landing gear components are still required to utilize EHC on non-line of sight areas and is in need of technology which will replace EHC for this application.

PHASE I: Determine the feasibility of applying non-line of sight coatings to landing gear bores. Results of Phase I are expected to show positive feasibility of applying coatings to non-line of sight applications on High Strength Steel (HSS) substrate materials.

PHASE II: Demonstrate and validate Phase I effort on coupons simulating landing gear components. Testing will include corrosion, coating hardness, fatigue debit, coating microstructure, bend, coating bond strength and coating integrity.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: To be used on DOD military aircraft landing gear bores.
Commercial Application: There is a possible use on civilian cargo and passenger aircraft landing gear components. Industrial uses also include sealing surfaces.

REFERENCES:
1. 200310641-Coatings, Tungsten Carbide on High Strength Steel High Velocity Oxygen/Fuel Process.
2. 200925098-Qualification Requirements for High Velocity Oxygen Fuel WC-Co, WC-Co-Cr Coatings on High Strength Steel Substrates (>180 KSI) Landing Gear Components.

KEYWORDS: High Strength Steel (HSS), High Velocity Oxygen Fuel (HVOF), Electrolytic Hard Chrome Plate (EHC), Non-Line of Sight, Line of Sight, Hard Chrome Alternatives Team (HCAT)
OBJECTIVE: Develop synergistic corrosion-resistant coatings aimed at mitigating the destructive effect of oxygen. Oxygen is the primary element which causes deterioration of organic materials.

DESCRIPTION: The protection of metallic surfaces from degradation caused by corrosion and other mechanisms is an ongoing effort critical to both civilian and military applications. Many technical articles are available detailing the transformational process of hydrocarbons (C-H) when exposed to thermal, chemical, biological and electrochemical stimuli; to a combination of fluoro and perfluoroalkyl groups. [1] This degradation can be slowed by incorporating metal centers to tune the frontier molecular orbitals in such a way, that the molecules no longer lose their outer shell electrons. [2] Furthermore, the tuning process simultaneously creates the ability to transfer waste solar energy to molecular oxygen in the surrounding air to generate reactive singlet oxygen. [3] This property, in combination with (i) the capability to resist the reactive oxygen generated, (ii) the proven ability to form insulating films, [4], and (iii) exhibit hydrophobicity that in can exceed that of polytetrafluoro ethylene, renders the new molecules candidates for robust, self-cleaning, corrosion protective coatings and coating components.

The desired solution space should exhibit: (i) a low-energy surface with a hydrophobicity approaching that of a water-repelling lotus leaf, imparted by perfluoroalkyl groups; (ii) an encapsulated metal center that regulates the electronic properties of the surface such that electrons can no longer be lost under corrosion-relevant conditions; (iii) a total absence of C-H bonds, thus the elimination of all chemical pathways leading to oxidative destruction of the surface; (iv) a high thermal stability under a variety of conditions; (v) the ability to photo-generate very reactive singlet oxygen from air, imparting a self-cleaning feature to the surface while avoiding its own degradation.

PHASE I: Conceptualize and design a class of organic molecules that exhibit corrosion resistance coating systems for Aerospace and Infrastructure applications.

PHASE II: Develop a prototype for submitting the newly developed corrosion resistant coating system for aerospace and military applications.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Finalize the advanced corrosion resistant coating system for implementation with DoD end customer for wide scale fielding.
Commercial Application: Identify systems/facilities that share a basic similar configuration, components and operating conditions, where such advanced corrosion resistant coatings technologies may be applicable.

REFERENCES:

KEYWORDS: Corrosion resistant, Hydrophobicity
OBJECTIVE: Establish measurement systems and improved methods for evaluating the performance of coatings and alloy combinations in accelerated corrosion tests simulating and operational environment.

DESCRIPTION: Corrosion related maintenance and repair of aircraft is a significant cost to the Air Force and adversely impacts safety and readiness. Selection and use of corrosion control materials for aircraft are based on environmental compliance and performance characteristics. In part, qualification of coatings is based on accelerated laboratory testing of flat painted panels with artificial defects (e.g. scribe). Flat panel test coupons do not subject the coating system and alloy to failure processes that may be of greatest significance in actual service environments, where galvanic couples, crevices or mechanical stresses may cause coating system breakdown and alloy corrosion. Corrosion and environmental resistance property tests, such as ASTM B117 salt spray, may yield results of no blistering nor scribe pitting after 2000 hours of exposure. These types of pass/fail results make comparative performance development studies difficult, provide little information on failure processes and progression, and only support the selection of materials that meet requirements, as opposed to the best material. Although advances have been made in the development of more representative accelerated corrosion test cycles over past decades (GM 9540P, ASTM G85, SAE J2334), test panel design and performance measurements have not substantially changed. There is a need to improve coatings and materials corrosion testing by leveraging advances in sensing and instrumentation to obtain high fidelity data on corrosion performance and degradation processes.

Improved testing and measurement systems will facilitate materials development, failure mechanism analysis and materials screening and characterization to reduce corrosion of aircraft structures. There is a critical need for improved accelerated laboratory and operational environment condition testing to more rapidly and accurately screen new materials and material combinations for use in military systems. Accelerated test methods would benefit from smart test coupons that can record the environmental exposure conditions for a given test, and assess, in situ, the amount of corrosion and state of the materials being tested. Also, an active smart coupon could provide dynamic measurements to track coating barrier properties and inhibitor effectiveness, as well as changes in mechanical properties and load bearing capacity of alloy or composite structural materials. A smart test coupon may induce mechanical loads to more realistically evaluate material service performance. A smart test coupon must be low cost, easy to assemble and prepare within a laboratory environment, and be durable enough to survive harsh environment testing. Finally, the capacity for real time data acquisition via wired or wireless interfaces in accelerated laboratory or operational environment condition tests is sought to provide on-demand automated recording of test conditions and results. Continuous data acquisition would enabling users to track test results and determine test coupon damage state at any point during a test cycle to aid in material comparisons.

PHASE I: Develop preliminary design for a smart test coupon system capable of measuring a range of corrosion damage modes associated with coated aircraft structures. Fabricate and assemble a breadboard prototype device and demonstrate the feasibility of detecting corrosion properties of coatings and alloys.

PHASE II: Finalize prototype system development and deliver a set of smart test coupons, wired and wireless interface devices, a data acquisition system, processing algorithms for property quantification, data storage and a user interface to demonstrate system performance in long-term accelerated corrosion tests and operational environment conditions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Accelerated corrosion testing technology would support rapid development, product improvement and qualification of high performance, environmentally compliant coatings for military applications.
Commercial Application: Smart test coupon technology would support the rapid development, product improvement and qualification of high performance, environmentally compliant coatings for commercial applications.

REFERENCES:
http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA515424

AF112-219  TITLE: Solar and Waste Heat Powered Environmental Control for Buildings

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop a heating and cooling system for buildings that utilizes solar heat to maintain the building environment.

DESCRIPTION: The Air Force is looking for ways to reduce its dependence on fossil fuels and electricity use. This goal is driven by economic, environmental and security reasons. A significant amount of fossil fuel is spent each year providing a livable, conditioned environment in Air Force Facilities. A large amount of fossil fuel use could be eliminated if the energy needed for environmental conditioning came from solar or waste heat. Reduction in fossil fuel use would assist the Air Force in reaching its goals and mandates to provide sustainable or environmental friendly buildings and support its goal to reach the highest ratings in the Leadership in Energy and Environmental Design (LEED) program.

Solar powered absorption cycle refrigeration or cooling units have been studied and demonstrated as a viable air conditioning method. By combining solar heating and cooling technologies, a Heating, Ventilation and Air Conditioning (HVAC) System could be developed that would significantly reduce the fossil fuel needs for many facilities. Solar based systems are most suitable in climates that have a high degree of unobstructed sunlight. However, by selecting backup systems carefully or even making use of available sources of waste heat, the utilization of solar based systems could be extended to more variable climates while still significantly reducing the use of fossil fuel based energy sources.

The Air Force is seeking novel and creative designs matching solar collector and refrigeration technologies along with supplemental or back-up options to provide HVAC units that require significantly less electricity than the current systems. It is highly desirable that these systems be modularized and standardized to reduce the need for providing each facility with a specialized and unique system and yet still be available in a wide range of sizes to accommodate the wide range of facilities in Air Force inventory. The systems will also need to utilize technologies that are environmentally friendly, recyclable, and suitable for non-hazardous disposal.

PHASE I: Demonstrate via design and calculations, a workable design concept for a solar powered and/or waste heat HVAC system as described for a typical administrative facility at Robins AFB. System energy savings shall be sufficient to pay for any additional cost over the cost of a similar conventional system in 10 years or less.

PHASE II: Demonstrate a prototype system for one year to demonstrate adequate heating in the winter and cooling in the summer. The energy usage and function of the prototype system shall be compared to a similar installation of a conventional system under similar conditions.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: This technology has the potential for application in portable and deployable systems.

Commercial Application: Packaged systems of this type could be used in residential, commercial and industrial facilities for nationwide energy savings.
REFERENCES:


KEYWORDS: solar, cooling, HVAC, air conditioning, absorption cycle, refrigeration, waste heat, sustainable building

AF112C-117 TITLE: Advanced Noncontact Inspection for Rapid Measurement of Machined Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Establish pilot manufacturing capability for a high throughput, noncontact measurement system for inspection of machined detail parts and assemblies.

DESCRIPTION: Advanced fighter aircraft designs mandate extremely meticulous control of machined component/assembly tolerances as close to the as-designed condition as possible in order to maintain aggressive performance/signature requirements. In current DoD fighter industry practice, a time-consuming touch probe process is utilized to inspect large detail parts and structures after machining. Touch probes are attached to costly coordinate measuring machines or precision milling machines and utilized as a secondary inspection process, preventing these capital assets from performing higher value processing. The defense aircraft production industry requires innovative solutions to allow for rapid, accurate measurement and analysis of large tools, parts, and assemblies in order to sustain anticipated full-rate production volumes. It is anticipated that successful implementation of these solutions can reduce measurement and analysis cycle times by as much as 50 percent, thereby enabling maximum production rates of one aircraft ship set per day.

The focus of this effort is to establish an initial production capability to rapidly measure and evaluate large tools, parts, and assemblies to rigorous tolerance engineering requirements utilizing a noncontact method. The application requires developing and validating a noncontact measurement system to affordably and accurately measure parts. The use of inline verification and rapid analysis from production to final acceptance will enhance productivity. Special consideration will be given to solutions that innovatively leverage and integrate commercial-off-the-shelf components with new technologies to realize the desired capability. The rate, process control, quality, repeatability, and reliability will be critical elements for demonstration. Additionally, any system developed must be able to rapidly acquire part data and integrate these data with end user legacy analysis software and databases.

The noncontact measurement system should be capable of measuring a minimum volume of approximately 16.5 ft L x 10 ft W x 6 ft T with scaling ability for future applications. Parts may consist of a variety of materials, including composite (carbon/epoxy, carbon/bismaleimide (BMI), glass/epoxy, fiberglass/BMI, Kapton, etc.), metallic (aluminum, invar, and steel), and moldable plastic shim. The system should be capable of measuring features such as surface profile, chamfer profile, edge profile, hole position, and hole diameter. These features will be measured in pockets, radius, faces, tapers, and seal grooves. The system should be capable of measuring with a threshold accuracy of +/-0.002 inch and a goal accuracy of +/-0.001 inch. The current baseline for inspection is 1.5 to 3 hours per part, but the desire is for the measurement time not to exceed 15 minutes per part.
At a minimum, the final system should consist of the following elements: (1) a measurement system capable of collecting high-fidelity 3-D geometric data suitable to allow for high-confidence comparison of as-machined to as-designed components/assemblies; (2) a permanently mounted system for quick deployment and switch over from part to part; (3) common software interfaces to integrate with existing end-user analysis and database software such as CATIA and Infinity QS; and (4) a user-friendly interface to expedite measurement and provide interactive guidance to the user.

PHASE I: Demonstrate feasibility of a noncontact measurement system to measure affordably and accurately machined detail part features and as-built aircraft assemblies as described. Teaming is encouraged. It is preferred that Manufacturing Readiness Level (MRL) 4 is achieved at completion.

PHASE II: Develop and demonstrate (to MRL 7) an integrated noncontact metrology system suitable for initial production capability with manufacturing improvements identified in Phase I. Conduct capability demonstration for incoming parts/assemblies and document. Full system architecture is to be submitted in detail with operator interface concepts and verification/integration plans.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Low-cost and high-resolution measurement and analysis of advanced military aircraft.
Commercial Application: Low-cost, high-speed, and high-resolution measurement and analysis of commercial aircraft, automotive components, and medical components; any high-tolerance machining measurement application.

REFERENCES:

KEYWORDS: measurement system, metrology, noncontact inspection, noncontact measurement system, noncontact metrology system

TITLE: High temperature electro-magnetic actuators (HTEMA)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and validate high temperature electro-magnetic actuators (HTEMA)

DESCRIPTION: Engine nozzle actuation is presently accomplished using fuel as a working medium for current fifth generation fighters. Nozzle actuation has a low duty cycle, but the heat generated is a continuous, and significant, load on the aircraft/engine thermal management system. An electrically driven actuator could reduce the heat load of the aircraft, because the engine and aircraft fuel systems are highly intertwined, thereby reducing the thermal management limitations. Recent studies have identified component technology challenges and solutions related to the development of an electro-mechanical actuator that can operate and meet the requirements for the fifth generation fighter engine nozzle actuation.

Two actuation configurations stand out as critical applications:
(i) The Three Bearing Swivel Duct (3BSD) motors provide the power to position and control the engine nozzle for vertical take-off and landing of the military engine STOVL variant.
(ii) The Convergent Nozzle Actuation System (CNAS) provides the power to position the nozzle as required for the pilot selected engine Power Level Angle (PLA).
The CNAS actuators are mounted to the aft end of the 3BSD (the current housing material for the CNAS and the 3BSD is Titanium. The offeror may want to recommend a housing material, which is more cost-effective). Current fuel hydraulic actuators for the 3BSD and CNAS are limited by the fluid “O”-ring material (May want to explore other materials for the O-ring) and fluid temperature limits. The fluid temperature limit approaches 325 °F. The seal temperature limits approach 400 °F. The current engine actuators are able to operate in a harsh temperature environment approaching 325 °F continually and up to 560 °F for transients of 10 seconds by using the operating fluid as a means of cooling. The military jet STOVL variant actuators are unique in that they have to meet extreme high temperature requirements but also must meet strict packaging limitations. The STOVL variant is capable of vertical take-off and thus weight is critical. Following close behind is volume. The engine CNAS and 3BSD actuators are located on the swivel duct and must move with the duct during STOVL operation. CNAS actuators have a linear stroke of 4 inches, a combined stall load (for 4 actuators) or 42000 lbf, and weigh about 52 lbm (actuation system hardware including routing). Envelope requirements are 11” long by 2.5” high by x 6.5” wide. The power type is 270 Vdc. 3BSD actuators use the same power but are rotary actuators with a stroke of up to 62 inches. The max stall load per actuator is 11000 lbf and the weight is about 100 lbm. They have to be packaged in a volume of 22” wide by 20” long by 9” high.

PHASE I: HTEMA feasibility demonstration and analysis. The offeror should be able to demonstrate the HTEMA for engine application must meet stringent design requirements to be able to used with the engine harsh environment as well aircraft requirements.

PHASE II: Demonstrate the capability of the prototype system under simulated laboratory conditions. Develop rig test, validate/verify a prototype system including software/algorithms, capability and performance characteristics/specifications within reasonable cost (development / maintenance). A detailed cost analysis must be performed to be able to transition this technology to the warfighter needs.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Potential military applications include development and legacy systems. Present and future military engine applications requiring actuators with high temp capabilities located inside/outside engine. Commercial Application: Commercial aircraft gas turbine engine will benefit from higher temperature capabilities as technology developed is adapted to actuation devices located in hot areas at the rear of engine nacelle.

REFERENCES:


3. Electromagnetic Actuators – Current Developments and examples


KEYWORDS: high temperature Electro-magnetic Actuators, Magnetic device characterization, design, and modeling, Thermo-electromagnetic and other devices, reluctance actuator, permanent magnet, high temperature, electromagnetic actuator; fuzzy control; dynamic behavior.