DEPARTMENT OF THE NAVY (DON)
23.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

IMPORTANT

- **The following instructions apply to STTR topics only:**
  - **N23B-T030 through N23B-T034**
- **The information provided in the DON Proposal Submission Instructions document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).**
- **DON Phase I Technical Volume (Volume 2) page limit is not to exceed 10 pages.**
- Phase I Technical Volume (Volume 2) and Supporting Documents (Volume 5) templates, specific to DON topics, are available at https://www.navysbir.com/links_forms.htm.
- The DON provides notice that Basic Ordering Agreements (BOAs) may be used for Phase I awards, and BOAs or Other Transaction Agreements (OTAs) may be used for Phase II awards.
- This BAA is issued under regulations set forth in Federal Acquisition Regulation (FAR) 35.016 and awards will be made under "other competitive procedures". The policies and procedures of FAR Subpart 15.3 shall not apply to this BAA, except as specifically referenced in it. All procedures are at the sole discretion of the Government as set forth in this BAA. Submission of a proposal in response to this BAA constitutes the express acknowledgement to that effect by the proposing small business concern.

INTRODUCTION

The DON SBIR/STTR Programs are mission-oriented programs that integrate the needs and requirements of the DON's Fleet through research and development (R&D) topics that have dual-use potential, but primarily address the needs of the DON. More information on the programs can be found on the DON SBIR/STTR website at www.navysbir.com. Additional information on DON's mission can be found on the DON website at www.navy.mil.

Digital Engineering. DON desires the ability to design, integrate, and test naval products by using authoritative sources of system data, which enables the creation of virtual or digital models for learning and experimentation, to fully integrate and test actual systems or components of systems across disciplines to support lifecycle activities from concept through disposal. To achieve this, digital engineering innovations will be sought in topics with titles leading with DIGITAL ENGINEERING.

The Program Manager of the DON STTR Program is Mr. Steve Sullivan. For questions regarding this BAA, use the information in Table 1 to determine who to contact for what types of questions.

TABLE 1: POINTS OF CONTACT FOR QUESTIONS REGARDING THIS BAA

Type of Question	When	Contact Information
Program and administrative	Always	Program Managers list in Table 2 (below)

Topic-specific technical questions	BAA Pre-release	Technical Point of Contact (TPOC) listed in each topic. Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
	BAA Open	DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions) Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
Electronic submission to the DoD SBIR/STTR Innovation Portal (DSIP)	Always	DSIP Support via email at dodsbirsupport@reisystems.com
Navy-specific BAA instructions and forms	Always	Navy SBIR/STTR Program Management Office usn.pentagon.cnr-arlington-va.mbx.navy-sbir-sttr@us.navy.mil

TABLE 2: DON SYSTEMS COMMANDS (SYSCOM) SBIR PROGRAM MANAGERS

Topic Numbers	Point of Contact	SYSCOM	Email
N23B-T030 to N23B-T034	Ms. Kristi DePriest	Naval Air Systems Command (NAVAIR)	navair-sbir@us.navy.mil

PHASE I SUBMISSION INSTRUCTIONS

The following section details requirements for submitting a compliant Phase I Proposal to the DoD SBIR/STTR Programs.

(NOTE: Proposing small business concerns are advised that support contract personnel will be used to carry out administrative functions and may have access to proposals, contract award documents, contract deliverables, and reports. All support contract personnel are bound by appropriate non-disclosure agreements.)

DoD SBIR/STTR Innovation Portal (DSIP). Proposing small business concerns are required to submit proposals via the DoD SBIR/STTR Innovation Portal (DSIP); follow proposal submission instructions in the DoD SBIR/STTR Program BAA on the DSIP at https://www.dodsbirsttr.mil/submissions. Proposals submitted by any other means will be disregarded. Proposing small business concerns submitting through DSIP for the first time will be asked to register. It is recommended that small business concerns register as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process. Proposals that are not successfully certified electronically in DSIP by the Corporate Official prior to BAA Close will NOT be considered submitted and will not be evaluated by DON. Please refer to the DoD SBIR/STTR Program BAA for further information.

Proposal Volumes. The following six volumes are required.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR Program BAA.
- **Technical Proposal (Volume 2)**
  - Technical Proposal (Volume 2) must meet the following requirements or the proposal will be REJECTED:

- Not to exceed 10 pages, regardless of page content
- Single column format, single-spaced typed lines
- Standard 8 ½" x 11" paper
- Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
- No font size smaller than 10-point
- Include, within the 10-page limit of Volume 2, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified. Phase I Options are exercised upon selection for Phase II.
- Work proposed for the Phase I Base must be exactly six (6) months.
- Work proposed for the Phase I Option must be exactly six (6) months.

- Additional information:
  - It is highly recommended that proposing small business concerns use the Phase I proposal template, specific to DON topics, at https://navysbir.com/links_forms.htm to meet Phase I Technical Volume (Volume 2) requirements.
  - A font size smaller than 10-point is allowable for headers, footers, imbedded tables, figures, images, or graphics that include text. However, proposing small business concerns are cautioned that if the text is too small to be legible it will not be evaluated.

- **Cost Volume (Volume 3).**
  - Cost Volume (Volume 3) must meet the following requirements or the proposal will be REJECTED:
    - The Phase I Base amount must not exceed $140,000.
    - Phase I Option amount must not exceed $100,000.
    - Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.
    - For Phase I a minimum of 40% of the work is performed by the proposing small business concern, and a minimum of 30% of the work is performed by the single research institution. The percentage of work requirement must be met in the Base costs as well as in the Option costs. The percentage of work is measured by both direct and indirect costs. To calculate the minimum percentage of effort for the proposing small business concern the sum of all direct and indirect costs attributable to the proposing small business concern represent the numerator and the total cost of the proposal (i.e., Total Cost before Profit Rate is applied) is the denominator. The single research institution percentage is calculated by taking the sum of all costs attributable to the single research institution (identified as Total Subcontractor Costs (TSC) 1 in DSIP Cost Volume) as the numerator and the total cost of the proposal (i.e., Total Cost before Profit Rate is applied) as the denominator.
      - Proposing Small Business Concern Costs (included in numerator for calculation of the small business concern):
        - Total Direct Labor (TDL)
        - Total Direct Material Costs (TDM)
        - Total Direct Supplies Costs (TDS)
        - Total Direct Equipment Costs (TDE)
        - Total Direct Travel Costs (TDT)
        - Total Other Direct Costs (TODC)
        - General & Administrative Cost (G&A)

NOTE: G&A, if proposed, will only be attributed to the proposing small business concern.

- Research Institution (numerator for Research Institution calculation):
  - Total Subcontractor Costs (TSC) 1
- Total Cost (i.e., Total Cost before Profit Rate is applied, denominator for either calculation)

- Additional information:
  - Provide sufficient detail for subcontractor, material, and travel costs. Subcontractor costs must be detailed to the same level as the prime contractor. Material costs must include a listing of items and cost per item. Travel costs must include the purpose of the trip, number of trips, location, length of trip, and number of personnel.
  - Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.
  - The "Additional Cost Information" of Supporting Documents (Volume 5) may be used to provide supporting cost details for Volume 3. When a proposal is selected for award, be prepared to submit further documentation to the SYSCOM Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors).

- **Company Commercialization Report (Volume 4)**. DoD collects and uses Volume 4 and DSIP requires Volume 4 for proposal submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details to ensure compliance with DSIP Volume 4 requirements.

- **Supporting Documents (Volume 5).** Volume 5 is for the submission of administrative material that DON may or will require to process a proposal, if selected, for contract award.

  All proposing small business concerns must review and submit the following items, as applicable:
  - **Telecommunications Equipment Certification.** Required for all proposing small business concerns. The DoD must comply with Section 889(a)(1)(B) of the FY2019 National Defense Authorization Act (NDAA) and is working to reduce or eliminate contracts, or extending or renewing a contract with an entity that uses any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As such, all proposing small business concerns must include as a part of their submission a written certification in response to the clauses (DFAR clauses 252.204-7016, 252.204-7018, and subpart 204.21). The written certification can be found in Attachment 1 of the DoD SBIR/STTR Program BAA. This certification must be signed by the authorized company representative and is to be uploaded as a separate PDF file in Volume 5. Failure to submit the required certification as a part of the proposal submission process will be cause for rejection of the proposal submission without evaluation. Please refer to the instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
  - **Disclosures of Foreign Affiliations or Relationships to Foreign Countries.** Each proposing small business concern is required to complete Attachment 2 of this BAA, "Disclosures of Foreign Affiliations or Relationships to Foreign Countries" and upload the form to Volume 5, Supporting Documents. Please refer to the following sections of the DoD SBIR/STTR Program BAA for details:
    - Program Description

    - Proposal Fundamentals
    - Phase I Proposal
    - Attachment 2
  - **Certification Regarding Disclosure of Funding Sources.** Each proposing small business concern must comply with Section 223(a) of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021. The disclosure and certification must be made by completing Attachment 4, Disclosure of Funding Sources, and uploading to Volume 5, Supporting Documents. Please refer to the following sections of the DoD SBIR/STTR Program BAA for details:
    - Phase I Proposal
    - Attachment 4

- Additional information:
  - Proposing small business concerns may include the following administrative materials in Supporting Documents (Volume 5); a template is available at https://navysbir.com/links_forms.htm to provide guidance on optional material the proposing small business concern may want to include in Volume 5:
    - Additional Cost Information to support the Cost Volume (Volume 3)
    - SBIR/STTR Funding Agreement Certification
    - Data Rights Assertion
    - Allocation of Rights between Prime and Subcontractor
    - Disclosure of Information (DFARS 252.204-7000)
    - Prior, Current, or Pending Support of Similar Proposals or Awards
    - Foreign Citizens
  - Do not include documents or information to substantiate the Technical Volume (Volume 2) (e.g., resumes, test data, technical reports, or publications). Such documents or information will not be considered.
  - A font size smaller than 10-point is allowable for documents in Volume 5; however, proposing small business concerns are cautioned that the text may be unreadable.

- **Fraud, Waste and Abuse Training Certification (Volume 6)**. DoD requires Volume 6 for submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details.

PHASE I EVALUATION AND SELECTION

The following section details how the DON SBIR/STTR Programs will evaluate Phase I proposals.

Proposals meeting DSIP submission requirements will be forwarded to the DON SBIR/STTR Programs. Prior to evaluation, all proposals will undergo a compliance review to verify compliance with DoD and DON SBIR/STTR proposal eligibility requirements. Proposals not meeting submission requirements will be REJECTED and not evaluated.

- **Proposal Cover Sheet (Volume 1).** The Proposal Cover Sheet (Volume 1) will undergo a compliance review to verify the proposing small business concern has met eligibility requirements and followed the instructions for the Proposal Cover Sheet as specified in the DoD SBIR/STTR Program BAA.

- **Technical Volume (Volume 2).** The DON will evaluate and select Phase I proposals using the evaluation criteria specified in the Phase I Proposal Evaluation Criteria section of the DoD

SBIR/STTR Program BAA, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. This is not a FAR Part 15 evaluation and proposals will not be compared to one another. Cost is not an evaluation criteria and will not be considered during the evaluation process; the DON will only do a compliance review of Volume 3. Due to limited funding, the DON reserves the right to limit the number of awards under any topic.

The Technical Volume (Volume 2) will undergo a compliance review (prior to evaluation) to verify the proposing small business concern has met the following requirements or the proposal will be REJECTED:

- Not to exceed 10 pages, regardless of page content
- Single column format, single-spaced typed lines
- Standard 8 ½" x 11" paper
- Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
- No font size smaller than 10-point, except as permitted in the instructions above.
- Include, within the 10-page limit of Volume 2, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified.
- Work proposed for the Phase I Base must be exactly six (6) months.
- Work proposed for the Phase I Option must be exactly six (6) months.

- **Cost Volume (Volume 3).** The Cost Volume (Volume 3) will not be considered in the selection process and will only undergo a compliance review to verify the proposing small business concern has met the following requirements or the proposal will be REJECTED:
  - Must not exceed values for the Base ($140,000) and Option ($100,000).
  - Must meet minimum percentage of work; 40% of the work is performed by the proposing small business concern, and a minimum of 30% of the work is performed by the single research institution. The percentage of work requirement must be met in the Base costs as well as in the Option costs.
- **Company Commercialization Report (Volume 4).** The CCR (Volume 4) will not be evaluated by the Navy nor will it be considered in the Navy's award decision. However, all proposing small business concerns must refer to the DoD SBIR/STTR Program BAA to ensure compliance with DSIP Volume 4 requirements.

- **Supporting Documents (Volume 5).** Supporting Documents (Volume 5) will not be considered in the selection process and will only undergo a compliance review to ensure the proposing small business concern has included items in accordance with the PHASE I SUBMISSION INSTRUCTIONS section above.

- **Fraud, Waste, and Abuse Training Certificate (Volume 6).** Not evaluated.

ADDITIONAL SUBMISSION CONSIDERATIONS

This section details additional items for proposing small business concerns to consider during proposal preparation and submission process.

Due Diligence Program to Assess Security Risks. The SBIR and STTR Extension Act of 2022 (Pub. L. 117-183) requires the Department of Defense, in coordination with the Small Business Administration, to

establish and implement a due diligence program to assess security risks presented by small business concerns seeking a Federally funded award. Please review the Program Description section of the DoD SBIR/STTR Program BAA for details on how DoD will assess security risks presented by small business concerns.

Discretionary Technical and Business Assistance (TABA). The SBIR and STTR Policy Directive section 9(b) allows the DON to provide TABA (formerly referred to as DTA) to its awardees. The purpose of TABA is to assist awardees in making better technical decisions on SBIR/STTR projects; solving technical problems that arise during SBIR/STTR projects; minimizing technical risks associated with SBIR/STTR projects; and commercializing the SBIR/STTR product or process, including intellectual property protections. Proposing small business concerns may request, in their Phase I Cost Volume (Volume 3) and Phase II Cost Volume, to contract these services themselves through one or more TABA providers in an amount not to exceed the values specified below. The Phase I TABA amount is up to $6,500 and is in addition to the award amount. The Phase II TABA amount is up to $25,000 per award. The TABA amount, of up to $25,000, is to be included as part of the award amount and is limited by the established award values for Phase II by the SYSCOM (i.e. within the $1,800,000 or lower limit specified by the SYSCOM). As with Phase I, the amount proposed for TABA cannot include any profit/fee by the proposing small business concern and must be inclusive of all applicable indirect costs. TABA cannot be used in the calculation of general and administrative expenses (G&A) for the SBIR proposing small business concern. A Phase II project may receive up to an additional $25,000 for TABA as part of one additional (sequential) Phase II award under the project for a total TABA award of up to $50,000 per project. A small business concern receiving TABA will be required to submit a report detailing the results and benefits of the service received. This TABA report will be due at the time of submission of the final report.

Request for TABA funding will be reviewed by the DON SBIR/STTR Program Office.

If the TABA request does not include the following items the TABA request will be denied.

- TABA provider(s) (firm name)
- TABA provider(s) point of contact, email address, and phone number
- An explanation of why the TABA provider(s) is uniquely qualified to provide the service
- Tasks the TABA provider(s) will perform (to include the purpose and objective of the assistance)
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must NOT:

- Be subject to any profit or fee by the STTR proposing small business concern
- Propose a TABA provider that is the STTR proposing small business concern
- Propose a TABA provider that is an affiliate of the STTR proposing small business concern
- Propose a TABA provider that is an investor of the STTR proposing small business concern
- Propose a TABA provider that is a subcontractor or consultant of the requesting small business concern otherwise required as part of the paid portion of the research effort (e.g., research partner, consultant, tester, or administrative service provider)

TABA requests must be included in the proposal as follows:

- Phase I:
    - Online DoD Cost Volume (Volume 3) – the value of the TABA request.
    - Supporting Documents (Volume 5) – a detailed request for TABA (as specified above) specifically identified as “TABA” in the section titled Additional Cost Information when using the DON Supporting Documents template.
- Phase II:
    - DON Phase II Cost Volume (provided by the DON SYSCOM) - the value of the TABA request.

— Supporting Documents (Volume 5) – a detailed request for TABA (as specified above) specifically identified as "TABA" in the section titled Additional Cost Information when using the DON Supporting Documents template.

Proposed values for TABA must NOT exceed:
- Phase I: A total of $6,500
- Phase II: A total of $25,000 per award, not to exceed $50,000 per Phase II project

If a proposing small business concern requests and is awarded TABA in a Phase II contract, the proposing small business concern will be eliminated from participating in the DON SBIR/STTR Transition Program (STP), the DON Forum for SBIR/STTR Transition (FST), and any other Phase II assistance the DON provides directly to awardees.

All Phase II awardees not receiving funds for TABA in their awards must participate in the virtual DON STP Kickoff during the first or second year of the Phase II contract. While there are no travel costs associated with this virtual event, Phase II awardees should budget time of up to a full day to participate. STP information can be obtained at: https://navystp.com. Phase II awardees will be contacted separately regarding this program.

Disclosure of Information (DFARS 252.204-7000). In order to eliminate the requirements for prior approval of public disclosure of information (in accordance with DFARS 252.204-7000) under this award, the proposing small business concern shall identify and describe all fundamental research to be performed under its proposal, including subcontracted work, with sufficient specificity to demonstrate that the work qualifies as fundamental research. Fundamental research means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons (defined by National Security Decision Directive 189). A small business concern whose proposed work will include fundamental research and requests to eliminate the requirement for prior approval of public disclosure of information must complete the DON Fundamental Research Disclosure and upload as a separate PDF file to the Supporting Documents (Volume 5) in DSIP as part of their proposal submission. The DON Fundamental Research Disclosure is available on https://navysbir.com/links_forms.htm and includes instructions on how to complete and upload the completed Disclosure. Simply identifying fundamental research in the Disclosure does **NOT** constitute acceptance of the exclusion. All exclusions will be reviewed and, if approved by the government Contracting Officer, noted in the contract.

Partnering Research Institutions. The Naval Academy, the Naval Postgraduate School, and other military academies are Government organizations but qualify as partnering research institutions. However, DON laboratories DO NOT qualify as research partners. DON laboratories may be proposed only IN ADDITION TO the partnering research institution.

System for Award Management (SAM). It is strongly encouraged that proposing small business concerns register in SAM, https://sam.gov, by the Close date of this BAA, or verify their registrations are still active and will not expire within 60 days of BAA Close. Additionally, proposing small business concerns should confirm that they are registered to receive contracts (not just grants) and the address in SAM matches the address on the proposal.

Notice of NIST SP 800-171 Assessment Database Requirement. The purpose of the National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171 is to protect Controlled Unclassified Information (CUI) in Nonfederal Systems and Organizations. As prescribed by DFARS 252.204-7019, in

order to be considered for award, a small business concern is required to implement NIST SP 800-171 and shall have a current assessment uploaded to the Supplier Performance Risk System (SPRS) which provides storage and retrieval capabilities for this assessment. The platform Procurement Integrated Enterprise Environment (PIEE) will be used for secure login and verification to access SPRS. For brief instructions on NIST SP 800-171 assessment, SPRS, and PIEE please visit https://www.sprs.csd.disa.mil/nistsp.htm. For in-depth tutorials on these items please visit https://www.sprs.csd.disa.mil/webtrain.htm.

Human Subjects, Animal Testing, and Recombinant DNA. Due to the short timeframe associated with Phase I of the SBIR/STTR process, the DON does not recommend the submission of Phase I proposals that require the use of Human Subjects, Animal Testing, or Recombinant DNA. For example, the ability to obtain Institutional Review Board (IRB) approval for proposals that involve human subjects can take 6-12 months, and that lengthy process can be at odds with the Phase I goal for time-to-award. Before the DON makes any award that involves an IRB or similar approval requirement, the proposing small business concerns must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human, animal, or recombinant DNA protocols. It will not impact the DON's evaluation, but requiring IRB approval may delay the start time of the Phase I award and if approvals are not obtained within two months of notification of selection, the decision to award may be terminated. If the use of human, animal, and recombinant DNA is included under a Phase I or Phase II proposal, please carefully review the requirements at: https://www.nre.navy.mil/work-with-us/how-to-apply/compliance-and-protections/research-protections. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

Government Furnished Equipment (GFE). Due to the typical lengthy time for approval to obtain GFE, it is recommended that GFE is not proposed as part of the Phase I proposal. If GFE is proposed, and it is determined during the proposal evaluation process to be unavailable, proposed GFE may be considered a weakness in the technical merit of the proposal.

International Traffic in Arms Regulation (ITAR). For topics indicating ITAR restrictions or the potential for classified work, limitations are generally placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

SELECTION, AWARD, AND POST-AWARD INFORMATION

Notifications. Email notifications for proposal receipt (approximately one week after the Phase I BAA Close) and selection are sent based on the information received on the proposal Cover Sheet (Volume 1). Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Debriefs. Requests for a debrief must be made within 15 calendar days of select/non-select notification via email as specified in the select/non-select notification. Please note debriefs are typically provided in writing via email to the Corporate Official identified in the proposal of the proposing small business concern within 60 days of receipt of the request. Requests for oral debriefs may not be accommodated. If contact information for the Corporate Official has changed since proposal submission, a notice of the change on company letterhead signed by the Corporate Official must accompany the debrief request.

Protests. Interested parties have the right to protest in accordance with the procedures in FAR Subpart 33.1.

Pre-award agency protests related to the terms of the BAA must be served to: osd.ncr.ousd-r-e.mbx.SBIR-STTR-Protest@mail.mil. A copy of a pre-award Government Accountability Office (GAO) protest must also be filed with the aforementioned email address within one day of filing with the GAO.

Protests related to a selection or award decision should be filed with the appropriate Contracting Officer for an Agency Level Protest or with the GAO. Contracting Officer contact information for specific DON Topics may be obtained from the DON SYSCOM Program Managers listed in Table 2 above. For protests filed with the GAO, a copy of the protest must be submitted to the appropriate DON SYSCOM Program Manager and the appropriate Contracting Officer within one day of filing with the GAO.

Awards. Due to limited funding, the DON reserves the right to limit the number of awards under any topic. Any notification received from the DON that indicates the proposal has been selected does not ultimately guarantee an award will be made. This notification indicates that the proposal has been selected in accordance with the evaluation criteria and has been sent to the Contracting Officer to conduct cost analysis, confirm eligibility of the proposing small business concern, and to take other relevant steps necessary prior to making an award.

Contract Types. The DON typically awards a Firm Fixed Price (FFP) contract or a small purchase agreement for Phase I. In addition to the negotiated contract award types listed in the section of the DoD SBIR/STTR Program BAA titled Proposal Fundamentals, for Phase II awards the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

Funding Limitations. In accordance with the SBIR and STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per small business concern per topic. Additionally, to adjust for inflation DON has raised Phase I and Phase II award amounts. The maximum Phase I proposal/award amount including all options (less TABA) is $240,000. The Phase I Base amount must not exceed $140,000 and the Phase I Option amount must not exceed $100,000. The maximum Phase II proposal/award amount including all options (including TABA) is $1,800,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $1,800,000 based on available funding. The structure of the Phase II proposal/award, including maximum amounts as well as breakdown between Base and Option amounts will be provided to all Phase I awardees either in their Phase I award or a minimum of 30 days prior to the due date for submission of their Initial Phase II proposal.

Contract Deliverables. Contract deliverables for Phase I are typically a kick-off brief, progress reports, and a final report. Required contract deliverables (as stated in the contract) must be uploaded to https://www.navysbirprogram.com/navydeliverables/.

Payments. The DON makes three payments from the start of the Phase I Base period, and from the start of the Phase I Option period, if exercised. Payment amounts represent a set percentage of the Base or Option value as follows:

Days From Start of Base Award or Option	Payment Amount
15 Days	50% of Total Base or Option
90 Days	35% of Total Base or Option
180 Days	15% of Total Base or Option

Transfer Between SBIR and STTR Programs. Section 4(b)(1)(i) of the SBIR and STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a BAA for SBIR may transition in Phase II to STTR and vice versa.

PHASE II GUIDELINES

Evaluation and Selection. All Phase I awardees may submit an **Initial** Phase II proposal for evaluation and selection. The evaluation criteria for Phase II is the same as Phase I. The Phase I Final Report, Initial Phase II Proposal, and Transition Outbrief (as applicable) will be used to evaluate the small business concern's potential to progress to a workable prototype in Phase II and transition technology to Phase III. Details on the due date, content, and submission requirements of the Initial Phase II Proposal will be provided by the awarding SYSCOM either in the Phase I contract or by subsequent notification.

NOTE: All SBIR/STTR Phase II awards made on topics from BAAs prior to FY13 will be conducted in accordance with the procedures specified in those BAAs (for all DON topics, this means by invitation only).

Awards. The DON typically awards a Cost Plus Fixed Fee contract for Phase II; but, may consider other types of agreement vehicles. Phase II awards can be structured in a way that allows for increased funding levels based on the project's transition potential. To accelerate the transition of SBIR/STTR-funded technologies to Phase III, especially those that lead to Programs of Record and fielded systems, the Commercialization Readiness Program was authorized and created as part of section 5122 of the National Defense Authorization Act of Fiscal Year 2012. The statute set-aside is 1% of the available SBIR/STTR funding to be used for administrative support to accelerate transition of SBIR/STTR-developed technologies and provide non-financial resources for the small business concerns (e.g., the DON STP).

PHASE III GUIDELINES

A Phase III SBIR/STTR award is any work that derives from, extends, or completes effort(s) performed under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR programs. This covers any contract, grant, or agreement issued as a follow-on Phase III award or any contract, grant, or agreement award issued as a result of a competitive process where the awardee was an SBIR/STTR firm that developed the technology as a result of a Phase I or Phase II award. The DON will give Phase III status to any award that falls within the above-mentioned description. Consequently, DON will assign SBIR/STTR Data Rights to any noncommercial technical data and noncommercial computer software delivered in Phase III that were developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and their subcontractors must follow the same guidelines as above and ensure that companies operating on behalf of the DON protect the rights of the SBIR/STTR firm.

Navy STTR 23.B Topic Index

N23B-T030 TITLE: Secure Mid-wave Free-space Mid-wave Infrared Optical Communication Using Chaotic Laser Mode

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber

OBJECTIVE: Develop mission capability of secure free-space mid-wave infrared communications that optimize data transfer rates and bit error rate (BER) while achieving physical-layer security such that eavesdroppers cannot decipher intercepted messages.

DESCRIPTION: Free-space optical (FSO) communication in the mid-wave infrared (MWIR) allows the transmission of signal in non-optimal atmospheric conditions with the presence of optical obscurants such as fog, rain or snow, taking advantage of the low-absorption windows in the 3–5 μm and 8–12 μm spectral ranges. Quantum Cascade Lasers (QCLs) have attained performance levels, which make them attractive as transmitter sources for FSO communication. The extremely fast carrier dynamics and pico-second scale upper-level photon lifetimes present the potential for high bandwidth with relatively low-temperature dependence and a small-package footprint. Semiconductor lasers with distributed feedback have shown strong longitudinal-mode selection, and are ideal candidates for communication applications. Although the narrow-beam, direct link between the FSO transmitter and receiver makes it more difficult to intercept an FSO signal than RF-wireless communication, the FSO is still not impervious to interception. Advances in high-speed computing threaten the ability of data encryption to prevent deciphering of intercepted messages. Additional measures to ensure data security are needed when absolute security is a requirement. Various methods of securing data at the physical level have been studied extensively for telecom lasers and wavelengths, but while these methods may conceivably be extended to mid-IR QCLs, the device dynamics for QCLs are much more complex. One method for secure communication is using lasers operating within the chaotic regime. Researchers using chaos in the fiber-optic telecom wavelength range have been able to theoretically show data transfer rates on the order of 4–10 Gbit/s while using chaos [Refs 1, 2].

Recent work [Refs 3-6] has shown that, similar to their interband (diode) semiconductor laser counterpart, QCLs exhibit chaotic behavior in both the temporal and frequency domains. However, this work has shown a relatively high BER for larger data transfer rates owing to a reduced correlation between the leader and follower lasers. In interband devices, the linewidth enhancement factor, which can influence chaotic behavior, is dependent on the feedback ratio, as well as the drive current and output power [Ref 7]. Further work is needed to control the onset of chaos in QCLs and demonstrate the feasibility of a QCL-based communication link using chaos to ensure security of high-data rate communications. For FSO communication over longer distances and in adverse weather conditions such as rain or haze, high-power MWIR sources are required. Furthermore, the degree of chaos is expected to increase with output power since for QCLs it has been found [Ref 8] that the linewidth enhancement factor increases as the drive current above threshold increases. Characterization of chaos at high-output powers will be necessary for the development and use of secure mid-IR FSO communications. To ensure security, an eavesdropper BER can be used as guidance with values above 25% [Ref 9].

PHASE I: Establish the feasibility of the proposed method to improve chaos bandwidth beyond 100 MHz and link distance beyond 100 m from an MWIR source operating within the ~ 10 μm low-absorption window. Support the analysis with QCL experimental data at any wavelength. Design a leader and follower laser to meet Phase II goals. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Demonstrate a transmitter and receiver using chaos in the 10 μm wavelength region to mask a signal with a BER of less than 4% and a data transfer rate greater than 100 Mbit/s at a link distance > 1 km. An eavesdropper should have an error rate of > 25%.

PHASE III DUAL USE APPLICATIONS: Develop a prototype based on the design from Phase II for transition to an operational test asset, which will be determined in Phase III. Issues related to test platform integration will be addressed in cooperation with the Government. Focus on risk management and mitigation (versus the test plan and schedule). Other Government applications within the Drug Enforcement Agency and the Intelligence Community for use with non-RF, covert communication under adverse weather conditions are also considerations.

Private sector use in telecommunication and local, urban communication (communication nodes—line of sight) would benefit from this technology due to its high-security and high-bandwidth capabilities even in adverse weather conditions.

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KEYWORDS: Secure; mid-wave; infrared; free-space; optical communication; chaotic laser Mode

N23B-T031 TITLE: Collaborative Multi-Robot Systems by RF-Optical-Quantum Ultra-Low Latency Wireless Networking

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): FutureG; Integrated Sensing and Cyber; Trusted AI and Autonomy

OBJECTIVE: Design and develop a fully autonomous robotic solution where a multi-robot team in a communication-degraded and GPS-denied environment can complete a mission with minimal human supervision under extreme environmental conditions.

DESCRIPTION: It is well known that the future battlefield will experience complex artificial intelligence (AI) competition. An automated group of drones, or unmanned ships/submarines, is expected to be a primary form of future weapon systems and surveillance/reconnaissance systems. Technology-wise, based on the collected sensor information, each robot collaboratively acts to accomplish the common mission goal of this multi-robot system (MRS) and multi-agent system (MAS). In the meantime, the adversary will develop similar collaborative MRS to form the "competition". A major focus on AI of a single agent or collective data analytics of battlefield, is desirable to elaborate the collaborative MRS to achieve superiority in the battlefield using intelligent machines and systems, provided there is:

(a) effective artificial intelligence/machine learning (AI/ML) among multi-robot, not just AI for a single robot, so that complex strategy and maneuver for these robots can be facilitated, and
(b) ultra-low latency wireless networking to enable fastest possible response to complicated situations in the battlefield, while maintaining low probability of interception and jamming.

The proposed technology is to dominate the winning edge in such "competitions" through the cyber warfare technology in communication and computation, with feature technologies:

1. Cyber topology control: A fully connected cyber topology (sensor observation and communication among robots) would assist achieving the mission. Smart topology control enhances the performance of collaborative MRS.
2. Predictive machine learning for adversary's movement: achievable through integrating multiple online machine learning techniques, while deep learning as offline reference may further assist.
3. Strategic maneuver to neutralize adversary's actions: In addition to AI, with the aid of communication, proper selection of action algorithms for each collaborative robot works.
4. Attack the cyber links of the adversary (both communication and AI), to destroy adversary's cyber topology control and ensures the success of the mission.

There is interest in innovating the two technological frontiers listed above (cyber topology and AI) and developing an integrated solution, to accomplish superior AI capability in the future battlefield, with the following long-term technologies:

1. An MRS that can accomplish the collective goal or mission in a sophisticated and dynamic policy subject to the dynamics in the battlefield, with the shortest possible response time. For example, (a) to intercept one or multiple hypersonic missile(s) toward an extremely high-value asset by collaborative lower-speed anti-missiles, and (b) a group of collaborative drones to attack an adversary's high-value asset. This research aims at innovative networked AI for MRS.
2. Current secure data links typically suffer delays in the range up to seconds or even tens of seconds, which is not possible to support any real-time collaboration of robots. The fundamental reason behind this is that the communication links and networks have been designed based on human-to-human (H2H) communication, rather than machine-to-machine (M2M) communication. This research aims at wireless M2M networking of minimal end-to-end latency (i.e., < 1 msec).

3. Given the adversary's capability of electronic warfare, the wireless network must be resilient against jamming and interception. In addition to post-quantum cryptography, a multimode wireless network shall be innovated, which consists of multi-frequency radio frequency (RF), optical wireless, and quantum optical wireless technologies to form the multimode multipath (M3P) transmissions as a secure and resilient ultra-low latency wireless networking for 2. Possible blockchain management of launching codes, and so forth, allows distributed battlefield management to better fit the efficiency of MRS.

There is interest in utilizing emerging classes of miniature (Group 1) Unmanned Vehicles (UVs) for a variety of surveillance and reconnaissance applications in support of the Department of the Navy's Strategic Blueprint for the Arctic. This SBIR topic seeks to develop and demonstrate a new class of miniature UVs (air, ground, surface, subsurface or a combination thereof). These systems will be air deployed and have the capability to traverse across difficult terrain such as swamps, desert, tundra, and snow or water bodies to satisfy the most demanding mobility requirements of airborne and expeditionary forces. The end goal is a fully autonomous robotic solution where a multi-robot team in a communication-degraded and GPS-denied environment can complete a mission with minimal human supervision under extreme environmental conditions, such as artic and desert temperatures, high altitudes, sand, rain, sleet, and ice.

System Attributes are:

(a) air, surface and subsurface capable,
(b) each robot/agent in the MRS/MAS has its own AI capability to act, and collaboratively accomplish a goal (or mission),
(c) end-to-end latency: less than 1 m/sec,
(d) operate in a communication-degraded and GPS-denied environment,
(e) real-time data output: longitude, latitude, altitude/height, velocity, roll, pitch, yaw/heading, angular rates, acceleration, health status, and calibrated raw data INS/GNSS (for post-processing)
(f) interfaces: RS422 (UART and HDLC/SDLC) interfaces, CANaero/ARINC825/CAN, ARINC429, Ethernet (TCP/IP and UDP), and SYNC-I/Os, and
(g) output and diagnostic measurement system included (full mission duration storage).

Work produced in Phase II may become classified.

Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret NAVY level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Describe offense and defense tactics via collaboration in order to compete against the adversary. Define the architecture and topology for ultra-low latency communications and networked AI/ML methodology and operational features. Identify specific sensors or sensor suites to be included and develop the strategy and design of integration and scale of the autonomous platform and onboard processing/architecture. Describe logistics and maintenance strategy. Define the autonomous behaviors, requirements of software and communications to allow cooperative sensor array technology collaboration. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a multimode wireless network architecture of ultra-low latency prototype platform and validate the component integration in terms of physical implementation: architectures, electronics, and communications to facilitate networked AI MRS. Conceptual demonstration of technology (i.e., networked AI to form the collaborative strategy), with one scenario of field demonstration and another scenario of computer simulations. Develop the autonomous behaviors, swarming software and communications defined in Phase I. Perform potential land/sea trial tests of cooperative swarming activities of multiple vessels. Evaluate performance using both single and swarming deployment. Demonstrate ability to operate in various EM environments.

Work in Phase II may become classified. Please see note in Description section.

PHASE III DUAL USE APPLICATIONS: Complete final testing and perform necessary integration and transition for use in multi-platform operations with appropriate current platforms and agencies, and future combat systems (FCS) under development.

Commercially this architecture and product could be used to enable remote airborne environmental monitoring and surveying.

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KEYWORDS: Artificial Intelligence/Machine Learning; AI/ML; Quantum; Communication Architecture; Ultra Low-Latency; Communication; GPS denied

N23B-T032 TITLE: Development of an Additive Manufacturing (AM) Candidate Assessment Tool

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

OBJECTIVE: Design and develop a data access tool that can determine if a part could be and should be produced via additive manufacturing (AM). These disciplines can include, but are not limited to the following: engineering design, manufacturability, producibility, testing, and machine learning to develop expert-guided algorithms to identify which readiness degraders, sustainment issues, and next generation components can be produced via AM.

DESCRIPTION: AM has the potential to increase readiness and improve maintenance and sustainment operations by reducing long lead times and eliminating obsolescence related issues. Furthermore, the technology enables improvements to current systems (e.g., light-weighting, part count reduction, increased system performance) through designs that are not possible by conventional manufacturing techniques. However, for the technology to continue to transition from indirect uses to efficiently producing qualified end use parts several technology barriers need to be overcome. One of the primary needs is the development and integration of data access tools with analytical capability to optimize the selection of viable families of AM candidate parts without requiring the burden of manual item-by-item review. The solution also should include analytical capabilities to effectively manage product technical and logistics information and provide users with substantive assessments on an item's suitability to AM production.

Knowledge of computer aided design (CAD), technical data packages (TDPs), and product lifecycle management (PLM) tools is required, as well as the ability to quantify the limitations of existing AM systems and processes. Innovative design concepts are being sought for the development of an AM candidate assessment tool with the ability to:

(1) coarsely filter and screen for irrelevant parts,
(2) identify candidate parts using criteria such as material, performance requirements and parts family types,
(3) predict production estimates and delivery schedules by building/expanding upon a cost and time estimation tool, and
(4) automatically search Navy databases for parts most suitable for AM and subsequently validate them using a machine learning model or algorithm.

PHASE I: Develop, design, and demonstrate feasibility of a concept for an AM candidate assessment tool utilizing representative data. Develop a "coarse" filter or screening mechanism for candidate parts. The filter will use binary (yes/no) expert judgments, combined with active machine learning (ML) (e.g., adding expert judgements iteratively to understand the value of additional information), to filter parts unsuitable for AM. The tool will screen by critical dimensions (i.e., work envelope or bounding box) and known limitations of existing additive manufacturing systems of interest. Design should consider other criteria such as material, performance requirements, and parts family when determining the suitability of a part for AM. Refine existing cost and time estimation tools to predict production cost estimates and delivery schedules for representative AM part candidates. Production cost estimates should consider all post-processing operations (e.g., heat treatment, surface treatment, final machining, and inspection) required to meet the part's acceptance criteria. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Extend the decision model(s) developed under Phase I to address Navy part characteristics and mission priorities to develop a mutually agreed upon prioritization schema. Produce a ML algorithm, seeded with the aforementioned models, to integrate and search Navy databases for parts most suitable for

AM, and the value of potentially (costly) additional information. Demonstrate and validate the prototype by utilizing actual Navy data.

PHASE III DUAL USE APPLICATIONS: Transition the tool under the guidance of PEO-CS Digital Thread team and/or NAWCAD LKE's Digital Enterprise Tools Branch. Commercialize the tool resulting from the Phase I/II R/R&D activities. This would likely involve further integration with existing, commercially-available CAD and PLM platforms.

Military and Commercial sectors that could benefit from this AM part identification tool include: aerospace, shipping, space, transportation, rail, automobile, and medical. Applications include almost all technology areas such as engine parts, structural parts, mechanical or electrical parts, medical prosthetics, and dental implants. Support the Navy/DoD to help transitioning the system to a DoD SYSCOM in support of various programs.

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KEYWORDS: Additive Manufacturing; AM; Artificial Intelligence; AI; Machine Learning; ML; ; Neural Networks; Laser-Based Powder Bed Fusion; Candidate Identification; Decision Making

N23B-T033 TITLE: Electron Beam Additive Manufacturing (EBAM) Capability for Large, Complex, Metallic Components

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Materials; Sustainment

OBJECTIVE: Develop the capability to additively manufacture large, high-complexity, high-criticality metallic parts using wire-fed directed energy deposition (DED) electron beam additive manufacturing (EBAM) and establish a qualification approach for these parts.

DESCRIPTION: Traditional manufacturing techniques used to produce large, high-complexity, high-criticality metallic parts involve significant cost and schedule investments related to machine time and material waste. Alternatively, these parts can be manufactured using wire-fed DED EBAM to create near-net fabrications to reduce final machine time, raw material lead time, and material waste. In addition to these part-specific benefits, developing this capability will impact readiness by reducing manufacturing lead times, as well as sustainment by producing difficult to acquire parts or part repairs. Naval Air Warfare Center Aircraft Division (NAWCAD) Lakehurst is seeking innovative solutions to develop this capability through the material and process qualification and production of a large (~12 in. x 16 in. x 56 in. [30.48 cm x 40.64 cm x 142.24 cm]; ~400 lb [181.44 kg]) critical safety item (CSI) part belonging to the Aircraft Launch and Recovery (ALRE) Department made from a custom high-strength steel. Access to commercially available EBAM technology that can deposit steel wire feedstock and the ability to characterize the material properties of AM produced parts in order to develop an optimized parameter set resulting in repeatable mechanical properties for the selected part are required for this SBIR effort. The goal is to produce and test AM material in two stages. The initial stage of this initiative aims to produce an optimized parameter set for depositing custom high-strength steel with a wire-fed DED EBAM system. This will consist of initial bead on plate deposition trials, preliminary material analysis, larger volume depositions to optimize hatch spacing and layer height, coupon fabrication, and material property characterization. The intent of the second stage of this initiative is to apply the optimized parameter set to manufacture the near-net fabrication of the custom high-strength steel part. This will include the development of a process control document, toolpath generation, part deposition, final machining, establishment of qualification considerations, and Non-destructive Inspection/Non-destructive Testing (NDI/NDT) requirements, final part inspection and testing, coupon testing, and the documentation of all processes referenced here. The final deliverable will be a prototype part that meets the engineering requirements of the high-strength steel CSI ALRE part as well as the procedures and documentation required to establish a repeatable wire-fed DED EBAM process for manufacturing the part.

PHASE I: Develop optimized wire-fed DED EBAM process parameters for the targeted ALRE component using initial bead on plate trials and preliminary material analysis for the deposition of custom high-strength steel wire feedstock deposited onto a compatible substrate material (most likely made from the same alloy as the wire feedstock). The resulting plates will be sectioned and analyzed with respect to density, hardness, porosity, bead geometry, microstructure, adhesion, and visual defects. Once a suitable baseline parameter set is achieved, larger volume depositions will be required to optimize hatch spacing and layer height. These depositions will be designed to section, polish, and etch in order to determine porosity and grain structure. Further large volume depositions will be used to machine coupons that will be tested to determine the following mechanical properties: tensile strength, density, porosity, hardness, and thermal distortion. At the end of Phase I, an optimized and repeatable parameter set will be developed and demonstrated to meet the qualification test plan (QTP) requirements for the deposition of this custom high-strength steel. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design and develop a near-net fabrication process based on the results of Phase I, for a large CSI ALRE part made from high-strength steel on a wire-fed DED EBAM system. This process will cover system setup, material selection, parameter set selection, toolpath generation, feed rates, preheating, and

post-build processing. Produce a near-net fabricated part along with ride-along coupons necessary to determine the final mechanical properties of the build using the process outlined. After deposition, the near-net fabrication will be final machined, inspected, tested, and qualified. Alongside the NDI/NDT of the part, the ride-along coupons will be machined and prepared for destructive testing. The final deliverable will be a prototype part produced by wire-fed DED EBAM utilizing the custom high-strength steel, an approved process control document, and material test data that meets the performance requirements set forth in the agreed upon part certification plan.

PHASE III DUAL USE APPLICATIONS: Work with Navy programs of record to certify and implement components manufactured using wire-fed DED EBAM. Developing this capability using pathfinder parts like this CSI ALRE component will help to identify other parts throughout the Navy that would be good candidates for wire-fed DED EBAM technology. Wire-fed EBAM technology can be utilized on any metallic parts that have high-material waste, machine time, procurement lead time, procurements costs, or other issues that could be solved with EBAM technology. Once the material has been qualified and the part has been certified, the procedures can easily be replicated for a family of parts in the same material and part classification level.

Military and Commercial sectors that could benefit from this AM system include: aerospace, shipping, space, transportation, rail, and automobile. Applications include almost all technology areas such as: engine parts, structural parts, mechanical parts, and support equipment.

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KEYWORDS: Additive Manufacturing; AM; Electron Beam; Directed Energy Deposition; Wire-fed DED; Metal AM; Large Format AM

N23B-T034 TITLE: Silicon Photonics Integration

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics

OBJECTIVE: Develop new methodologies (or improve existing methodologies) to determine the reliability of silicon Photonic Integrated Circuit (PIC) devices and identify failure mechanisms with an emphasis on determining the influence of neighboring intra-chip devices, input/output components, and packaging.

DESCRIPTION: PICs provide a tremendous opportunity to significantly improve the performance of future generation microelectronic systems. PICs of continuously increasing complexity are finding applications in analog signal processing, optical communication, light detection and ranging (lidar), chemical and biological sensing, artificial intelligence (AI), quantum applications, and custom Department of Defense (DoD) applications. For example, PICs are a key part of high-capacity transceivers and switches for internet data centers, and are under investigation for transmitters and receivers for free space optical communications, hyperspectral imaging devices, light sources for medical diagnostic equipment, and light sources for atomic clocks and gyroscopes. The reliability of PIC devices applicable to DoD avionics, sensors, and electronic warfare (EW) continues to be under study by the DoD Science & Technology community. Verification and validation of integrated photonic device reliability is paramount to opening the door for technology transition opportunity discussions with programs. Laboratory testing of state-of-the-art silicon photonic devices under development in the DoD or in commercial-sector production requires integration with electrical and optical input/output devices at the package level.

Military uses of PICs require environmental ruggedness and reliable operation on the order of 100,000 hr mean time or longer between failures. Device operation has to be sustained under extreme conditions, such as high temperature (> 100 ºC), low temperature (< -40 ºC), high radiation, vibration, shock, and humidity. This SBIR topic seeks to evaluation of the underlying reliability physics of silicon based PIC chips and their corresponding packages, to improve the understanding of their failure mechanisms. Representative silicon-based PICs should be selected, and the main degradation modes should be experimentally and theoretically evaluated. Possible degradation modes include semiconductor crystal point defects and dislocations, dielectric and semiconductor optical absorption changes, material transition interface damage and passivation, dopant diffusion, material mechanical stress, metal diffusion, outgassing, solder creep, and intermetallic compound instability. At the package level possible degradation modes include optical coupling efficiency degradation at optical waveguide and/or fiber optic interfaces, electrical bond (bump or wire) failure, and loss of hermetic seal. These representative PICs should be subjected to Highly Accelerated Life Test (HALT) experiments to uncover failures, which will then improve the understanding of device failure physics and packaging failures after appropriate analysis. Individual chips, chip-on-carrier (CoC), and fully packaged devices should be considered for HALT plan creation and evaluation. Acceleration factors such as temperature, electrical bias, optical power, radiation and mechanical stress should be considered according to MIL-HDBK 217 and MIL-STD-810. Particular emphasis should be placed on understanding the influence of individual PIC devices on the reliability of the optical coupling and packaging. PIC integration with planar lightwave circuits (PLCs) and other optical waveguide devices should also be investigated.

Possible failure mechanism evaluation tools to be used include X-Ray radiography, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Optical beam induced current (OBIC), Focused Ion Beam Etching (FIB), Deep-level Transient Spectroscopy (DLTS), and Atomic Force Microscope (AFM) among many others.

The models verified through experimental testing and the improved understanding of PIC/PLC device and package reliability physics will be used to create reliability prediction models and software for PICs/PLCs planned for use in military environments. Due to the large variety of PIC/PLC architectures and base materials, both in fabrication and under development, it is possible that several methods will be identified to extrapolate the PIC lifetime depending on the device specifics.

PHASE I: Define innovative methods to model, and predict silicon PIC and packaged silicon PIC reliability, including experimental test plans based on state-of-the-art reliability physics of failure and modeling, and simulation analyses to ascertain existing software prediction shortcomings. Develop models and experimental test plans for application to silicon-photonic integrated circuit devices, including circuit layouts and packages designed to accommodate these test plans. The focus should be on PIC circuits and components relevant to microwave and analog signal processing. Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Acquire representative silicon PIC and packaged silicon PIC devices for experimental testing and perform testing. Develop, demonstrate, and validate the reliability prediction models. Subject silicon PIC and packaged silicon PIC devices to environmental and mechanical test stresses based on modeling and simulation results, reliability engineering principles, and experimental test plans. Perform root cause analyses of device failures to understand silicon PIC, optical input/output, electrical input/output device, and package interactions and reliability prediction interdependencies. Develop, demonstrate, and deliver a packaged silicon PIC reliability software package for subsequent independent verification and validation.

PHASE III DUAL USE APPLICATIONS: Transition the software package to enable DoD and silicon photonic device producers to predict reliability. Commercial data centers or internet facilities are commercial sector applications of silicon photonics.

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