AIR FORCE
12.B SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
PROPOSAL PREPARATION INSTRUCTIONS

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

The responsibility for the implementation and management of the Air Force Small Business Technology Transfer (STTR) Program is with the Air Force Research Lab, Wright-Patterson Air Force Base, Ohio. The Air Force STTR Program Manager is Mr. Augustine Vu, (800) 222-0336. The Air Force Office of Scientific Research (AFOSR) is responsible for scientific oversight and program execution of Air Force STTRs.

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For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm ET). For technical questions about the Topics during the pre-solicitation period (26 July through 26 August 2012), contact the Topic Authors listed for each Topic on the website. For information on obtaining answers to your technical questions during the formal solicitation period (27 August through 26 September 2012), go to http://www.dodsbir.net/sitis.

For additional information regarding the SBIR/STTR Programs, a Defense Acquisition University (DAU) Continuous Learning Module, FAC010, entitled "Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)", may be accessed (subject to availability) at https://learn.dau.mil/html/clc/Clc1.jsp?cl. It is recommended that those taking the course register as "General Public" and select "only browse the module not getting credit". Site performance is enhanced by utilizing Internet Explorer. General information related to the AF Small Business Program can be found at the AF Small Business website, http://www.airforcesmallbiz.org. The site contains information related to contracting opportunities within the AF, as well as business information, and upcoming outreach/conference events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers, www.aptac-us.org/new/Govt_Contracting/index.php. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

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

Phase I period of performance is typically nine (9) months, not to exceed $150,000.

Phase II period of performance is typically two (2) years, with an initial value of $750,000.

The solicitation closing dates and times are firm.

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. 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. The last three months of the nine-month Phase I contract will provide project continuity for all Phase II award winners (see "Phase II Proposal Submissions" below); no modification to the Phase I contract should be necessary.

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, 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 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).

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

Voluntary Protection Program (VPP): VPP promotes effective worksite-based safety and health. In the VPP, management, labor, and the Occupational Safety and Health Agency (OSHA) establish cooperative relationships at workplaces that have implemented a comprehensive safety and health management system. Approval into the VPP is OSHA's official recognition of the outstanding efforts of employers and employees who have achieved exemplary occupational safety and health. An "Applicable Contractor" under the VPP is defined as a construction or services contractor with employees working at least 1,000 hours at the site in any calendar quarter within the last 12 months that is NOT directly supervised by the applicant (installation). The definition flows down to affected subcontractors. Applicable contractors will be required to submit Days Away, Restricted, and Transfer (DART) and Total Case Incident (TCIR) rates for the past three years as part of the proposal. Pages associated with this information will NOT contribute to the overall technical proposal page count. NOTE: If award of your firm's proposal does NOT create a situation wherein performance on one Government installation will exceed 1,000 hours in one calendar quarter, **SUBMISSION OF TCIR/DART DATA IS NOT REQUIRED**.

COMMERCIAL POTENTIAL EVIDENCE

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing STTR or other research, particularly as reflected in its Company Commercialization Report http://www.dodsbir.net/submission; 2) the existence of second phase funding commitments from private sector or non-STTR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

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-i) 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-i below) on how funds will be used if the contract is awarded. The on-line Cost Proposal and Itemized Cost Proposal Information (a-i) 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-i) information.

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

b. 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 cost share contracts or portions of contracts do not allow fee. NOTE: Subcontract arrangements involving provision of Independent Research and Development (IR&D) 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 a research institution is required in the project. Involvement of other subcontractors or consultants may also be desired. Describe in detail the tasks to be performed in the Technical Proposal and include information in the Cost Proposal for the research institution and any other subcontractors/consultants. The proposed total of all consultant fees, facility leases or usage fees, and other subcontract or purchase agreements may not exceed 60 percent of the total contract price or cost, unless otherwise approved in writing by the Contracting Officer. The STTR offeror’s involvement must equate to not less than 40 percent of the overall effort and the research institutions must equate to not less than 30 percent.

NOTE: The Small Business Administration has issued the following guidance: “Agencies participating in the STTR 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 3.5 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. DD Form 2345: For proposals submitted under ITAR-restricted topics, a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, http://www.dlis.dla.mil/jcp/.

PHASE I PROPOSAL SUBMISSION CHECKLIST

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

1) The Air Force Phase I proposal shall be a nine-month effort and the cost shall not exceed $150,000.

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

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

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

It is mandatory the complete proposal submission -- DoD Proposal Cover Sheet, Technical Proposal with any appendices, Cost Proposal, Cost Proposal Itemized Listing (a-i), 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, 26 September 2012**, **deadline.** A hardcopy **will not** be accepted.

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without discussions (except clarifications as described in FAR 15.306(a)). Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. 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 solicitation close 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 ensure your e-mail address listed in your proposal is current and accurate. By early October, you will receive an e-mail serving as our acknowledgement 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 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 where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror. The Air Force anticipates pricing will be based on adequate price competition. The next tie-breaker on essentially equal proposals will be the inclusion of manufacturing technology considerations.

The Air Force will utilize the Phase I evaluation criteria in Section 4.2 of the DoD solicitation in descending order of importance with technical merit being most important, followed by the qualifications of the principal investigator (and team), and followed by Commercialization Plan. The Air Force will use the Phase II evaluation criteria in Section 4.3 of the DoD solicitation with technical merit being most important, followed by the Commercialization Plan, and then qualifications of the principal investigator (and team).

PROPOSAL/AWARD INQUIRIES

We anticipate completion of proposal evaluation and Phase I contract award selection within approximately four months after proposal receipt. All questions concerning the evaluation and selection process should be directed to the Air Force Office of Scientific Research (AFOSR).

ON-LINE PROPOSAL STATUS AND DEBRIEFINGS

The AF has implemented on-line proposal status updates for small businesses submitting proposals against AF topics. At the close of the Phase I Solicitation – and following the submission of a Phase II via the DoD SBIR/STTR Submission Site (https://www.dodsbir.net/submission) – small business can track the progress of their proposal submission by logging into the Small Business Area of the AF SBIR/STTR site (http://www.afsbirsttr.com). The Small Business Area (http://www.afsbirsttr.com/Firm/login.aspx) is password protected and firms can view their information only.

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

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

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

PHASE II PROPOSAL SUBMISSIONS: Phase II is the demonstration of the technology found feasible in Phase I. Only those Phase I awardees that are **invited** to submit Phase II proposals , as well as all FAST TRACK applicants. Phase I awardees can verify selection for receipt of a Phase II invitation letter by logging into the "Small business Area" at http://www.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 STTR Program Manager, as found in the Phase I selection notification letter, for resolution. Please note that it is solely the responsibility of the Phase I awardee to contact this individual. There will be no further attempts on the part of the Air Force to solicit a Phase II proposal. The Phase I award winners must accomplish the majority of their primary research during the first six months of the contract. Each Air Force organization may request Phase II proposals prior to the completion of the first six months of the contract based upon an evaluation of the contractor's technical progress and reviewed by the Air Force technical point of contact utilizing the criteria in Section 4.3 of the DoD solicitation The awarding Air Force organization will send detailed Phase II proposal instructions to the appropriate small businesses. Phase II efforts are typically two (2) years in duration with an initial value of $750,000. (NOTE) All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system**. Get your DCAA accounting system in place prior to the AF Phase II award time frame. 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, Itemized Cost Proposal Information, 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, and the additional 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 this single file includes your complete Technical Proposal and the additional Cost Proposal information.) The preferred format for submission of proposals is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. **Please virus-check your submissions**.

FAST TRACK

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

NOTE:

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

For FAST TRACK applicants, should the outside funding not be available by the awarding Air Force organization's designated time, the offeror will not be considered for any Phase II award. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including FAST TRACK applicants.

PHASE II ENHANCEMENT POLICY

The Air Force currently does not participate in the DoD Enhancement Program.

SUBMISSION OF FINAL REPORTS

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

AIR FORCE STTR PROGRAM MANAGEMENT IMPROVEMENTS

The Air Force reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees that are invited to submit Phase II proposals will be notified. The Air Force also reserves the right to change any administrative procedures at any time that will improve management of the Air Force STTR Program.

Air Force STTR 12.B Topic Index

Air Force STTR 12.B Topic Descriptions

AF12-BT01 TITLE: Statistically Defensible Comparison of Similar But Disparate Tests

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop reliable methods for making statistically valid conclusions from test data sets that do not lend themselves to traditional statistical techniques.

DESCRIPTION: There are times when it is necessary to compare functional performance between subsystems where the base platform is not identical. A common form of this is when a subsystem upgrade is tested many years after testing of the original subsystem was performed. In such a case, the objective is to demonstrate that the new subsystem is at least as good as the old. Although the follow-on test for the new subsystem is likely to be tested on a vehicle of the same type and model (a similar vehicle), it is often not feasible (or not possible) to configure the base platform so as to duplicate all parameters affecting the particular subsystem under test (thus requiring a disparate vehicle). Further, even when performing an isolated sequence of tests there are statistically unfriendly aspects of the data. For example, the data may have significant non-linearities or the data cannot be correlated directly (particularly in time). Logistical difficulties do not allow tests to be randomized. For example, tests are often performed on vehicles that are part of the test fleet, whereas the fundamental question is how new subsystems perform on vehicles that are part of the operational fleet. Standard techniques do not allow for extrapolating test conclusions from one subset of vehicles to the other.

Contributions are sought to significantly advance the theoretical foundations of comparing data sets from similar tests that have disparate data parameters and for extrapolating conclusions from tests on a subset of test articles to other subsets.

Potential topics for consideration include, but are not limited to, the following:

- Statistical theory to allow comparison and extrapolation of data sets as described above.
- Algorithmic or computational methods for analysis of such data sets
- Methods for designing tests taking into consideration logistical constraints, existing related data sets, knowledge of various test article subsets, and known test objectives.
- Development of tools for implementing the statistical theory and associated methods.
- Methods for mining data sets for the information needed to validate these theories and methods.

PHASE I: Identify foundational theories and associated methods for comparing disparate but similar data sets and for extrapolating conclusions from tests on a subset of test articles to other subsets. Establish the types of conclusions that can be drawn using these methods and associated measures of validity. Mature specific theories and identify methods to be developed into tools for test analysis.

PHASE II: Mature the theoretical foundations identified in Phase 1 and develop specific reliable methods and processes based on this theory. Develop tools that implement the methods and allow for test design based on these methods and appropriate knowledge about the test assets and objectives. Develop tools to help automate data set analysis based on these methods and demonstrate their uses. Provide statistical documentation as to the degree to which derived conclusions are valid.

PHASE III: Integrate developed tools and methods into DoD test centers. Generalize tools for other applications, both military and commercial. Generalized tools should be useful to testing of commercial aircraft, other vehicles, medical and scientific devices, software systems, and other complex systems.

REFERENCES:
1. Bjorkman, E. A., & Brownlow, J. (2011). Statistically Defensible Test and Evaluation: The Air Force Flight Test Center Perspective. International Test and Evaluation Association Journal, 32(3), 261-266, Sept. 2011.

2. Deaconu, S., & Coleman, H. W. (2000). Limitations of Statistical Design of Experiments Approaches in Engineering Testing. Journal of Fluids Engineering, 122(2).

3. Gallagher, M. A, Weir, J. D., & True, W. D. (1997). Relating Weapon System Test Sizes to Warfighting Capability. Military Operations Research, 3(3).

4. Hahn, G. J., & Meeker, W.Q. (1993). Assumptions for Statistical Inference. The American Statistician, 47(1).

KEYWORDS: Statistical methods, sparse estimation, disparate test data

AF12-BT02 TITLE: Low Level Signal Detection for Passive Electro-Optical Space-based Surveillance

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Conceive and develop methods and techniques for optimizing signal detection and noise reduction for passive Signature Exploitation of lambertian scattered light modulated by vibrating surfaces with intended application from space.

DESCRIPTION: Achieving space-based surveillance requires detecting not only with a limited number of photons but also with potentially small fractional modulation detectable from orbit, including geosynchronous. Present understanding requires direct coupled sensors within a reasonable cost, and detection of small fractional photon modulation levels requires sensitive detectors with minimal added detector noise, which can severely limit detection. This requires a detailed understanding of the physics of the detected signal on orbit and the small modulation of the detected signal contained therein, while simultaneously minimizing all noise sources, especially in the first few stages of signal amplification. Metadata such as sensor calibration information, sensor characteristics, sensor geometry corresponding to each data collection, and so forth, are relevant to the observational description. As modulation information from sources with small fractional modulation is sought, the detection physics becomes increasingly relevant.

The Air Force Research Laboratory has a limited information database on these issues, and needs a more complete understanding of how to proceed.

This STTR topic solicits innovative approaches for optimizing this type of detector for orbits from LEO to GEO for lambertian scattered light with small fractional modulation, and especially for minimizing sources of noise.

PHASE I: The contractor shall define, model, and design innovative methods and techniques for optimizing signal detection and noise reduction for passive Signature Exploitation of Lambertian scattered light modulated by vibrating surfaces with intended application from space, but with other applications Air Force wide.

PHASE II: In Phase II of this STTR effort, the contractor will design, verify, construct, test, and demonstrate a prototype detector to collect and assemble various types of satellite relevant data. The contractor shall implement or simulate a prototype sensor design that shall improve substantially on current state of the art detection.

PHASE III: This technology can remotely monitor ground and surface vibrations from a distance, with a goal of detection from space, autonomous robotic vehicles, unpiloted aerial vehicles, and objects or vehicles that are well-characterized prior to use.

REFERENCES:
1. Pereira, W., Clark, F., Jeong, L., Noyes, B., Noah, P., Pacleb, C., Dalrymple, S., Westphal, A., Hypertemporal Imaging Diffuse Modulation (HTI-DM) Experiment, AFRL-RV-HA-TR-2011-1010, 28 February 2011.

2. Hay, J.R., Kielkopf, J.F., Clark, F.O., Non-Contact Stand-off Optical Sensing of Cable Vibrations for Monitoring Structural Health of the William H. Harsah Bridge, CSX Eastern Parkway Overpass, and The Sherman-Minton

Ohio River Bridge at Louisville, KY, Proceedings of the 15th International Conference on Experimental Mechanics (ICEM15) (Porto, Portugal) July 2012.

KEYWORDS: small signal detection, Lambertian, reduced noise, detection from space

AF12-BT03 TITLE: Biologically-inspired integrated vision systems

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Human-engineered imaging sensors are anthropomorphic and in some respects very limited in capability. Develop an advanced imaging sensor concept that samples all of the information in the radiation field, taking inspiration from biological systems.

DESCRIPTION: Develop advanced imaging sensors specifically designed to utilize most if not all of the information in the light field (spectral, temporal, polarization, detailed object shape) for applications enabling autonomous behavior, including egomotion determination, to aid in navigation; as well as target detection, recognition, ranging and tracking. Develop an integrated design that will include information processing at a fundamentally integrated level with the optics and transduction. Take inspiration from biological systems which are designed this way. Arthropods (insects, crustacea, and arachnids) have developed a variety of systems to exploit the information in the radiation field that are worth consideration.

Egomotion determination involves local motion detection which enables global motion detection (optic flow).

Target detection involves target-background discrimination which would involve motion detection for moving targets but could also involve spectral, shape, and polarization discrimination. Camouflage-breaking techniques are particularly interesting for static targets.

Direction sensing relative to the celestial polarization pattern is fairly well understood in insects, using the ommatidia in the Dorsal Rim Area of the compound eye.

Wide field of view (at least pi steradians) systems and ability to conform to shapes with smooth contours, such as airframes, would be especially valuable considerations.

PHASE I: Develop a design for a prototype system; analyze the design to demonstrate functionality and feasibility.

PHASE II: Produce a deliverable functional prototype with preliminary contractor testing, amenable to further in-depth testing by the sponsor.

PHASE III:
Commercial applications include surveillance sensors, and sensors for search and rescue. Military applications include ISR sensors and sensors for autonomous vehicles.

REFERENCES:
1. M.F. Land and D.E. Nilsson, Animal Eyes, Oxford, 2002.

2. E. Warrant and D.E. Nilsson, Invertebrate Vision, Cambridge, 2006.

3. F. G. Barth, J. A. C. Humphrey, T. W. Secomb, sensors and sensing in biology and engineering, Springer, 2003.

4. Harland, D. P. and R. R. Jackson (2004). "Portia Perceptions: The Umwelt of an Araneophagic Jumping Spider." in Complex Worlds from Simpler Nervous Systems. F. R. Prete. Cambridge MA, Bradford, MIT Press.

5. Chiou, T.H., S. Kleinlogel, et al. (2008). "Circular Polarization Vision in a Stomatopod Crustacean." Current Biology 18: 429-434.

6. Homberg, U., S. Heinze, et al. (2011). "Central neural coding of sky polarization in insects " Philosophical Transactions of the Royal Society of London B 366 (Theme Issue ‘New directions in biological research on polarized light’): 680-687.

KEYWORDS: arthropod vision, wide field of view sensing, integrated optical systems, compound eye

AF12-BT04 TITLE: Ultra-High-Performance Concrete

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop ultra high performance concrete (UHPC) materials and processes needed to produce large, high-strength test structures.

DESCRIPTION: Concrete materials science has experienced a revolutionary advance in terms of the aggregates, matrix, bonding agents, accelerators, plasticizers, and other additives employed to produce high-strength forms and structures capable of withstanding harsh and sometimes extreme environmental conditions. With these new formulations and techniques, compressive strengths exceeding 15,000 psi are realized and strengths in excess of 40,000 psi have been reported. Nanotechnology applications are also an active area of UHPC research and they could result in additional improvements in strength and crack resistance.

While the Air Force is interested in UHPC for buildings, command centers, and runways, the role that UHPC might play in protecting potential adversaries and their installations must also be considered. The Air Force’s capability to ground test against realistic targets at our test centers needs to keep pace with UHPC development. We are looking for UHPC formulations and methods that can be readily implemented at our test centers. Although high strength and impact resistance are of primary concern, the ability to use materials that are readily available in the region of test activity is also an important concern.

PHASE I: Identify UHPC materials, techniques, and capabilities suitable for use at Air Force test centers. Demonstrate laboratory scale fabrication of test articles with compressive strengths in excess of 30,000 psi. Develop a plan that identifies the hardware, processes, and materials required to construct full size test structures at test centers using local materials.

PHASE II: Increase demonstration unit scale sizes and evaluate construction processes. Cylinder and/or core load test scaled and full size units to demonstrate that the desired strength has been obtained. Develop requirements identified in small scale unit testing to allow proceeding to construction of 22’x22’x4’ full scale unit.

PHASE III: Construct full scale test structures with the desired strength at Air Force test centers. Formulations and techniques developed will have broad commercial application in the construction industry.

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KEYWORDS: Ultra High Performance Concrete (UHPC), concrete bunker, concrete construction, high compressive strength

AF12-BT05 TITLE: Real-time Location of Targets in Cluttered Environments

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To develop a process for real-time radar location of targets in cluttered environments, specifically air traffic targets in environments complicated by complex natural (e.g., hills and valleys) and manmade (e.g., wind turbines) features.

DESCRIPTION: Our nation is developing a diverse range of renewable energy projects. Some of these energy production sites are located near existing military bases or military test ranges. Furthermore, it has been observed that operation of these energy production sites can confound military equipment or otherwise negatively impact training or operational readiness. A prime example is the impact of interference to air traffic radar operation caused by the reflection of the air traffic radar signal from rotating wind turbine blades. Two broad classes of error can occur: one is false positives or targets which are produced by the scatter of radar signals from rotating blades and can be misinterpreted by radar systems as weather or aircraft; the other is false negatives or dropped targets which corresponds to a loss of radar signal strength and can cause the masking of actual air traffic radar returns. Note that the engineering standard for probability of target detection is 80%. Additional complications arise because of static clutter (examples of which are terrain and topography features, wind turbine masts, etc.) and dynamic clutter (examples of which are the spinning blades attached to these wind turbine masts together with the extra complication of slight vibrations, various rotation speeds, and orientation changes exhibited by the spinning blades). A first step in addressing this problem is to characterize and define the clutter. The second step would be to be able to extract information and signals from the radar reflections provided by moving targets in the clutter environment. To this end a modeling and simulation undertaking wherein the Maxwell's equations are solved for the scattering (from moving objects with correct Doppler shifts) of various radar signals is solicited. This undertaking should include careful error analysis of the numerical approach so that a third broad class of error in addition to the two mentioned above isn't introduced. Because the target could be masked during its track by terrain or wind turbines, both line-of-sight and non-line-of-sight methods are appropriate where it is to be understood that the latter is a source of multipathing.

PHASE I: Efforts should concentrate on the development of a mathematical construct for the characterization of the clutter environment. Fixed features will result in static clutter terms, but the construct should account for dynamic (e.g., spinning turbine) terms. Some consideration for inclusion of moving targets would be useful.

PHASE II: Efforts should expand the methodology of Phase I to address the detection of targets in the clutter field. This should account for targets within appropriate ranges of altitude, speed, and track trajectories. The probability of detection as demonstrated by simulation or actual flights should exceed the 80% standard.

PHASE III: Adoption into military air traffic control radar systems is anticipated. Transition to civil airports or high-traffic corridors serviced by current radar systems should be a goal.

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Keywords: Radar interference; probability of detection; radar clutter; signal propagation; wind turbines, (non) line-of-sight

KEYWORDS: Radar interference; probability of detection; radar clutter; signal propagation; wind turbines, (non) line-of-sight

AF12-BT06 TITLE: Innovative Electro Optic Signature Exploitation for Recognition Advancements

TECHNOLOGY AREAS: Sensors

OBJECTIVE: This topic seeks innovative methods for deriving a sparse set of physical target features that can be used for exploitation of air to ground signature data collected from electro-optic measurement systems including EO, IR and LADAR.

DESCRIPTION: Current methods for exploiting EO signature data include statistical pattern recognition techniques and model based approaches. Model-based approaches use simulated data in combination with measurement data to define features for potential exploitation. Current approaches designing algorithms based on feature extraction do not guarantee robustness because the extracted features are not linked to reliably known causal physics. Second, limitations of current approaches also include the lack of linkage to a systems theory model for disciplined trade space design of algorithm features.

Innovative methods for extracting salient physics based features that are associated with robust physical mechanisms are needed. Objects of interest for this topic include civilian vehicles including passenger vehicles and sport utility vehicles and dismounts. Although some exploitable features may change with background, this topics seeks methods that identify the dominant causal physics that both characterize the object and underlay the optimal inference solution. Associating the exploitable information content with the underlying causal physics based observables that each sensor can provide is a first step towards the development of new exploitation concepts and algorithms. Analysis methods are needed to efficiently produce the sparse cueing of salient physical features critical to the exploitation potential which exists within the full signature data.

In addition, methods of modeling realistic sources of signature uncertainty within a systems theory prototype are required for exploitation concepts and algorithm development. New analytical approaches are specifically sought for identifying observable physical features that can be reliably exploited. Methods for discovering salient features that contribute to exploitation should also account for and model uncertainties in the measurement process such that they are robust to realistic sensor measurement effects. Realistic uncertainties in civilian vehicles and dismounts should also be modeled. Feature robustness and persistence should be assessed using metrics tied to systems theory such that methods proposed have a theoretical basis. Example system theories that have application to discrimination could include Sparse Bayesian Learning Theory and Information Theory.

1. Sufficiently accounting for, or eliminating uncertainty in sensor feature measurements.

2. Sufficiently accounting for uncertainty sources in the object of interest.

3. Reliance on a priori information. If the proposed analysis methods rely on a database that is developed offline, sources of measured or methods of simulating data should be specifically identified in the proposal.

4. Target Feature Exploitation. Enhanced methods of deriving object physical properties from sensed observables that account for realistic sensor limitations should be specifically addressed.

PHASE I: Develop and conduct proof-of-concept demonstration of innovative physical feature based discrimination approaches using simulated data that model generic sensor characteristics. Characterize physical features with exploitation potential using metrics theoretically linked to system theory. Establish a mathematical foundation for cueing to underlying physical mechanisms responsible for inference.

PHASE II: Mature algorithms and methods developed on Phase I results and demonstrate technology using controlled measurement data.

PHASE III: Mature algorithms and methods developed on Phase II. Develop user friendly software tool and demonstrate technology using realistic sensor data.

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KEYWORDS: Multi-Sensor, Signature Exploitation, Physics-Based, Discrimination Algorithm, Long Range Sensing, Classification, Threat Modeling, Uncertainty Modeling, Information Theory

AF12-BT07 TITLE: Miniaturized, Power Efficient C-band Telemetry

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a miniaturized, power efficient C-band telemetry (TM) transmitter with performance comparable to current state of the art miniaturized S-band transmitters.

DESCRIPTION: A miniaturized TM subsystem for an airborne transmitter is needed in the 1-2 cubic inch form factor to support existing efforts to miniaturize flight test instrumentation. C-band transmitter RF devices are steadily improving, but their gain and efficiency are several years behind L-band and S-band devices that are available commercially. The challenge of designing test instrumentation with C-Band capable RF devices encompasses a trade space that includes size, power, and link margin requirements. Power consumption is a critical factor, and adequate reserves must be available to the actual equipment being tested.

The most difficult challenge is recovering the lost link margin. Moving from 2.2 GHz to 4.4 GHz costs 6 dB in path loss. In theory, the gain of the receiving antenna should increase by 6 dB to compensate for this loss, but in practice, the antenna gain will not improve that much. Any misalignment of the feed or slight shift in dish parabola accuracy will keep the antenna gain from getting the full 6 dB, and telemetry experts estimate that the gain is closer to 3 dB. This leaves the instrument platforms to manage a link margin 3 dB less capable than current operations in S-Band during times when the platforms need more data transmitted to the ground. This may require the transmitter to increase power output from current specification to a 10-watts specification, which will add a new level of complexity to the internal system design and impact to systems power sources. Power consumption and management are thus a critical considerations in unit development.

Miniaturized C-Band Transmitter Specific Needs:
Size: less than 2 cubic inches
Modulation Schemes: All ARTM waveforms (PCM/FM, SOQPSK, CPM)
Input Power: Less than 40 Watts
RF Output Power: At least 10 Watts
Operating Frequency: Selectable between 4400-4940, 5091-5150, and 5925-6700 MHz

PHASE I: Design C-band transmitter and develop concepts for telemetry support infrastructure in compliance with Mil-Std-461 EMI/EMC guidelines. Designed unit must be able to operate reliably and safely in concert with other test range electronic devices, including munitions. Designed unit must be able to maintain C-band link margins comparable to those of other TM subsystems operating in S-band.

PHASE II: Build a prototype TM transmitter unit and demonstrate that meets the stated performance objectives. Demonstrate capabilities in a test range environment and show that it can operate reliably and safely in concert with other test range electronic devices, including munitions. Demonstrate the ability to maintain C-band link margins comparable to those of other TM subsystems operating in S-band.

PHASE III: Integrate new C-band telemetry capabilities into test range environments and show that the unit reliably operates meeting stated objectives. To be successful, the device must comply with IRIG Std RCC106-09, Mil-Std-461 and environmental specification.

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KEYWORDS: miniaturized, power efficient, C-band, telemetry, transmitter, link margin

AF12-BT08 TITLE: Compact, Low-Cost THz Test System

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop a compact, low-cost test system with integrated control of temperature, electric field, and magnetic field for non-destructive characterization of novel electronic materials and devices at THz frequencies.

DESCRIPTION: The region from 0.1 THz (1011 Hz) to 10 THz (1013 Hz) is a largely unexplored region of the electromagnetic spectrum. The lower end of this region, 94 GHz, is now being developed for radar and communications applications, and the upper end can bridge the gap with long-wavelength infrared. To explore the THz region, it is important to know which materials and devices will work effectively as sources, detectors, interconnects, and other passive components at such frequencies. Presently, very few commercial test systems are available in the THz region and those available tend to be bulky and costly. In addition, there is no test system that can be easily used to characterize materials and devices over a broad range of THz frequencies with integrated control of temperature and magnetic field. Therefore, a compact and low-cost test system will greatly facilitate and further stimulate the exploration of the THz region. Ideally, such a test system should provide the same level of convenience as in microwave and infrared test systems. For best performance and convenience, THz sources and detectors should be placed in close proximity to materials and devices being tested. This may require THz generation and detection within cryogenic and magnetic field environments.

PHASE I: Design a prototype system operating in the frequency range 0.1 – 3 THz with integrated control of temperature, electric field and magnetic field. Process for making measurements and deriving selected material and device properties from measured THz spectral data should be outlined. Trade-off between size, cost and precision should be discussed.

PHASE II: Build the test system in commercial format and include software to allow convenient measurement and subsequent analysis of electronic properties. In particular, include algorithms to calculate optical mobility and optical concentration in order to provide a non-destructive determination of electrical material properties.

PHASE III: Demonstrate methods for effective non-destructive testing of specific device structures to determine their performance at THz frequencies. This test system is useful for characterizing materials and devices for radar, communications, chemical biological sensing, and other security applications.

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KEYWORDS: test, characterization, radar, communication, chemical sensing, biological sensing, imaging, security

AF12-BT09 TITLE: Game-Theoretic based Decision Support Tools for Persistent Space Denial

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop new game decision models and efficient computational algorithms for autonomous space systems with the capabilities for self defense when there are potential adversarial strikes.

DESCRIPTION: Former Air Force Space Command (AFSPC) Commander General Lance Lord defined space situation awareness (SSA) in simple terms: "The foundation of Space Superiority is Space Situation Awareness, which means having a complete understanding of what is happening in space." What exactly does this mean? General Lord goes on to say in his 2005 article in High Frontier that "It is no longer sufficient to simply know where a satellite is in space. We must know what the satellite is capable of doing, what it is being used for and what it may be used for in the future." Today the United States has a tremendous investment in space, especially in military, intelligence, scientific, and commercial sectors. However, one of the most important space vulnerabilities is the lack of persistent situation awareness of the space operational environment to ensure freedom of action. Space can be an important battlefield in modern warfare because intelligence information from the space has become extremely vital for strategic decisions. The presence of adversaries in addition to real-time and hidden information constraints greatly complicates the decision making process. It becomes necessary to perform space defense analysis and mission trade studies. Although pursuit-evasion game theory is relevant to this problem, most results in the existing literature are from the pursuers' perspective and thus not applicable.

Innovative solutions are sought for (a) proper game models and constructive game training for a space-based Low Earth Orbit (LEO) and/or near Geostationary Earth Orbit (GEO) defending scenario whereby multiple denying LEO/near GEO assets, defending LEO/near GEO assets and pursuing LEO/near GEO assets with either equal or unequal capabilities are assumed with imperfect, sporadic observations and jamming confrontations due to dynamic network topologies and inter-satellite links (ISLs); (b) possible constructive methods and approximate solution techniques on distributed learning under sparse communications and adverse environments due to orbital geometries, propagations and interferences; (c) efficient computational algorithms to determines real-time cooperative strategies for LEO/near GEO assets, neutral objects and threats in persistent area denial; and (d) assess the performance under technical failure inaccurate measurements and loss of communications. Proposed advances together with potential deliverables including novel mathematical developments, interaction modeling, performance metrics, advanced engagement concepts, and design principles shall set the foundations to enable assured operations of teams of autonomous defense systems to adapt to hostile and non-traditional environments which shall capitalize on effective utilization of modeling and analysis of uncertain systems as well as multi-level, multi-group, multi-agent control and decision analysis.

PHASE I: Develop constructive methods and analysis tools for a proof-of-concept entailing orbital geometries of LEO and/or near GEO assets, antenna beamwidths, crosslink angular velocities, ISL interferences, Doppler shifts and adversarial engagements including co-orbital threat models, levels of deception and collateral damages, asymmetric sensing and actuation capabilities for LEO and/or near GEO assets.

PHASE II: Refine Phase I system concept and algorithms of the proof-of-concept to include operational constraints of space-based visible/radar sensors, LEO/near GEO space platforms, maneuver capabilities, characteristics of orbital planes and space assets per plane on asset observability and reachability. Conduct 3D simulations and visualizations to characterize performance of decision support tools using NASA General Mission Analysis, OMNET++, Java programming, Service-Oriented-Architecture framework.

PHASE III: Adversarial decision analysis and robust decision making tools from Phase II activities are applicable to protected tactical space communications with dynamic spectrum sharing, routing adaptation and interference mitigations.

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KEYWORDS: Distributed learning, complex systems, competitive decision making, adversarial systems, distributed computation, multi-level command and control, active sensing

AF12-BT10 TITLE: Cryodeposit Mitigation and Removal Techniques for Radiometric Calibration Chambers

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop materials and instruments for cryodeposit mitigation and removal in radiometric calibration chambers.

DESCRIPTION: A better understanding of the cryodeposition process is required such that techniques can be developed to successfully remove cryodeposits that can be such a problem in test chamber performance. Water ice layers on the order of 100nm (and greater) can significantly affect the performance of an optical component. At some thickness (highly dependent upon temperature) there is a conversion from a transparent film to a highly scattering form. If the transition is thermally induced due to an increase or decrease of the substrate/film temperature, it may be correlated to a phase change in the ice from amorphous to a crystal state or from one crystal state to another which leads to a density gradient in the ice, while a non-thermally induced (i.e. thickness induced) transition could be the result of stresses from the changing density of the ice and the difference in elastic properties between ice films and the underlying substrate.

Prevention of cryodeposits could possibly be accomplished by various means that minimize the sticking coefficients of critical surfaces (hydrophilic coatings, helium curtain, electromagnetic fields, etc.). Removal of water cryodeposits can be accomplished by desorption of the water molecules. There are different types of desorption including, among others, thermal and photo-induced (using various wavelength regions) that have been evaluated. Other techniques may exist that can also accomplish the removal of these cryodeposits. The removal of other, more complex contaminants shall also be investigated.

A removal system is needed that will not contaminate the chamber directly through its use, and can be used in the chamber's cryogenic environment. The removal process can be utilized during the cryo pumpdown, but only at non-test times when radiometric data are not being acquired. The system must be of such a size that it does not impact the optical or other chamber systems. It must not contaminate or otherwise damage the targeted optical element or the System Under Test (SUT).

PHASE I: Identify cryodeposition mechanisms and phenomenology specific to optical and mechanical substrates used in cryo-vacuum test chambers. Investigate prevention mitigation, and removal techniques. Develop plan for prevention, mitigation, and removal.

PHASE II: Develop materials and instruments to minimize and address cryodeposit formation in cryo-vacuum test chambers. Demonstrate technology in cryo-vacuum test chamber environment or facsimile (<77 K, 10-6 Torr) for water and complex molecules (hydrocarbon or silicone) deposition.

PHASE III: Transition technology to Air Force cryo-vacuum test chambers. Other transition partners might include: NASA, Raytheon, Ball Aerospace, Kinetic Kill Vehicle-in-the-Loop Simulator (KHILS), Johns Hopkins University Applied Physics Lab, MIT Lincoln Labs, Alliant Techsystems, Inc (ATK).

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KEYWORDS: cryodeposit, cryo-vacuum test chamber, radiometric calibration, sticking coefficients, desorption

AF12-BT11 TITLE: <u>High-resolution Solar irradiance EUV Spectrum Forecast</u>

TECHNOLOGY AREAS: Battlespace

OBJECTIVE: Develop a solar irradiance spectrum forecast toolset that can accurately determine current and future high-resolution solar extreme ultraviolet irradiance spectra using near real-time solar observations.

DESCRIPTION: The solar spectral irradiance at the top of the atmosphere is the main energy input to Earth's thermosphere. It excites, dissociates and ionizes the neutral constituents in the thermosphere. It is important to accurately determine the solar irradiance spectrum at very high-resolution to make it possible to compute the effects of radiation on the various absorbing species.

Thermosphere density is a critical factor in determining orbital drag used for providing collision avoidance warnings for manned spaceflight and other high-value assets, accurately cataloging orbiting objects, predicting reentry times, and estimating satellite lifetimes, on-board fuel requirements, and attitude dynamics. Uncertainties in neutral density variations are the major limiting factor for precise low-Earth orbit determination at altitudes below about 700 km. Long-standing shortfalls in satellite drag prediction have been, in large part, due to inadequate prediction capability for solar EUV spectra. R&D effort in this area has recently been enhanced by an AFOSR-supported Multi-University Research Initiative entitled "Neutral Atmosphere Density Interdisciplinary Research." It has greatly improved the understanding of the neutral density profiles under various solar and geomagnetic conditions. While near real time data and indices including EUV data and solar flux are now becoming available, thermospheric models have not yet taken advantage of the data for improving neutral density modeling.

Empirical solar irradiance specification models (e.g. HEUVAC and SOLAR2000 models) have provided proxy-based solar EUV for characterizing solar irradiance variability across the solar spectrum. Current EUV forecast models commonly rely on time series analysis of past solar measurements. Forecasts of the daily F10.7 cm solar radio data adjusted to 1 AU, the E10.7 EUV proxy index, and a Lyman-alpha index (from Mg II index) are now routinely available. Recent research has indicated the feasibility of forecasting the solar F10.7 index utilizing advanced predictions of the global solar magnetic field generated by a flux transport model. Other researchers have shown that daily solar irradiance spectra can be efficiently constructed based on a set of semi-empirical physical models of solar features and their emitted spectra as a function of viewing angle, combined with solar images.

A challenging R&D effort beyond the current state of art is to be able to efficiently nowcast and forecast of high-resolution EUV spectra in the range of 0.1 to 100 nm using the available near real-time observations of solar features.

This topic thus requests innovative R&D to develop a semi-empirical physical model of solar atmosphere that can be assimilated with near real-time solar observations. The objective of this STTR is to establish technical feasibility of specification and forecast of high-resolution EUV spectra that can be used to drive thermospheric neural density modeling for near real-time operations. This STTR will also provide motivation for improving EUV-driven ionospheric processes. Successful proposals will help develop innovative algorithms employing new physical models and near real time solar data and indices. The new algorithms will eventually be utilized in the modeling of satellite drag by the Air Force Space Command (AFSPC) and the Joint Space Operations Center (JSpOC).

PHASE I: Develop and assess a solar irradiance spectrum modeling system of empirical and/or physical models of solar atmosphere using near real-time solar observations. Demonstrate that the proposed physical model is feasible to achieve the goal of accurately determining current and future high-resolution solar extreme ultraviolet irradiance spectra.

PHASE II: Develop a system of tools that can assimilate semi-empirical physical model of solar atmosphere with the available near real-time solar observations. Develop innovative algorithms that forecast high-resolution EUV spectra. Demonstrate that the developed model can be used as input to improve thermosphere and ionospheric physical modeling. Deliverables will include at least the models, prediction algorithms, software system, and validation reports.

PHASE III: Results of this work can be used to improve AF space catalog accuracy, a critical component for space situational awareness. The developed model can be utilized in DoD operational centers. New algorithms under this grant can be used in high accuracy collision avoidance in commercial applications.

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KEYWORDS: Satellite drag, Solar irradiance spectrum, EUV spectrum forecast, near real time, thermosphere, ionosphere, empirical model, physical model, neutral density forecast

AF12-BT12 TITLE: Characterization of the aero-structure environment of a scaled fighter at transonic conditions

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a full aircraft (scaled fighter sized) test articles for transonic aeroelastic research. Collect test article wind tunnel and other performance data and demonstrate utility for CSE tool application and CFD validation.

DESCRIPTION: Physical understanding and modeling of real world full aircraft dynamics is required in order to support test and evaluation of future aircraft and weapons systems. Improvements in testing time could be realized if enhanced decision data become available, potentially resolving issues and reducing uncertainty. The full value of aircraft dynamics modeling and simulation has not yet been realized, however, due to the paucity of appropriate validation data. Although there is often an abundance of data obtained from flight tests, these data do not always lend themselves to resolving model discrepancies due to uncertainties in instrument performance and local range conditions. In addition, flight test data are not conducive to the systematic variations of key parameters needed for computational fluid dynamics (CFD) model validation, especially when the conditions of interest compromise flight safety. The current publically available data sets, cited below, add little or no value to our ability to gain insight into relevant full aircraft performance during test and evaluation. In order to assist the acquisition cycle as a whole, high fidelity data sets must be utilized in conjunction with multi-physics computational science and engineering (CSE) tools as applied to these systems. Validation data are needed for CSE tool application, in particular, to address single discipline structure and multi-disciplinary design optimization issues. Ultimately these data sets will improve physical understanding and build confidence in the predictive capabilities of CSE tools with respect to aeroelastic instabilities, aerodynamic characteristics, etc. and help establish the relevant envelope boundary prior to open air flight tests.

We seek to address this problem through the construction of aircraft physical models suitable for wind tunnel testing and capable of providing relevant validation data to assist in CFD model and CSE tool development. If successful, the data sets could significantly improve lifecycle costs and reduce the risk associated with the testing and certification of military and commercial aircraft. During Phase 1, the contractor shall develop test article design and fabrication techniques, design 3 or more test articles, and assess merits and deficiencies of each with respect to fabrication, testing, and validation applications. Detailed designs and design specifications for each model must be made available in the public domain. During Phase 2, the contractor shall fabricate one or more full aircraft (scaled fighter sized) aeroelastic configuration transonic aeroelastic research and test articles. Advanced model construction processes, such as 3D printing, additive manufacturing, or rapid prototyping should be employed, if feasible. Updated public domain designs with actual build specifications for each test article will be provided by the contractor. Sufficient wind tunnel test data should be collected during Phase 2 to demonstrate the utility of test article design and fabrication and the ability of test articles to provide relevant validation data. The contractor will also corroborate data and physical characteristics of both the fluid and structural components through the use of CSE tools. At the end of Phase 2, all test articles, designs, and design specifications shall be delivered to a test facility for additional testing and assessment.

PHASE I: Develop test article design and fabrication techniques. Design 3 or more test articles and assess merits and deficiencies of each with respect to expected performance, fabrication, and testing. Although designs capable of advancing transonic aeroelastic research are of particular interest, designs that facilitate subsonic testing are also desired.

PHASE II: Produce one or more test articles. Update designs with actual build specifications for each. Collect test article wind tunnel and other performance data. Demonstrate utility for CSE tool application and CFD modeling and simulation validation. Deliver test articles to test facility for additional testing and assessment. Although test articles capable of advancing transonic aeroelastic research are of particular interest, articles that facilitate subsonic testing are also desired.

PHASE III: Produce new and more complex test articles on demand. Demonstrate repeatability of design structure, article measurement, and simulation objectives. Potential government customers include Air Force, Navy, and NASA. Commercial potential with Boeing, Lockheed Martin, and other primes.

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KEYWORDS: Aerodynamics, Structures, Dynamic Structures, Experimentation, Data Collection, Test Methodology, Multi-Physics, Wind Tunnel, Computational Science and Engineering, Finite Element, Computational Fluid Dynamics

AF12-BT13 TITLE: Subaperture Adaptive Optics for directed energy phased arrays

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: Develop an adaptive optics system using a fiber laser array as the spatial phase correction system within the subaperture of an array of discrete telescopes.

DESCRIPTION: Recent advances in laser array weapons (a system of discrete telescopes) may drive the subapertures to a diameter larger than Fried diameter. In addition to inter-subaperture phasing (between subapertures) this requires intra-subaperture (within a subaperture) phase conjugation to control the atmospheric phase distortions. An array of fiber lasers will feed the subaperture providing the opportunity to accomplish power scaling and spatial phase control given accurate wavefront data.

Each subaperture is required to be phase stabilized near the exit pupil, canceling high frequency phase noise from both the remote amplifier bank and optical path from the master oscillator.

The architecture should provide a means for beaconless intra-subaperture phase sensing and control, (inter-aperture phase sensing is not required for this research). Attention should be paid to transmit/receive isolation, viable controls design where conflicts may arise with slow and fast bandwidth control, and multi-input/multi-output sensing and correcting. The subaperture should accommodate 7-19 fibers in a high area-fill-factor arrangement. The closed-loop bandwidth should be scalable to accommodate aircraft boundary layer disturbances and moderate atmospheric disturbances.

PHASE I: Develop an architecture to accomplish subaperture wavefront sensing and fiber-laser based phase conjugation in the context of a viable laser array weapon.

PHASE II: Validate the theoretical approach by conducting tests in a laboratory environment. The validation should focus on fundamental measurement/correction limits in stressing environments with less emphasis placed on obtaining a bandwidth optimized product.

PHASE III: Combining the laser-source-power-scaling with spatial phase control can be used for other monolithic applications such as compensated beacons for astronomy or free space optical communication. The inherently ultra-fast actuation rate may provide other uses.

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KEYWORDS: adaptive optics, fiber lasers, phased arrays

AF12-BT14 TITLE: <u>Adaptive multi-sensor wide area situational awareness system</u>

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop machine learning technology that can significantly improve warfighter wide area situational awareness based on multiple sensors.

DESCRIPTION: Layered sensing enables situational awareness (SA) about an area of interest (AOI) by providing multiple high-resolution views of the area. SA in a wide area of operations is particularly challenging as the sensor resources have to be stretched to satisfy a large number of warfighter requests. Typical wide area sensor layering consists of a patchwork of high and low resolution sensor views. For example, SAR/GMTI radars may first provide low-revisit data over large areas and then high-resolution high-revisit data over pre-defined areas of where an activity of interest is suspected. EOIR and WAMI sensors can scan a large area of interest at low resolution and then provide high-resolution images over small areas of interest. Depending on the availability of the resources and time constraints, multiple sensors can be layered over the same activity or each sensor can cover different activities. AF and Army users then have the challenge of fusing this disparate data to uncover activities of interest.

The objective of this topic is to develop machine learning technologies that can address two challenges in the wide area sensor layering: (1) improve analyst's ability to detect activities of interest in wide area layered sensor data, (2) to deliver the sensor data to the AF and Army users in time to make a decision over a combination of satellite, airborne and mobile low-bandwidth networks.

Machine learning technologies can improve the performance of activity detection methods by taking advantage of the training data arising during the operations. The activity detection system has an opportunity to learn from the detections provided by the users, and from ad hoc multi-sensor co-collects provided by the layered sensors. Traditional machine learning uses labeled examples, generated by analysts by analyzing the collected data, to train the learning algorithms; the training process produces a decision rule which can be applied to detect activities in the future data. In a typical scenario, however, more data is available; for instance each low-resolution may have corresponding high-resolution views and analysts might have enhanced parts of the data by describing the situation in detail. Such additional data from the high-resolution sensors or the analyst may not be available in the operational environment when activities of interest must be detected in real time. Advanced machine learning technology that can use additional information during training is desired. Furthermore, the machine learning technology should take into account the specifics of operational sensor data: high variability of observed activities and sensor observations, internal structure within the classes of interest; presence of large number of clutter classes, limited amount of learning samples, and the need to integrate machine learning into the human analytical process. Such adaptive activity detection system can significantly increase probability of detection of activities of interest and reduce the false alarm rate.

The goal of the adaptive network management system is to ensure that the right information flows to the right users in time to provide situational awareness. The system will monitor network performance under varying sensor output and user requests, learn to predict future bottlenecks, and develop proactive network management and prioritization policies.

PHASE I: Propose novel machine learning technologies which can operate on training data containing additional information not available during the test stage, and consider the complex structure of classes of interest and large number of clutter classes. Conduct preliminary tests using simulated data. Generate final report including the description of new technology, performance metrics and plans for Phase II.

PHASE II: Develop a prototype software system incorporating the technology in Phase I and apply it to detection of activities in sensor data and management of sensor networks. Apply developed technology to forensic datasets from radar, EOIR, WAMI sensors. Demonstrate detection and false alarm performance. The deliverables include working prototype of the technology, specifications for its development, and performance evaluation with real world data.

This technology will have applications in both military and commercial domains. In the area of C4ISR the technology will be incorporated into the systems that help warfighters process more information with greater efficiency, for example in the counter-insurgency and counter-IED area. In the commercial sector this technology is applicable to situations with the amounts of data that need to be analyzed exceeding the capabilities of personnel and additional information is often available for training examples but not during normal operation, for example in marketing applications targeting social network users.

PHASE III: Integrate and deploy the developed prototype with ground stations.

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KEYWORDS: Layered Sensing, Activity Detection, Situational Awareness, Machine Learning

AF12-BT15 TITLE: New Paradigms in High Pressure Combustion Dynamics Prediction and Control

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop new paradigms in high pressure combustion dynamics that can render conventional approaches obsolete. Explore innovative applications of emerging research in methods to extract key models and information from large data sets.

DESCRIPTION: Advanced combustion systems are becoming increasingly dependent on factors which are controlled by the dynamics of the system. The combustion system dynamics are, in turn, controlled by interacting physiochemical processes such as chemical kinetics, turbulence, multiphase flows, and acoustic motions. In addition, combustion systems are designed to operate at the highest possible pressure in order to maximize thermodynamic efficiency. High pressures increase the energy release density and are known to exacerbate the problem. Modern computational and experimental capabilities are now making it possible to explore increasingly complex combustion dynamic behavior, but come at the expense of swamping analytical systems with vast amounts of data. The sheer amount of data can make it extremely challenging to extract the root causes of the behavior required to solve problems. The increasing geometrical complexity of advanced combustion systems contributes significantly to the problem. Rapid advances are being made in computational mathematics in recent times, however, in extracting key information from large data sets and in building efficient reduced numerical models which maintain the physical fidelity of the complete system to a high degree. Some examples of these innovative methods include the extraction of dynamically relevant modal information (Schmid, 2010), construction of “certifiable” reduced basis models for parameterized systems (see the review by Quarteroni et al, 2011) and the implementation of such techniques as the parameter space becomes very large (Bui-Thanh et al, 2008). To a large extent, integration of advances in these other fields into large scale simulations or experimental data sets has not been explored. There is therefore a broad opportunity for significant innovations leading to new paradigms that could render conventional approaches used today obsolete. Innovations are solicited here in the particular area of high pressure combustion dynamics. Significant interest exists in developing reduced order models (ROM) of complex physical phenomena through systematic model reduction. Interest also exists but is not limited to applying these techniques under conditions of geometric complexity, where component-wise analysis might be required leading to systems of ROMs or systems of ROMs that interact with high fidelity simulations or experiments. Reduced order models that are limited only to chemical kinetics schemes are excluded from this solicitation.

PHASE I: Identify and demonstrate the feasibility of innovative applications of emerging research to extract key models and information from large data sets to large scale simulations and experimental data related to high pressure combustion dynamics.

PHASE II: Develop the innovation or innovations identified in phase I into a workable framework and demonstrate the approach on a variety of cases.

PHASE III: Combustion dynamics controls key factors affecting the performance of a large variety of military applications, including liquid rockets, solid rockets, gas turbines, and augmentors, and non-military applications, including large gas turbines for land based power.

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KEYWORDS: combustion dynamics, high pressures, reduced order models, systematic model reduction