

DEPARTMENT OF THE AIR FORCE
23.C Small Business Technology Transfer (STTR) Phase I
Proposal Submission Instructions
Amendment 2

This Amendment adds language to the **AIR FORCE PROPOSAL EVALUATIONS** section of these Component-specific instructions:

In accordance with Section 4 of the SBIR and STTR Extension Act of 2022, the DAF will review all proposals submitted in response to this BAA to assess security risks presented by small business concerns seeking a Federally funded award. The DAF will use information provided by the small business concern in response to the Disclosure of Foreign Affiliations or Relationships to Foreign Countries and the proposal to conduct a risk-based due diligence review on the cybersecurity practices, patent analysis, employee analysis, and foreign ownership of a small business concern, including the small business concern and employees of the small business concern to a foreign country, foreign person, foreign affiliation, or foreign entity. The DAF will also assess proposals utilizing open-source analysis and analytical tools, for the nondisclosures of the information set forth in 15 U.S.C. 638(g)(13). If DAF assesses that a small business concern has security risk(s), DAF will review the proposal, the evaluation, and the security risks and may choose to either 1) create a plan to mitigate the risk(s) or 2) DAF may decide not to select the proposal for award based upon a totality of the review.

All other terms and provisions remain unchanged as a result of this Amendment.

DEPARTMENT OF THE AIR FORCE
23.C Small Business Technology Transfer (STTR) Phase I
Proposal Submission Instructions
Amendment 1

1. This Amendment modifies several of the topics associated with the DAF STTR Phase I offering. Topic numbers that are highlighted have been updated.
2. All other terms and provisions remain unchanged as a result of this Amendment.

DEPARTMENT OF THE AIR FORCE
23.C Small Business Technology Transfer (STTR) Phase I
Proposal Submission Instructions

The Air Force intends these Phase I proposal submission instructions to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein.

Offerors must ensure proposals meet all requirements of the STTR 23.C BAA posted on the Defense SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.

Proposers are encouraged to thoroughly review the DoD Program BAA and register for the DSIP Listserv to remain apprised of important programmatic and contractual changes.

- The DoD Program BAA is located at: <https://www.defensesbirstr.mil/SBIR-STTR/Opportunities/#announcements>. Be sure to select the tab for the appropriate BAA cycle.
- Register for the DSIP Listserv at: <https://www.dodsbirstr.mil/submissions/login>.

Complete proposals **must** be prepared and submitted via <https://www.dodsbirstr.mil/submissions/> (DSIP) on or before the date published in the DoD SBIR 23.C BAA. Applicants are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

The DAF recommends early submission, as computer traffic gets heavy near the proposal submission date/time and could slow down the system. **Do not wait until the last minute.** The DAF is not responsible for incomplete proposal submission due to system lag or inaccessibility. Please ensure contact information, i.e., names/phone numbers/email addresses, in the proposal is current and accurate. The DAF is not responsible for ensuring notifications are received by firms for which this information changes after proposal submission without proper notification. Changes of this nature shall be sent to the Air Force SBIR/STTR One Help Desk.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The DAF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF SBIR/STTR One Help Desk.** The message shall include the subject line, "23.C Address Change".

Points of Contact:

- General information related to the AF SBIR/STTR program and proposal preparation instructions, contact the AF SBIR/STTR One Help Desk at usaf.team@afsbirstr.us.
- Questions regarding the DSIP electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.
- For technical questions about the topics during the pre-announcement and open period, please reference the DoD SBIR 23.C BAA.
- Air Force SBIR/STTR Contracting Officer (CO):
 - Mr. Daniel J. Brewer, Daniel.Brewer.13@us.af.mil

General information related to the AF Small Business Program can be found at the AF Small Business website, <http://www.airforcesmallbiz.af.mil/>. The site contains information related to contracting opportunities within the AF, as well as business information and upcoming outreach events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers (PTACs), <http://www.ptacus.us.org>. These centers provide

Government contracting assistance and guidance to small businesses, generally at no cost.

PHASE I PROPOSAL SUBMISSION: The DoD STTR 23.C Broad Agency Announcement, <https://www.dodsbirsttr.mil/submissions/login>, includes all program requirements. Phase I efforts should address the feasibility of a solution to the selected topic's requirements.

The complete proposal must be submitted electronically through DSIP. Ensure the complete technical volume and additional cost volume information is included in this sole submission. The preferred submission format is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. **VIRUS-CHECK ALL SUBMISSIONS.**

The System for Award Management (SAM) allows proposing small business concerns interested in conducting business with the Federal Government to provide basic information on business structure and capabilities as well as financial and payment information. Proposing small business concerns must be registered in SAM. To register, visit www.sam.gov. A proposing small business concern that is already registered in SAM should login to SAM and ensure its registration is active and its representations and certifications are up-to-date to avoid delay in award.

On April 4, 2022, the DUNS Number was replaced by the Unique Entity ID (SAM). The Federal Government will use the UEI (SAM) to identify organizations doing business with the Government. The DUNS number will no longer be a valid identifier. If the proposing small business concerns has an entity registration in SAM.gov (even if the registration has expired), a UEI (SAM) has already been assigned. This can be found by signing into SAM.gov and selecting the Entity Management widget in the Workspace or by signing in and searching entity information. For proposing small business concerns with established Defense SBIR/STTR Innovation Portal (DSIP) accounts, update the Small business concern profile with the UEI (SAM) as soon as possible.

For new proposing small business concern registrations, follow instructions during SAM registration on how to obtain a Commercial and Government Entry (CAGE) code and be assigned the UEI (SAM). Once a CAGE code and UEI (SAM) are obtained, update the Small business concern's profile on the DSIP at <https://www.dodsbirsttr.mil/submissions/>.

PHASE I PROPOSAL FORMAT

Complete proposals must include all of the following:

Volume 1: DoD Proposal Cover Sheet

Note: If selected for funding, the proposal's technical abstract and discussion of anticipated benefits will be publicly released. Therefore, do not include proprietary information in this section.

Volume 2: Technical Volume

Volume 3: Cost Volume

Volume 4: Company Commercialization Report

Volume 5: Supporting Documents

Volume 6: Fraud, Waste, and Abuse Training

DoD PROPOSAL COVER SHEET (VOLUME 1)

Complete the proposal Cover Sheet in accordance with the instructions provided via DSIP. The technical abstract should include a brief description of the program objective(s), a description of the effort, anticipated benefits and commercial applications of the proposed research, and a list of keywords/terms. The technical abstract of each successful proposal will be submitted to the Office of the Secretary of Defense (OSD) for publication and, therefore, must not contain proprietary or classified information.

TECHNICAL VOLUME (VOLUME 2):

The Technical Volume should include all graphics and attachments but should not include the Cover Sheet, which is completed separately as Volume 1. The Phase I technical volume (uploaded in Volume 2) shall contain the required elements found below. Ensure that all graphics are distinguishable in black and white.

The Phase I Technical Volume page/slide limits identified for the topics do not include the Cover Sheet, Cost Volume, Cost Volume Itemized Listing (a-h). The Technical Volume must be no smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins. Only the Technical Volume and any enclosures or attachments count toward the page limit. In the interest of equity, pages/slides in excess of the stated limits will not be reviewed. The documents required for upload into Volume 5, "Other", do not count toward the specified limits.

Key Personnel: Identify in the Technical Volume all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship.

- A technical resume of the principal investigator, including a list of publications, if any, must be included
- Concise technical resumes for subcontractors and consultants, if any, are also useful.
- Identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants.
- Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For all non-U.S. citizens, 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, as appropriate. Additional information may be requested during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement. **Note:** Do not upload information such as Permanent Resident Cards (Green Cards), birth certificates, Social Security Numbers, or other PII to the DSIP system.

Phase I Work Plan Outline

NOTE: The DAF 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, if selected, and may delay contract award.

Include a work plan outline in the following format:

Scope: List the effort's major requirements and specifications.

Task Outline: Provide a brief outline of the work to be accomplished during the Phase I effort.

Milestone Schedule

Deliverables

Progress reports

Final report with SF 298

COST VOLUME (VOLUME 3)

Cost information should be provided by completing the Cost Volume in DSIP and including the Cost Volume Itemized Listing specified below. The Cost Volume detail must be adequate to enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information (a.-g. below) regarding funds use. The DSIP Cost Volume and Itemized Cost Volume Information will not count against the specified page limit. The itemized listing also may be submitted in Volume 5 under the "Other" dropdown option.

- a. **Direct Cost Materials:** Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, prices and where appropriate, purpose. Material costs may include the costs of such items as raw materials, parts, subassemblies, components, and manufacturing supplies.
- b. **Other Direct Costs:** This category includes, but is not limited to, specialized services such as machining, milling, special testing or analysis, and costs incurred in temporarily using specialized equipment. Proposals including leased hardware must include an adequate lease v. purchase justification.
- c. **Direct Labor:** Identify key personnel by name, if possible, or by labor category, if not. Direct labor hours, labor overhead and/or fringe benefits, and actual hourly rates for each individual are also necessary for the CO to determine whether these hours, fringe rates, and hourly rates are fair and reasonable.
- d. **Travel:** Travel costs must relate to project needs. Break out travel costs by trip, number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each, should be reflected. Recommend budgeting at least one trip to the Air Force location managing the contract.
- e. **Subcontracts:** Involvement of consultant in the project's planning and/or research stages may be appropriate. If so, describe in detail and include information in the Cost Volume. A minimum of 40% of each STTR project must be conducted by the SBC and a minimum of 40% of the effort performed by the single partnering Research Institution. Deviations from these performance of work requirements are not permitted. The STTR funded work percentage calculation considers both direct and indirect costs after removal of the SBC's proposed profit. Support subcontract costs with copies of executed agreements. The documents must adequately describe the work to be performed. At a minimum, include a Statement of Work (SOW) with a corresponding detailed Cost Volume for each planned subcontract. Additionally, see DoD SBIR 23.3 BAA for more information regarding the required Allocation of Rights Agreement.
- f. **Special Tooling, Special Test Equipment, and Material:** The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness to the work proposed. Special tooling and special test equipment purchases must, in the CO's opinion, be advantageous to the Government and relate directly to the effort. These toolings or equipment should not be of a type that an offeror would otherwise possess in the normal course of business. These may include items such as innovative instrumentation and/or automatic test equipment.
- g. **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 the hourly rate.

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without exchanges. Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. If there are questions regarding the award document, contact the Phase I CO identified on the cover page. The Government reserves the right to reopen negotiations later if the CO determines doing so to be necessary.

COMPANY COMMERCIALIZATION REPORT (VOLUME 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR 23.C BAA for full details on this requirement. Information contained in the CCR will not be considered by the Air Force during proposal evaluations.

SUPPORTING DOCUMENTS VOLUME (VOLUME 5)

The following documents are required for all proposal submissions:

1. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1 to the DOD SBIR 23.C BAA)
2. Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Attachment 2 to the DOD STTR 23.C BAA)
3. Disclosure of Funding Sources (Attachment 4 to the DOD STTR 23.C BAA)

The following documents may be required if applicable to your proposal:

1. DD Form 2345: For proposals submitted under export-controlled topics, either International Traffic in Arms or Export Administration Regulations (ITAR/EAR), a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, <http://www.dla.mil/HQ/InformationOperations/Offers/Products/LogisticsApplications/JCP/DD2315Instructions.aspx>. DD Form 2345 approval will be required if proposal is selected for award.
2. Verification of Eligibility of Small Business Joint Ventures (Attachment 3 to the DOD STTR 23.C BAA)
3. Technical Data Rights Assertions (if asserting data rights restrictions)

FRAUD, WASTE, AND ABUSE TRAINING (VOLUME 6)

Note that the FWA Training must be completed prior to proposal submission. When training is complete and certified, DSIP will indicate completion of the Volume 6 requirement. The proposal cannot be submitted until the training is complete.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

The Air Force does not participate in the Discretionary Technical and Business Assistance (TAB A) Program. Proposals submitted in response to DAF topics shall not include TAB A.

AIR FORCE PROPOSAL EVALUATIONS

Proposals will be evaluated for overall merit in accordance with the criteria discussed in the 23.C BAA.

In accordance with Section 4 of the SBIR and STTR Extension Act of 2022, the DAF will review all proposals submitted in response to this BAA to assess security risks presented by small business concerns seeking a Federally funded award. The DAF will use information provided by the small business concern in response to the Disclosure of Foreign Affiliations or Relationships to Foreign Countries and the proposal to conduct a risk-based due diligence review on the cybersecurity practices, patent analysis, employee analysis, and foreign ownership of a small business concern, including the small business concern and employees of the small business concern to a foreign country, foreign person, foreign affiliation, or foreign entity. The DAF will also assess proposals utilizing open-source analysis and analytical tools, for the nondisclosures of the information set forth in 15 U.S.C. 638(g)(13). If DAF assesses that a small business concern has security risk(s), DAF will review the proposal, the evaluation, and the security risks and may choose to either 1) create a plan to mitigate the risk(s) or 2) DAF may decide not to select the proposal for award based upon a totality of the review

DAF USE OF SUPPORT CONTRACTORS

Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors TEC Solutions, Inc., APEX, Oasis Systems, Riverside Research, Peerless Technologies, HPC-COM, Mile Two, Montech, Wright Brothers Institute, and MacB (an Alion Company). In addition, only Government employees and technical personnel from Federally Funded

Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space and Missiles Centers may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. Contact the AF SBIR/STTR CO Daniel J. Brewer (Daniel.Brewer.13@us.af.mil) with concerns.

PROPOSAL STATUS AND FEEDBACK

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. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced.

Automated feedback will be provided for Phase I proposals designated Not Selected. Additional feedback may be provided at the sole discretion of the DAF.

IMPORTANT: Proposals submitted to the DAF are received and evaluated by different organizations, handled by topic. Each organization operates within its own schedule for proposal evaluation and selection. Updates and notification timeframes will vary. If contacted regarding a proposal submission, it is not necessary to request information regarding additional submissions. Separate notifications are provided for each proposal.

The Air Force anticipates that all proposals will be evaluated and selections finalized within approximately 90 calendar days of solicitation close. Please refrain from contacting the BAA CO for proposal status before that time.

Refer to the DoD STTR 23.C BAA for procedures to protest the Announcement. As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Air Force SBIR/STTR Contracting Officer Daniel J. Brewer, Daniel.Brewer.13@us.af.mil.

AIR FORCE SUBMISSION OF FINAL REPORTS

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

PHASE II PROPOSAL SUBMISSIONS

DAF organizations may request Phase II proposals while technical performance is ongoing. This decision will be based on the contractor's technical progress, as determined by an DAF Technical Point of Contact review using the Phase II review criteria outlined above.

Phase II is the demonstration of the technology found feasible in Phase I. Only Phase I awardees are eligible to submit a Phase II proposal. All Phase I awardees will be sent a notification with the Phase II proposal submittal date and detailed Phase II proposal preparation instructions. If the physical or email addresses or firm points of contact have changed since submission of the Phase I proposal, correct information shall be sent to the AF SBIR/STTR One Help Desk. Phase II dollar values, performance periods, and proposal content will be specified in the Phase II request for proposal.

NOTE: The DAF primarily makes STTR Phase I and II awards as Firm-Fixed-Price contracts. However, awardees are strongly urged to work toward a Defense Contract Audit Agency (DCAA)-approved accounting system. If the company intends to continue work with the DoD, an approved accounting system will allow for competition in a broader array of acquisition opportunities, including award of

Cost-Reimbursement types of contracts. Please address questions to the Phase II CO, if selected for award.

All proposals must be submitted electronically via DSIP by the date indicated in the Phase II proposal instructions. Note: Only ONE Phase II proposal may be submitted for each Phase I award.

AIR FORCE SBIR/STTR PROGRAM MANAGEMENT IMPROVEMENTS

The DAF reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees will be notified. The DAF also reserves the right to change any administrative procedures that will improve management of the DAF SBIR/STTR Program at any time.

Air Force STTR 23.C Topic Index

Topic Number	Topic Name	Maximum Value*	Maximum Duration (in months)**	Technical Volume Page Limit***
AF23C-T001	Data-Centric AI in Multi Domain Awareness	\$200,000.00	6	20
AF23C-T002	Tunable, Integrated Electro-optic Frequency Comb for Space-based Communications and Precision, Navigation and Timing (PNT) Applications	\$200,000.00	6	20
AF23C-T003	Advanced Dynamic Inlet Distortion Generators	\$200,000.00	6	20

***Proposals that exceed this amount will be disqualified**

****Proposals that exceed this duration will be disqualified**

*****Pages in excess of this count will not be considered during evaluations**

AF23C-T001 TITLE: Data-Centric AI in Multi Domain Awareness

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop, test, and demonstrate a data-centric AI solution for processing Multi Domain Awareness data. Identify and illustrate the potential negative effects of insufficient training data in automated processing of multi-domain data streams.

DESCRIPTION: Enhanced situational awareness and flight safety support in the space domain within and beyond geosynchronous orbit (GEO) is achievable given sufficient data strategies. Observational evidence of spacecraft anomalies is manifest in multiple datatypes to include raw EO/IR imagery features, astrometric and photometric features, and features associated with their radio-frequency/RF payload. When this data is collected in great volume, from multiple modalities, and geographic locations, there is significant opportunity to enable reliable automated alerting. Today defining normal operations in space so that abnormal behavior can be flagged and more deeply observed is an area of research which addresses fundamental developments required to begin to define a baseline for real-time automated alerting for increasingly crowded orbit neighborhoods, as well as inform how this baseline may be extended to support missions in orbits beyond GEO. This is a significant need as new activities in cislunar space are planned for the coming years. This topic seeks to 1.) define data-driven methods to drive the development and testing of an ontology of automated alerts in support of government and commercial applications and 2.) develop foundational mathematical solutions needed to enable these mappings on multiple timescales and to properly quantify the uncertainty in these mappings to effectively support decision making. This includes mapping high frequency and geometrically diverse collection data to: a.) Specify/classify maneuver alerts as station-keeping or not, b. Specify observed anomaly types and classify them on the basis of astrometric, photometric and RF features observed, and c.) quantify confidence/uncertainty in the mapping from input data to selected alerts. To develop an explainable alert ontology, the offeror will develop a supervised learning approach which combines feedback from experts in space domain awareness with Generative Adversarial Networks (GANs) and Convolutional Neural Networks (CNNs). They will show the regrets associated with insufficient training of SDA models and compare the assessed results of their solution at different levels and qualities of training using available SDA data. Importantly the offeror will identify various forms of “data cascades” which can occur when insufficient data work is performed in the development of automated processing routines applied to the interpretation of SDA data. When do leaks and false alarms manifest into undesired downstream effects?

PHASE I: Conceive of, develop, and demonstrate multiple methods for automated processing of SDA data which result in meaningful conclusions regarding the observed operations of spacecraft. Exercise these algorithms using available SDA data.

PHASE II: Extend these methods to fuse multiple modalities and evaluate when and where errant conclusions can be made and what the underlying data conditions are that lead to these non-ideal conclusions.

PHASE III DUAL USE APPLICATIONS: Develop a strategy to transition prototype residual capabilities and incremental proliferation based on operational requirements.

REFERENCES:

1. <https://www-forbes-com.cdn.ampproject.org/c/s/www.forbes.com/sites/gilpress/2021/06/16/andrew-ng-launches-a-campaign-for-data-centric-ai/amp/> 2. <https://storage.googleapis.com/pub-tools-public-publication-data/pdf/0d556e45afc54afeb2eb6b51a9bc1827b9961ff4.pdf> 3. <https://towardsdatascience.com/data-centric-vs-model-centric-ai-the-answer-is-clear-4b607c58af67>

KEYWORDS: machine learning; artificial intelligence; data fusion; space domain awareness

AF23C-T002

TITLE:

Tunable, Integrated Electro-optic Frequency Comb for Space-based Communications and Precision, Navigation and Timing (PNT) Applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber;Human-Machine Interfaces

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design, fabricate, and demonstrate a photonicly integrated electro-optic modulator capable of generating an optical frequency comb with 1-10 GHz spacing in the 1540-1560 nm band.

DESCRIPTION: Optical frequency combs, including electro-optic-generated optical frequency combs [1], have been a revolutionary technology across many areas, including a host of applications in spectroscopy, communications, and Position, Navigation and Timing (PNT). Photonicly integrated electro-optic modulator platforms [2] offer the potential for robust, chip-scale, optical frequency comb generation with full electrical control, and the eventual deployment of comb technologies into mobile and space-based applications. The recent emergence of new integrated modulator material platforms, such as thin film lithium niobate [3] and barium titanate [4], as well as novel modulator designs offer the potential for enhanced efficiency, bandwidth, and packaging [5 - 7] to fully exploit the potential of optical frequency combs outside of the laboratory. These advances warrant further investigation into photonicly integrated electro-optic modulators as well as their packaging, with an emphasis on a reduction in V_{pi} , high conversion efficiency, low waveguide propagation and insertion loss, and high optical and RF power handling.

PHASE I: Develop a platform fabrication and integration plan with supporting preliminary results (i.e., measurements, modeling/simulation, etc.) toward realizing the Phase II device specifications and deliverables. Material platform(s), pump-to-comb conversion efficiency and insertion losses with a full power budget should be included. Low RF power modulator driving requirements are desirable. Proposals should include a plan to either generate and characterize optical frequency comb performance or to provide full modulator characterization to predict comb performance. Phase I deliverables include a final report motivating the platform fabrication and integration plan.

PHASE II: Phase II will include fabrication and testing of prototype integrated modulator devices demonstrating:

- tunability of phase and amplitude to support frequency comb generation and control with 1 - 10 GHz line spacing;
- low V_{pi} (< 1 V) and RF power requirements (proposal should identify anticipated V_{pi} and modulator power requirements) across the 1 - 10 GHz tuning range supporting 5 nm broad electro-optic comb generation at 1 GHz repetition rate within the 1540 - 1560 nm band;
- low waveguide to modulator coupling losses (proposals should identify anticipated coupling losses);
- polarization maintaining fiber-coupled interconnects for coupling onto and off from the integrated chip-scale modulator platform;
- high optical power handling (>500 mW of input power) at desired wavelengths.

Phase II prototypes should include all necessary electronics to support modulator operation and thermal control. Electronics may reside off chip (on-chip integration is desirable); however, a path should be identified for full integration, including projected power budget improvements. Multiple

devices demonstrating modulator uniformity are desirable. At the completion of Phase II, four (4) prototype devices will be delivered to government laboratories of AFOSR's specification for characterization and integration with space-focused technology demonstrators. The final devices should be adequately packaged and integrated with all relevant supporting electronics for delivery to and operation by the test verification facility. Guidance/documentation for device operation should be provided for test facility personnel. Deliverables include a final technical report, at least four (4) prototype devices and supporting documentation. The Technology Readiness Level to be reached is 5: Component and/or bread-board validation in relevant environment.

PHASE III DUAL USE APPLICATIONS: Integrated optical frequency comb technology is anticipated to be broadly applicable across applications spanning the scientific, commercial, and defense domains, as evidenced by the impact of bulk-scale optical frequency comb technologies and the burgeoning impact of competing chip-scale comb technologies which currently offer less robustness, efficiency, and control. Many of the same applications revolutionized by bulk-scale laboratory optical frequency comb technology may be accessible to integrated comb generation technologies at a size, weight, and power (SWaP), robustness, and level of control which allows for operation outside of the laboratory and potentially for optimized comb parameters in applications including communications. There will be a need to demonstrate foundry level fabrication and robust packaging techniques for large scale production as well as testing long term performance in environments such as large temperature fluctuations, high shock and vibration, and vacuum compatibility.

REFERENCES:

1. Advances in Optics and Photonics, 12, 223 (2020);
2. Journal of Semiconductors, 42, 041301 (2021);
3. Nature Communications, 11, 4123 (2020);
4. Optics Express, 12, 5962 (2004);
5. Nature Photonics, 16, 679 (2022);
6. Optics Express, 30, 23177 (2022);
7. Optica 9, 408-411 (2022)

KEYWORDS: RF Integrated Photonics, Integrated Optical Modulator, Electro-optic Device, Frequency Comb

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Quantum Science;Microelectronics;Advanced Materials

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this topic is to develop an advanced dynamic inlet-distortion generator capable of producing time-varying pressure, swirl, or combined pressure and swirl flowfields in front of a turbine engine or fan rig for ground test evaluations. Phase I efforts shall focus on ideation of the concept and development of design parameters that scale to the application. Phase II shall focus on prototyping development and culminate with a rig demonstration with or without turbomachinery. Phase III efforts will focus on commercialization for the military application as well as the urban air mobility and next gen commercial airliner applications.

DESCRIPTION: Next generation air platform designs pose critical challenges to propulsion systems due to the complex integration of the engine into the airframe. The use of boundary-layer-ingesting inlets and integrated airframe-propulsion designs that eliminate podded propulsion in favor of drag-reducing streamlined designs can reduce the propulsion system performance and life.

Current practices for airframe-propulsion integration utilize advanced design tools and modeling software to predict performance and structural response of the propulsion system integrated with the airframe, but many conditions must be thoroughly tested to validate the predictions. Previous experience has shown the installation effects and the resulting inlet distortion ingested by the engine can lead to costly development efforts with sub-optimal results.

A broad spectrum of complex inlet distortions comprising non-uniform total pressures and velocities must be evaluated for performance and operability changes and aeromechanic responses of representative compression systems to fully understand the impact on conventional fan designs. Based on evaluation of component designs, design practices will be adjusted to account for complex total pressure and velocity fields.

Current methods for producing inlet distortion have mainly focused on producing total pressure distortions with porous screens. This method utilizes the natural pressure drop and velocity reduction that occurs as the inlet air passes through the screen [1-3]. Less common are inlet distortion generators designed for producing non-axial velocities, or swirl, at the inlet of the turbomachinery [4, 5]. These swirl generators have historically relied on turning vanes with prescribed placement such that the desired swirl profile is recreated at the face of the turbomachinery. In most cases, the resulting distortion pattern is assumed to be static, and may represent a time-averaged flowfield.

This SBIR/STTR topic aims to develop an advanced inlet distortion generator for turbine engine ground testing that can produce user-prescribed time-varying pressure, swirl, or both simultaneously within one-and-a-half-duct diameters downstream of the generating device. The distortion generator should be compatible with existing SAE ARP 1420 [6] best practices for distortion testing and evaluation as well as standard practices for engine and fan rig testing. The distortion generator should be capable of producing standard inlet distortion patterns as defined in SAE AIR 1419 [7] (pressure distortion) and SAE AIR 5686 [8] (swirl distortion) as well as capable of generating complex aircraft patterns. Design concepts should be scalable to accommodate various sizes of turbine engines as well as fan and compressor component rigs. The device should be able to reproduce an end user's defined pattern which may include localized areas with a time-varying reduction in total pressure and/or time-varying swirl flowfield. Knowledge of the flowfield interaction involving deficits of total pressure and non-uniform velocities

as it develops axially will be critical for the success of the distortion generator. The device may use fixed geometry to match desired flow fields at one condition or contain movable geometry capable of reproducing numerous flow fields. The device should have a mechanical design with low risk of failure and a low cost for research programs.

PHASE I: Develop methodology and feasibility of a low-cost concept for a novel distortion generator system capable of producing a user-prescribed time-varying total-pressure loss or time-varying non-uniform velocity field within one-and-a-half duct diameters downstream of the device. Methodology should be model-based and build upon fundamental concepts and literature. Governing equations and design parameters should be specified that show how the device can be scaled for different sizes, time scales, and magnitudes. Direct to Phase II proposals should demonstrate existing methodologies and concepts mature enough for prototype demonstration.

PHASE II: Develop proof of concept prototype using the methodology developed in Phase I and test under relevant conditions the ability to reproduce a complex flowfield with a time-varying component with localized pressure deficits of at least 10% at tunable frequencies up to 2x of the fan speed or with non-axial velocities equivalent to 10 degrees of swirl with a periodic variation at half the rotor speed. Continue development of design methodology to accurately predict and place complex flow features with a specified frequency up to one-and-a-half duct diameters downstream of the device. Continue development of the commercial merit of the device and its application to both civilian and military sectors.

PHASE III DUAL USE APPLICATIONS: Develop commercialization of the device, manufacturing methods, and finalize device form factor and capabilities. Evaluate market potential for military and civilian applications and assess required infrastructure for continued technology readiness level (TRL) and manufacturing readiness level (MRL) development. It is expected that this technology will be at a TRL of 4 at Phase III entry. AFRL/RQTT is a potential transition customer that may purchase a functional product. AFRL/RQTT plans to use this technology in a fan rig for Phase III efforts, demonstrating TRL of 6 for this planned technology.

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KEYWORDS: Inlet distortion generator; dynamic inlet distortion generator; time varying inlet distortion; embedded engine; turbine engine inlet distortion; distortion tolerant fans