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

IMPORTANT

- **The following instructions apply to STTR topics only:**
  - **N24A-T001 through N24A-T024**

- Submitting small business concerns are encouraged to thoroughly review the DoD Program BAA and register for the DSIP Listserv to remain apprised of important programmatic changes.
  - The DoD Program BAA is located at: https://www.defensesbirsttr.mil/SBIR-STTR/Opportunities/#announcements. Select the tab for the appropriate BAA cycle.
  - Register for the DSIP Listserv at: https://www.dodsbirsttr.mil/submissions/login.

- 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.

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	Navy SBIR/STTR Program Management Office usn.pentagon.cnr-arlington-va.mbx.navy-sbir-

		sttr@us.navy.mil or appropriate Program Manager listed 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
N24A-T001 to N24A-T006	Ms. Kristi DePriest	Naval Air Systems Command (NAVAIR)	navair-sbir@us.navy.mil
N24A-T007 to N24A-T009	Mr. Jason Schroepfer	Naval Sea Systems Command (NAVSEA)	NSSC_SBIR.fct@navy.mil
N24A-T010 to N24A-T024	Mr. Steve Sullivan	Office of Naval Research (ONR)	usn.pentagon.cnr-arlington-va.mbx.onr-sbir-sttr@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. Proposals that are encrypted, password protected, or otherwise locked in any portion of the submission will be REJECTED unless specifically directed within the text of the topic to which you are submitting. 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)

— Cost Sharing: Cost sharing is not accepted on DON Phase I proposals.

- 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. The information considered for this decision will come from Volume 2. 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. The Due Diligence Program to Assess Security Risks will be implemented for all Phases.

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 <u>NOT</u>:

- Be subject to any indirect costs, 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. A small business concern selected for an award MUST have an active SAM registration at the time of award or they will be considered ineligible.

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 (as stated in the BAA). The Phase I Final Report and Initial Phase II Proposal will be used to evaluate the small business concern's potential to progress to a workable prototype in Phase II and transition the 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 Navy 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 24.A Topic Index

N24A-T001 TITLE: High-Bandwidth Multimode Fiber-Optic Cabling

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Network Systems-of-Systems; Microelectronics; Sustainment

OBJECTIVE: Design and develop a high-bandwidth multimode optical fiber for avionic and sensor applications.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic (EO), communications, and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight, and power (SWaP). The replacement of shielded twisted pair wire and coaxial cable with earlier generation, bandwidth-length product, multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, and throughput, and a reduction in size and weight on aircraft. The effectiveness of these systems hinges on optical communication components that realize high-per-lane throughput, low-latency, and large link budget, and are compatible with the harsh avionic environment.

In the future, data transmission rates of 100 Gbps and higher will be required. Substantial work has been done to realize data rates approaching this goal based on the use of multilevel signal coding, but multilevel signal encoding techniques trade off link budget and latency to achieve high-digital bandwidth. To be successful in the avionic application, existing non-return-to-zero (NRZ) signal coding with large link budget and low-latency must be maintained. There has been considerable focus on the transmitters and receivers for future optical interconnects, but limited attention to optimizing the fiber cabling. Current aircraft have a mix of fiber types that were not anticipated for such high-speed operation. Multimode optical fiber is strongly preferred over single mode optical fiber given the environmental and operating conditions. To further future proof the embedded optical cabling, the Navy seeks a new class of multimode optical fiber that can support operation of 100 Gbps and higher NRZ while maintaining efficient coupling to the optical transmitters and receivers and compatibility with military style fiber-optic termini.

The proposed optical cabling must operate across a -55 °C to +165 °C temperature range, and maintain performance upon exposure to typical naval air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments. The optical fiber must be compatible with lasers in the 850 to 1500 nm band operating at 100 Gbps and higher NRZ to support bandwidth in excess 10 GHz*km. Optical attenuation loss should be consistent with current OM5 multimode fiber.

PHASE I: Design a multimode optical fiber with bandwidth > 10 GHz*km that is compatible with lasers in the S band (850 to 1050 nm) and the O-band (1260 nm to 1400 nm). Develop differential mode dispersion measurement techniques to profile the optical fiber in both the S and O band. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the fiber for high-speed operation over temperature. Measure and define specific launch conditions needed to maintain the bandwidth. Characterize link error potential as a function of connector misalignment, transmitter and receiver optical subassembly design, and environmental conditions.

PHASE III DUAL USE APPLICATIONS: Support transition of the technology to military aircraft platforms. Commercial datacenters will be able to use this new fiber optic cable to connect routers and servers.

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KEYWORDS: non-return-to-zero (NRZ); multimode fiber; 10 GHz*km; launch condition; the S band (850 to 1050 nm) and the O-band (1260 nm to 1400 nm); fiber optic cable.

N24A-T002 TITLE: In-situ AM-2 Aluminum Mat Repair

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

OBJECTIVE: Evaluate the implementation of a novel repair technique for AM-2 aluminum matting repair in-situ. The idea is to analyze the repair effectiveness by comparing virgin AM-2 specimens to specimens artificially damaged and repaired, in terms of mechanical performance.

DESCRIPTION: Rapid deployment of Expeditionary Airfields (EAF) is critical to expedited military transportation and sustained presence across multiple military theaters around the world. At the core of EAF, utilization of aluminum matting, referred to as EAF AM-2 matting, is essential to lay down for air vehicles to successfully land in a variety of soil environments. Maintenance of such a system ensures prevention of premature structural failure, thereby preventing in-service landing failures and loss of life. However, AM-2 matting is often shipped back to a refurbishment facility for various reasons, one of which includes significant structural damage.

The decision to repair is influenced by the type of damage and the defect size encountered when the matting is damaged. Guidance will be provided to awardees. Damage due to forklift tines are also taken into account, where the maximum allowable hole dimensions for repair are 1.5 in. (3.81 cm) wide by 10 in. (25.4 cm) long. If the matting is damaged, the EAF Marines have to pull up and remove all of the surrounding mat to be able to remove and replace the affected piece. Depending on where the damaged mat is in the airfield the current process of removal and replacement can take a substantial amount of time and labor to complete both while downing that portion of the airfield. With the ability to rapidly repair in situ, the mean time to repair (MTTR) will be greatly decreased, thus improving the Operational Availability.

The EAF Marines are an expeditionary force, therefore a premium is placed on weight, size, and maneuverability of materials, which imposes constraints on any solution. The EAF Marines must be prepared to operate in any feasible climate, a requirement that extends to their equipment as well. AM-2 matting is manufactured in either 6 ft (1.83 m) or 12 ft (3.66 m) by 1.5 in. (3.81 cm) by 2 ft (.61 m) pieces of aluminum and weigh 75 lbs (34.02 kg) or 150 lbs (68.04 kg) respectively. AM2 mats are additionally treated with nonskid coating.

The aim of this STTR topic is to enhance the repair and refurbishment capability of EAF AM-2 aluminum matting. Ultimately, an ideal application would involve on-site repair of holes and cracks that form on AM-2 matting while installed on an airfield. Areas of consideration for a potential solution should include fuel/power consumption (if needed), time to repair, and comparable mechanical properties to undamaged AM-2. The threshold for this effort is to repair the damaged aluminum AM-2 matting utilizing a preferred repair technique or method. The objective is to repair the damaged matting and provide some semblance of a friction surface for the repaired surface area.

PHASE I: Provide a conceptual design for a process for the repair and refurbishment of EAF AM-2 aluminum matting. Prove the engineering and economic feasibility of meeting the stated requirements through analysis and lab demonstrations. Identify specific strategies for meeting performance and reliability goals. Optimize the processing parameters for application to various hole and crack sizes on AM-2 matting specimens. Assess representative macrostructural matting specimens under flexure loading is recommended in this phase. Sustainment or improvement of mechanical properties is to be evaluated with use of the chosen repair method/technique. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Demonstrate prototype performance with AM-2 matting. Provide an estimate of costs including manufacturing. Provide a failure analysis, service life estimate, and assessment of meeting requirements. Using optimized parameters evaluated in Phase I, repairs would ideally be conducted on full-scale AM-2 matting structures (6 ft–12 ft) (1.83 m–3.66 m), and full-scale mechanical testing is to be conducted. Data sets are to be obtained and compared to existing data on AM-2 mechanical analyses.

PHASE III DUAL USE APPLICATIONS: In partnership with the PMA and the Arresting Gear IPT, new repair/refurbishment cost and logistics estimates are to be assessed given the optimal materials and parameters established in the previous phases. This will ultimately prepare the repair method for fielding. Any aluminum paneling or matting that is utilized in commercial systems (e.g., stiffener walls for a train, aircraft fuselage paneling and floorboard repair, building materials and building structures) can be repaired with relative ease without having to replace or even remove the part from the rest of the structure or system.

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KEYWORDS: aluminum; matting; in-situ; repair; expeditionary; airfield

N24A-T003 TITLE: High-Frequency 40 GB/s MWIR and LWIR Metamaterials-based Electro-Optical Modulators for Free-Space Optical Communications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Network Systems-of-Systems; Sustainment; Trusted AI and Autonomy

OBJECTIVE: Develop tunable metamaterials that enable narrow-linewidth multi-watt laser transmitter, which operate with ultrafast modulation (40 GHz) and high-beam quality in the 4 to 12 μ spectral region, to provide optical communications in RF-denied environments.

DESCRIPTION: Free-space optical (FSO) communication links provide high-data rate, low latency, secure, wireless mobile communication that are difficult to jam or intercept and do not require spectrum management. FSO communication is an especially compelling alternative to a radio-frequency (RF) link with external RF Interference (RFI) in RF-denied and/or contested environments. Most current proposed or deployed FSO systems are in the short wave Infrared (SWIR) regime at around 1.55 μm due to ubiquity of the laser and optical components customized for fiber-optical communications. Exceptionally high-data rates at this wavelength range are possible when atmospheric effects are not present [Ref 1] and laser-based FSO communication is the leading solution for interconnecting new constellations of low-earth-orbit satellites. Terrestrial FSO links and satellite uplinks have seen some success, but the link budget in the SWIR regime is often limited by optical obscurants such as haze, fog, clouds, atmospheric absorption, and turbulence presence in the atmosphere. SWIR links with stabilized telescopes have been demonstrated to achieve gigabit per second (Gb/s) communication between naval vessels in ship-to-ship and ship-to-shore configurations at ranges of 12 and 45 km (Ref 2), despite the link limitation to 1 km when the visibility was impaired by heavy fog. For FSO laser communications systems operating in the SWIR bands, including 1300 nm and 1550 nm, the photonic wavelength is comparable to the size of aerosols that scatter and attenuate the laser-beam propagation in the channel.

Recent analysis has verified that there are advantages to using long-wave infrared (LWIR) wavelengths for FSO links through the atmosphere [Ref 3]. When the channel transmission is affected by fog, clouds, haze, dust, or turbulence, a near-IR (~ 1.55 μm wavelength) FSO link suffers significantly more attenuation relative to LWIR systems. With the exception of fog and clouds, mid-wave infrared (MWIR) systems share the advantages of LWIR and benefit from higher performance lasers and detectors, as well as reduced diffraction relative to LWIR. Unfortunately, the high-cost, low-bandwidth, and low-output power of otherwise suitable MWIR and LWIR sources has prevented their adoption for this application. Quantum Cascade Lasers (QCLs) and Intraband Cascade Lasers (ICLs) have seen significant development in the past decade, to the point where devices with watt-level output are now feasible at wavelengths covering most of the MWIR, 3-5 μ and LWIR, 8–14 μ spectral regions. Unfortunately, the functionality of these devices is limited, particularly for laser communications, due to the lack of an appropriate modulator. The carrier population in a QCL may be modulated to ~ 100 GHz due to ultrafast carrier dynamics, but the optical modulation bandwidth is significantly less than 10 GHz due to the photon lifetime in the cavity. As the cavity is made longer to produce more power, the modulation speed is reduced by increased photon lifetime, as well as the difficulty of modulating the large current, > 1 A, required in a multi-watt device. Furthermore, high-power devices experience beam pointing instability under large-signal modulation [Ref 4]. These problems are solved in near-IR communications through external modulation and optical amplification, but optical amplification that is compatible with a modulated signal is not available over the majority of the spectral ranges of interest, nor has an appropriate modulator been demonstrated.

Optical metamaterials (MMs), sub-wavelength electromagnetic structures that exhibit optical properties not readily found in natural materials [Ref 5], have huge potential for use in LWIR devices where sub-wavelength structures are > 1 μm and so may be readily fabricated with well-established lithography.

These materials are presently being explored for numerous applications including tunable filters [Ref 6], multicolor IR imaging [Ref 7], ultracompact IR optical components [Ref 8], and optical switching [Ref 9]. However, to be useful as an active device such as a modulator, the metamaterial must be tunable at speeds greater than 10 GHz. Extremely compact plasmonic devices have been demonstrated for on-chip collimation, as well as other optical functions [Ref 8], but so far appear to be difficult to fabricate and lack tunability.

Recently, tunable metamaterial devices based on carrier depletion have been demonstrated with the fastest published result reaching 1.5 GHz (750 MHz 3-dB bandwidth) and projected operation up to 10 GHz [Ref 10]. Further development of these materials is needed to achieve low-insertion loss, high-modulation depth, and modulation to speeds > 40 GHz. The metamaterial-based optical modulator is a viable and feasible technology and the following metrics are the Higher efficiency, longer FSO link for this project:

	Threshold	**Goal**	**Primary Benefits**
Signal bandwidth (3-dB)	> 10 GHz	> 40 GHz	Larger data rate, lower cost per bit
Insertion loss	< 3 dB	< 1 dB	Higher efficiency, longer FSO link
Optical output power	> 0.5 W	> 4 W	Longer FSO link
Optical aperture	> 50 µ	> 500 µ	Lower cost (simpler alignment)
Optical bandwidth	> 10 nm	> 100 nm	Lower cost (wavelength control)
Modulation depth	> 5%	> 90%	Higher efficiency, longer FSO link

PHASE I: Develop concepts for a tunable metamaterial-based optical modulator capable of providing dynamic narrow linewidth tunable properties within the MWIR/LWIR spectral range. It is expected that these concepts will be breadboard demonstrated in order for the tunable metamaterial-based optical modulator to be optimized to operate with a laser transmitter (e.g., QCLs or ICLs).
Demonstrate the feasibility of the proposed tunable metamaterial-based optical modulator concept through numerical simulation and breadboard demonstration of the basic physics of the device compatible with achieving the above topic description threshold performance requirements.
Required Phase I deliverables will include a report with a modeling plan, device designs, and performance goals.

The Phase I effort will include prototype plans to be implemented under Phase II.

PHASE II: Fabricate and demonstrate a prototype system having a laser transmitter operating with a tunable metamaterial-based optical modulator operating in a MWIR or LWIR atmospheric window. The prototype system will be evaluated to determine its capability in meeting the performance goals defined in the Phase I report. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters. Evaluation results along with military specification considerations that were not addressed in the Phase I concept design will be used to refine the prototype into a design that will meet this STTR topic description requirements.

PHASE III DUAL USE APPLICATIONS: Finalize packaging for transition to military and commercial applications. Develop a plan and demonstrate capability to fabricate and package devices for military platforms and outline design for typical avionic ruggedness requirements. Perform final avionics integration activities and qualification testing. Demonstrate plan for device manufacturing. Provide support for operational testing and validation and qualify the system for Navy use.

Commercial applications for this technology could include telecommunications, imaging, sensing, satellite communications, fiber-optic networks, wireless networking, terrestrial optical links, infrared dynamic labels, and object identifiers.

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KEYWORDS: Laser; Modulator; Optical Transceiver; Metamaterial; Tunable; Communications

N24A-T004 TITLE: Automated Performance Monitoring for Rotorcraft Turboshaft Engines Using a Multimodel Approach

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

OBJECTIVE: Develop and integrate multiple models using machine learning and artificial intelligence to continuously and accurately estimate and predict power available for rotorcraft turboshaft engines across all aircraft operating conditions.

DESCRIPTION: Accurate estimates of engine health are critical for ensuring safe operation of helicopters supporting heavy-lift operations. Various approaches exist to assess engine health and available power in a rotorcraft context, and the rapid evolution of machine learning and artificial intelligence is further expanding the realm of possible solutions. The development and maturation of algorithms that utilize existing aircraft data parameters and that have the potential for real-time, or near real-time performance, are of considerable interest. In particular, significant operational efficiencies can be obtained if engine performance deterioration can be accurately determined and predicted over a wide range of operating conditions. Maintenance can be planned in advance, with necessary personnel and resources pre-positioned to minimize mission and readiness impacts. Specific aircraft operating conditions that lend themselves to accurate estimation of power available may not occur with regularity, thereby limiting the potential effectiveness of any individual approach. Optimal predictive performance can be achieved by combining multiple models and algorithms via decision-fusion, ensemble learning, and so forth. An ideal solution would also provide the means to monitor and evolve the models over time, support the incorporation of new models, provide interpretability and explainability, and be broadly applicable to different engines.

PHASE I: Design and demonstrate multiple approaches for engine health and/or power available estimation using Navy datasets and commercially available, open-source computing languages and packages (Python, etc.). Design and demonstrate technical feasibility for combining the models using machine learning and artificial intelligence approaches to improve model performance. The raw data may need to be filtered, manipulated, or normalized to enable implementation of the models. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a multimodel approach for accurately estimating and predicting engine health and/or power available over a wide range of operating conditions. Demonstrate and validate the approach within a Navy data environment in an automated context.

PHASE III DUAL USE APPLICATIONS: Demonstrate scenarios involving model re-training, updating, and incorporation of new models, within the Navy data environment. Develop tools and processes to monitor model performance and assist with long-term management.
This software capability would be broadly applicable to aerospace, turboshaft engines, and could be commercialized as an engine management tool for commercial operators.

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KEYWORDS: Ensemble Learning; Artificial Intelligence; Machine Learning; Prognostic Health Management; Engine Health Monitoring; Turboshaft Engine

N24A-T005 TITLE: Real-time Computational Enhancement of Video Streams

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

OBJECTIVE: Develop and implement efficient computational algorithms for fast, low-latency deblurring, denoising, and super-resolution of video streams under dynamic conditions.

DESCRIPTION: Intelligence, surveillance, and reconnaissance (ISR) and automatic target acquisition (ATA) systems are continuously challenged to view at longer distances. Under long-range conditions, atmospheric disturbances, platform motion, and object motion often introduce blur and other artifacts in the imagery of video streams from ISR missions, limiting effectiveness. With the advance of computation hardware and algorithms, computational methods can be applied to video streams to passively enhance imagery in real time by removing blur and artifacts and in some cases providing super-resolution. These approaches have the potential to be applied to any video stream whether live or recorded. Blind deconvolution techniques are a promising approach [Refs 1-5]. This approach can provide automatic estimation of compensation parameters such as point spread function (PSF), which can then be applied to imagery for enhancement such as the increase in signal-to-noise ratio (SNR). Implementation on efficient and scalable single- or multi-GPU or other processors can ensure real-time operation with minimal latency.

The Navy requires a real-time computational algorithm and implementation for passive video enhancement of video streams under dynamic conditions (e.g., defective pixels, non-uniform backgrounds, clipped objects, dropped frames, abrupt scene changes, significant haze, strong glint, and saturated pixels). Sustained computation rates for imagery with > 1 mega-pixels per frame or more should be 30 Hz (threshold) and 60 Hz (target) with latency of 200 ms (threshold) and 50 ms (target). Power consumption should be less than 150 W (threshold) and 50 W (target) in a compact, reliable compute module. This low size, weight, and power (SWaP) enables integration on mobile platforms and other SWaP-constrained vehicles. The computational algorithm and implementation must be automatic, providing low-latency simultaneous deblurring (100% reduction in PSF width in some cases), denoising (50% increase in SNR in some cases), and in some cases super-resolution, contrast enhancement, and glint suppression of video. The algorithms should show that in some cases deblurring reduces PSF width by 100%, and denoising increases SNR by 100%. The algorithms and hardware should ideally be future-proof and scalable to a range of mission scenarios. Trade-offs in image quality, processing speed, and hardware SWaP should be documented. Minimally this system should include: (a) software framework to use real-time video enhancement for receiving and sending real-time video with network-based message passing protocols and recorded formats; (b) read and write selected image and video file formats; (c) supporting the simultaneous processing of multiple image streams; (d) multi-stream co-aligning (registering) technique for the estimation of arbitrarily large angles of rotation and the estimation of geometric scaling factors (i.e., zoom-in or zoom-out); (e) a Graphical User Interface (GUI) that displays compensated imagery in real time and enables operators with all levels of experience to easily use and configure the system; (f) techniques for mitigating the adverse effects of defects in the raw imagery and objects extending beyond the field of view; (g) techniques for automating the selection of near optimal compensation parameters; (h) performing online Multiframe Blind Deconvolution (MFBD) contrast and feature enhancement, and super-resolving imagery; (i) restoring and displaying turbulence-degraded imagery from live sensor feeds in real time; and (j) tuning of parameters and configuration for sustained, autonomous operation.

PHASE I: Develop a real-time video enhancement approach for tactical optical ISR systems imaging. Perform feasibility analysis of hardware and software for implementations of the system, including a study of types of video streams and under what conditions they can be enhanced and for what types of blurs, noise, and other artifacts. Develop an initial design specification for a prototype system to be fabricated and tested in Phase II. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design, fabricate, and test the prototype system. Demonstrate performance and SWaP that meets the above specifications using Government furnished and/or synthetically generated datasets in either long distance air, land, and/or sea imaging applications as either part of a real-time image enhancement system or as an advanced pre-processing filter for image intelligence analyses.

PHASE III DUAL USE APPLICATIONS: Finalize software with appropriate SWAP-C and form factor based on human factors testing. Determine the best integration path as a capability upgrade to existing or future systems, including software and interfaces required to meet software interoperability protocols for integration into candidate systems as identified by the Navy.

Military Application: Surveillance, Technical Intelligence, Zoom Imaging Systems.
Commercial Application: Security and police surveillance attempting to identify threats and, Medical imaging procedures.

Transition of the STTR-developed products to both DoD and commercial markets, targeting applications where more compact and lighter weight hardware provides an order of magnitude improvement over current technology.

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KEYWORDS: Video; Imagery; Processing; Super-Resolution; Deblurring; Denoising; Turbulence

N24A-T006 TITLE: Manufacturing Method Development of Nanocomposite Steel Wire for Arresting Gear Purchase Cable

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

OBJECTIVE: Develop a manufacturing method capable of producing nanocomposite steel wires (steel infused with carbon nanotubes) with requisite volumes to produce metal matrix composite (MMC) arresting gear purchase cable at a cost that is comparable to steel-only cable.

DESCRIPTION: Aircraft are recovered on Navy carriers by means of a steel arresting gear cable that catches the aircraft tailhook. The cable is connected to arresting gear below decks that absorbs the aircraft's kinetic energy and stops the aircraft. Service life of the cable under repeated mechanical loading and degradation-inducing environmental conditions is critical, since the cable is the largest driver of operational cost in the Aircraft Launch and Recovery Equipment (ALRE) program. Service use cycles, as well as corrosion and bend-over-sheave wear and fatigue, are critical performance factors for such cables. To improve these characteristics, the Navy has been investigating composite carbon nanotube (CNT)/steel material as an alternative cable material to steel. The issue is manufacturability – current methods of extruding steel wire require applying 1,400–1,500 °C heat, which would degrade CNTs. The Navy is interested in a novel extrusion process that can effectively produce wire at a maximum 400 °C to protect the CNT properties. Additionally, process costs must be comparable to current steel-only processing costs for the CNT/steel cable to be viable.

The arresting gear cable is comprised of two separate cables: the cross-deck pendant and the purchase cable that is connected via a terminal and pin. The cross-deck pendant is the portion of the cable that is stretched across the landing area and interfaces with the aircraft tailhook. It is approximately 100 feet (30.48 m) long, and is replaced after approximately 125 cycles. The purchase cable is the portion of the cable that is reeved through the fairlead system and the arresting engine below the flight deck. It is comprised of 31 wires in a lang-lay construction, 1-7/16 in. (3.65 cm) in diameter and 2,200 ft (609.6 m) long. It is subject to bending stresses from the many sheaves, which with it is in contact, and is replaced after approximately 1,500 cycles. This composite cable SBIR topic addresses only the purchase cable. Cable construction should match current cable dimensions to facilitate direct replacement. The base metal for a new MMC cable should remain extra improved plow steel or a compositional equivalent. The nominal breaking strength of the composite cable should, at minimum, match the current cable's 215,000 lbs (97,522.35 kg), in addition to improving the bend-over-sheave fatigue life.

The Navy requires the development of a manufacturing method capable of cost-effectively producing composite wires for arresting gear cables. The manufacturing method must be able to produce enough wire to fabricate a test batch of full-scale arresting gear purchase cables by the end of Phase II.

PHASE I: Develop and demonstrate a manufacturing method capable of bulk production of enough MMC wire to manufacture arresting gear purchase cable. Perform wire-wrap testing for ductility, reverse bend testing for fatigue resistance, along with tensile strength and reduction-of-area testing to ensure that all material standards are maintained. Demonstrate production of 100 ft (30.48 m) wire lengths and show scalability to meet the 2,200 ft (670.56 m) requirements for full-scale arresting gear purchase cables. Perform a cost-and-lifecycle analysis to determine any potential savings from extending the life of the purchase cable. Prepare a Phase I Option that, if exercised, will produce a sub-scale arresting gear purchase cable for bend-over sheave lifecycle testing. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Demonstrate manufacturing of full-scale arresting gear purchase cables. Determine maximum production rate and final wire rope properties. Final demonstration shall be on a composite cable in a test environment representative of the arresting gear aboard ship, (either a test bench or arresting gear at NAVAIR Lakehurst, depending on the availability of non-SBIR funding. During a final demonstration, the composite cable will be cycled to failure, and the prototype must improve current service life and meet current performance requirements, particularly mechanical strength. Prepare a Phase III development plan to transition the technology to the Navy and potential commercial use.

PHASE III DUAL USE APPLICATIONS: Work with the PMA to field the technology, accounting for any requirements, restrictions, or performance parameters. The Arresting Gear IPT and pertinent engineering teams are planned to be synchronized during the entire process.

Commercial systems and infrastructure that requires high-performance load-bearing cables, as well as durable, highly conductive electronics cables can greatly benefit from the efforts in this topic, and can result in additional design flexibility. Elevator cables, bridge cables, electronic wiring, and other cable-supported stabilizing structures are among a few of several commercial applications that can benefit from the results of this topic.

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KEYWORDS: Manufacturing; nanocomposite; steel; cable; arresting; gear

N24A-T007 TITLE: Integrated Environmental Model System for Platform Situational Awareness

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

OBJECTIVE: Develop an Integrated Environmental Model System (INTEMS) that acquires, aggregates, and validates shore-based environmental predictions for naval platforms systems.

DESCRIPTION: The Navy provides a comprehensive set of global forecasts via Fleet Numerical Meteorology and Oceanography Center (FNMOC), but they are not available on most platforms or accessible to on-board systems. Safety of navigation, mission logistics, operational efficacy, electromagnetic and acoustic sensor performance, and other aspects of maritime operations depend on atmospheric and oceanic conditions that change suddenly, and which are hard to predict. Environmental models, especially shore-based supercomputer models, empower the Navy to capitalize on favorable conditions and to prepare for extreme weather events. This is especially true in shallow littoral environments where conditions such as ocean currents, wind, waves, and eddies are harder to predict and are more impactful. It is therefore desirable to have an integrated environmental model as an on-board system that acquires and provides estimates of current and future environmental conditions as a service to other ship-board systems.

The Program Executive Office Command, Control, Communications, Computers and Intelligence (PEO C4I) currently deploys a powerful environmental modeling computer system named Navy Integrated Tactical Environment System Next (NITES-Next). NITES-Next contains a broad range of tools for tasks such as data maintenance, environmental analysis, Meteorology and Oceanography (METOC) visualization, optical and radio-frequency sensor performance prediction, sonar performance prediction, environmental impact estimation, coastal environment predictions, hazard predictions, and search and rescue tools. These tools are powerful but require an on-platform operator, both to manually access shore-based predictions from FNMOC and to operate the complex modeling software environment.
National Oceanic and Atmospheric Administration, on the other hand, utilizes the Environmental Response Management Application (ERMA), a web-based geographic information system (GIS) tool developed to support environmental planning and response efforts. ERMA integrates various types of data, including environmental, weather, and oceanographic information, into a centralized platform. It facilitates real-time visualization, analysis, and collaboration among response teams and stakeholders during environmental incidents such as oil spills, hazardous material releases, and natural disasters.
In addition to these capabilities, there is a growing emphasis on Maritime Domain Awareness (MDA) systems, specifically those focused on environmental risks. These MDA systems integrate various data sources, including environmental, weather, and oceanographic information, to provide a comprehensive understanding of potential environmental risks in the maritime domain. By monitoring and analyzing factors such as sea state, wind conditions, ocean currents, and water temperature, MDA systems can identify and assess environmental hazards that may affect naval operations.

The Navy seeks a capability for an integrated environmental system that can passively download, curate, and calculate operational parameters in an ongoing manner, making the data available to NITES, ERMA, MDA or other on-board systems. Despite the name, the current NITES-Next systems are not integrated. They primarily act as decision aids for human operators and do not provide parameters to any on-board sensors or weapon systems. The Navy aims to enhance the integration and automation of environmental data within on-board systems to streamline operations, improve situational awareness, and support timely decision-making across various naval platforms. There is currently no commercial capability that meets the Navy needs.

A solution is needed for an INTEMS that provides pertinent environmental information to ship-board systems as a service. The solution must be capable of ingesting, processing, validating, and publishing environmental data from potential authoritative data sources such as FNMOC, National Oceanic and Atmospheric Administration, National Weather Service, or Naval Oceanographic office. It must assess the accuracy, feasibility, storage requirements, and computational requirements for each of the processes. Using the shore-based forecasts, climatology, on-board sensors, or algorithms the INTEMS shall provide parameters pertaining to surface currents, surface waves, sea state, abyssal current, salinity, temperature, thermocline depth, wind, visibility (dust, moisture, ice), precipitation, atmospheric pressure, temperature, cloud cover (type, density, height), turbulence, aircraft icing, the boundary layer, and ionospheric conditions effecting electro-magnetic signal propagation.

The INTEMS must be able to incorporate a high-fidelity regional bathymetric map to provide improved predictions of surface currents, surface waves, temperature, and salinity in littoral areas.
The INTEMS solution will be implemented, either as software that runs on an on-board Navy computer system, or as a stand-alone computer system, based on computational requirements. It must be able to process graphical or gridded database environmental estimates and forecasts into gridded environmental estimates, which will be provided as a service for other on-board systems, displays, and geophysical databases. To interface with other systems, such as NITES, the INTEMS will be compatible with Open Geospatial Consortium compliant data formats (for example, NetCDF4). The now-casts and forecasts provided by the INTEMS must be available at multiple altitudes and depths with a fine enough resolution to model atmospheric and oceanic boundary layers.

The INTEMS will be required to provide timely global nowcasts and forecasts in situations where shore-based data is fully, partially, or not available. In all cases accuracy shall exceed or match climatology, but when additional shore-based or sensor data is available, the prediction skill should exceed persistence. The system shall provide statistical maximum, minimum, standard deviation, and mean estimates based on climatology and/or incorporated shore-based forecasts. Additional figure of merit shall indicate whether or not shore-based predictions are incorporated and if the data is valid based on its quality, consistency, or inherent unpredictability (due to qualitative factors).

PHASE I: Develop a concept of an INTEMS system. Demonstrate the INTEMS feasibly meets the parameters of the Description through analysis and modeling. The concept will be evaluated based on its soundness of the underlying analysis and the variety of environmental predictions offered. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype INTEMS based on the Phase I concept. Demonstrate functionality under the required service conditions as described in the Description. Demonstrate the prototype performance through the required range of parameters given in the Description. The INTEMS predictions will be evaluated over a multi-week period, conducted by the government and compared against both climatology and measurements occurring at distant weather stations to verify prediction accuracy and figure of merit reliability.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The INTEMS will be ruggedized, finalized, and adapted for integration with ship-board information systems and will undergo certification prior to final product testing on the naval platform.
This technology will benefit commercial shipping platforms, oil and gas exploration, and industrial operations in coastal regions by providing essential and up-to-date environmental data that can power decision making and enhance the ability for automated systems and sensors to compensate for environmental conditions.

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KEYWORDS: Fleet Numerical Meteorology; Environmental Modeling; Open Geospatial Consortium; littoral environments; bathymetric map; Navy Integrated Tactical Environment System

N24A-T008 TITLE: Kilowatt Class Stimulated Brillouin Scattering Reduced Hollow-Core Fiber (HCF) Dip Loop Cable Assembly

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

OBJECTIVE: Develop an innovative design and manufacturing approach for a kilowatt (kW) class Stimulated Brillouin Scattering (SBS) reduced Hollow-Core Fiber (HCF) marine connectorized cable assembly with Optical Hull Penetrator (OHP) for submerged operation.

DESCRIPTION: Currently, the Navy has a need for a kW class SBS reduced HCF dip-loop-assembly for Directed Energy (DE) beam delivery. Through separate initiatives, the Navy has developed an SBS reduced HCF bundle capable of achieving the kW transmission per each HCF channel. The ability to connect the number of fibers required has not been achieved in industry, and the hull side kW class connector for the newly developed hull penetration internals does not exist. Reliable and repeatable manufacturing of a fiber cable of this size capable of submerged application when subject to long-duration complex stress states with Navy platforms has yet to be developed. Dip Loop cable assembly shall include seven (7) quad for a total of 28 HCF. Additionally, the cable assembly must be as flexible as an outboard pressure proof hybrid fiber-optic interface cable assembly for undersea application. A kW class cable assembly with connector is an outboard and inboard cable assembly for undersea platforms, terminated at each end with deep submergence molded optical hull penetrator plug connecters, which can handle the kW class laser optical power. A kW class optical cable assembly is defined as a ship-set and provides kW optical interconnection between one Beam Director and one OHP. kW optical cable assemblies shall run within the Universal Modular Mast (UMM) Fairing Cable Handling Assembly (FCHA). Minimum bend radius shall be less than 2 inches of diameter and cable assembly shall not exceed 55 pounds including outboard kW class connector.

PHASE I: Develop a concept and demonstrate the feasibility of an innovative kW class SBS reduced HCF connectorized cable assembly that will be connected with an OHP for submerged operation. Develop the general model of innovative concept and identify the technology for cabling and connection for submerged operation. Accomplish the feasibility through modeling, simulation, analysis, or other formal methods. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver the kW class SBS reduced HCF dip-loop-assembly for DE beam delivery prototype. Through separate initiatives, the Navy has developed an SBS reduced HCF bundle capable of achieving the kW transmission desired. Phase II awardee(s) will coordinate with the company that has developed the SBS reduced HCF fiber. Information on how to purchase the necessary length of the SBS reduced HCF bundle for demonstration and prototype development of the marine connectorized dip-loop-assembly system will be provided to Phase II awardee(s). Demonstrate the broad requirements of the cabling and perform the required marine environment qualification testing to include submerged operation and pressure proof testing. If the performance and technical requirements are met during the evaluation, continue development of the technology utilizing additional Navy-provided performance data.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final design will be the kW class SBS reduced HCF dip-loop-assembly for DE beam delivery, which possesses the potential for use in oil and gas Industries.

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KEYWORDS: Stimulated Brillouin Scattering; SBS; hollow core fiber; HCF; optical hull penetrator; OHP; dip-loop-assembly; directed energy; DE; cable connectors; Dip Loop; Cable; outboard; submerged operation

N24A-T009 TITLE: Smart Exhaust Waste Heat Recovery Unit (SEWHRU)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

OBJECTIVE: Develop and demonstrate a self-cleaning Smart Exhaust Waste Heat Recovery Unit (SEWHRU) for internal combustion engines flue gas ranging in temperature from 500 to 1200 °F, for use in electric generation and/or heating and cooling processes.

DESCRIPTION: A typical diesel engine attains approximately 42% brake thermal efficiency, with approximately 28% of fuel energy dissipated to the environment through engine exhaust flue gas as waste heat. Effective recovery and conversion of the waste heat into useful work would increase the diesel engine's thermal efficiency, resulting in a reduction in the engine's fuel consumption for equivalent work. This STTR topic seeks a SEWHRU to capture and transfer at least 50% of the heat from the exhaust flue gas to an intermediate working fluid, and on to the components that will convert the heat into useful work. WHRUs for legacy internal combustion engines exist commercially as an afterthought for prime movers. The WHRUs are dependent on the prime mover, with a WHRU that consists of a Heat Exchanger (HX) placed directly into the flue gas pathway and expected to work effectively without interfering with the operation of the prime mover. Some WHRUs designs incorporate dampers and a bypass system that redirects the flue gas around the HX; however, the legacy systems do not provide the following features that would be beneficial to the life, efficiency, reliability, and maintainability of the HX:

- Controlled flow rate of the flue gas through the HX
- Controlled flow rate of the working fluid through the HX
- Flue gas treatment for reducing particulate matter and other contaminants
- Even distribution of the flue gas through the HX
- Protective mechanism or process to protect the HX from over heating
- Control mechanism or process that prevents condensation within the HX
- Forced air system to counteract pressure losses
- Modular design to ensure maintainability

The legacy WHRUs that utilize conventional processes to recover waste heat from flue gas are plagued with multiple problems as follows:

- Thermo-mechanical stress due to transient flue gas temperature profiles
- Resonance within the heat exchanger when flow of the secondary fluid is secured
- Maintenance due to fouling and corrosion
- Secondary fluid thermal and pressure constraints, decomposition limits of fluid
- Unrestricted prime mover or plant operations
- Effect on efficiency or power output due to exhaust stack backpressure

A self-cleaning SEWHRU design is needed by the Navy with systems and processes incorporated and synchronized with the prime mover and the waste heat recovery system's operation sequences in order for the WHRU to work effectively.

The WHRU shall transfer heat from the diesel engine's flue gas to a working fluid with an inlet temperature range between 60 and 190 °F. Pressure drops across hot flue gas side of the WHRU shall not exceed 4 inches of water and/or interfere with the prime mover's efficiency. The heat recovery unit design shall be capable of withstanding thermal shock effects when a working fluid at 60 °F enters a 1200 °F heat exchanger. The WHRU shall possess a self-cleaning function that mitigates fouling and corrosion effect from combustion byproducts and operates with minimal operator intervention. Weight and volume of the WHRU shall be comparable or less than the prime mover's weight and size to power ratio. The WHRU shall be utilized in place of a silencer and shall be comparable to or better than the existing silencer in attenuating engine exhaust noise. The WHRU shall be scalable to 4000 Brake Horse-Power (BHP) marine diesel engines.

PHASE I: Develop a concept for a self-cleaning SEWHRU that meets the needs of the Navy as defined in the Description. Evaluate the unit's economic, technical, and manufacturing feasibility and quantify the SEWHRUs efficiency and operating parameters. Demonstrate the design and manufacturing concepts through modeling, analysis, and bench top experimentation where appropriate. Document the ability and impact of scaling engine size. Include in the Phase I final report the technical and economic feasibility of the proposed solution. The Phase I Option, if exercised, should include an initial detailed design and specifications to build a prototype with the Phase II effort.

PHASE II: Develop, fabricate, deliver, and test a prototype of a WHRU at an appropriate scale that captures at least 50% of the heat in the flue gas of a demonstration engine. Demonstrate the ability to withstand the flue gas temperature cycles. Validate analytic models developed in Phase I and evaluate scalability of design up to 4000 BHP. Perform testing activities that include demonstration and characterization of key parameters and objectives at the proposer's facility or other suitable testing facility identified by the offeror. Design the full-scale waste heat recovery unit for a rated diesel engine that fits in place of the existing exhaust stack silencer and integrate the unit with the rated diesel engine. Test the unit to demonstrate the ability to meet the design characteristics. Provide an updated economic and manufacturability study with updated designs that result from developments during prototype testing. Test the waste heat recovery unit in a relevant environment and ensure that the system meets the unique requirements for deployment on a U.S. Naval vessel such as shock and vibration. Analyze the ability to complete more than one prototype with the Phase II funding.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use. Develop a transition strategy through research, analysis, and identification to establish production-level manufacturing capabilities and facilities that will produce and fully qualify a SEWHRU. Based on the results of the cost-benefit analysis, provide an economic and manufacturability study with updated designs that result from developments during prototype testing, DDG(X) may assess potential for design insertion for potential forward fit/back fit application.
This technology has commercial application in the internal and external combustion engine industry, electric power generation industry, and other manufacturing or production process that rejects low grade waste heat into the environment. This technology will enable lowered operation and production costs, reducing effects on the environment.

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KEYWORDS: Heat Exchanger; Waste Heat Recovery Unit; Internal Combustion Engines; Diesel Engines; Thermal Recovery; Prime Mover

N24A-T010 TITLE: Subminiature Digital Pitot-static Sensor (SDPSS)

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

OBJECTIVE: Develop a subminiature digital pitot-static sensor (SDPSS) that fully integrates all sensing and readout electronics within the body of the probe, improving GPS-denied navigation on small unmanned aircraft systems (UASs).

DESCRIPTION: Aircraft have used pitot-static air-data systems for measurement of airspeed and altitude since the dawn of the aviation era and are essential to safe navigation in US / international airspace as well as operation in GPS-denied environments. Technical limitations of current air-data system create integration challenges that degrade their utility in important DoD and civilian applications, including guidance, navigation, and control of small UASs.

The conventional approach to integration of air data system typically pairs a centralized air-data measurement system, containing mechanical or digital pressure transducers, plumbed with tubing to a relatively simple mechanical probe. Pitot-static probes provide pressure-tight connections to a small hole in the center of the rounded tip (pitot port) and to a ring of holes around the periphery of the probe (static pressure port), usually located about 5 probe diameters aft of the tip.

Pressure altitude is calculated using comparison of the absolute (vacuum referenced) static pressure measurement to standard conditions of the International Standard Atmosphere. Correction for ground-level barometric pressure (e.g., as measured at the local airport) permits estimation of the local altitude above ground level – essential for altitude deconfliction of aircraft, as well as terrain and obstacle avoidance. Correction for non-standard temperature and dew point permits computation of the density altitude, which is an important factor in aircraft performance (e.g., lift, drag, and power).

Using Bernoulli's principle, a differential pressure measurement between pitot (ram air) pressure and static (ambient) pressure indicates the airspeed in the direction of the probe. Correction for installation effects of the probe mounted to the aircraft, compressibility effects at high speed, and air density yields the calibrated, equivalent, and true airspeed, respectively.

Although the pitot-static system has been a reliable component of manned and unmanned aviation for more than a century, several drawbacks persist, especially for integration on very small aircraft, including compact drones in wide usage by DoD and civilian operators. In many cases, these small UASs operate without airspeed / altitude sensing entirely and can only navigate with GPS, leaving them susceptible to GPS interference (intentional or unintentional). Furthermore, operation without (or with a sub-par) pitot-static system can reduce the robustness of the flight controls due to adverse weather and limit the safe flight envelope (reducing efficiency / loiter time or maximum climb / dash performance). These challenges include:

- Physical space occupied by centralized air data computer systems, including individually packaged absolute and differential pressure transducers, signal conditioning, analog-to-digital conversion, and microprocessor, as well as their accompanying mechanical interfaces (tubing, quick disconnects, strain relief bracketry, etc.)
- Hidden failures within pressure plumbing (e.g., leaks or obstructions) due to human error (e.g., pinched tube, contaminated connectors) or operations in a severe environment (e.g., icing, thermal / chemical / UV degradation of plastics)
- Need to provide separate static pressure connection to absolute sensor and reference port of differential pressure sensor, requiring a splitter and additional tubing bulk
- Pressure lags due to long tubing runs in small diameter tubing, degrading the speed, stability, and accuracy of key navigation inputs

- Limited availability of commercial sensors in miniature packages with required accuracy, stability, speed, resolution, and port configuration
- Reliance on separate sensors (or operator inputs) [e.g., outside air temperature] to apply proper correction factors – potentially introducing new sources of error
- Scalability (number of sensors) - challenges above are compounded when multiple sources of air-data measurements are desired or required to achieve desired reliability levels
- Scalability (physical size) – traditional construction relying on physical tubing interconnects between probe and readout device imposes scalability limitations preventing scaling to very small sizes, such as for integration on micro-air vehicles
- Calibration of probes separately from readout equipment creates challenges for traceability and integration

The Navy requires development of a new class of digital pitot-static sensors that sidesteps or mitigates each of these problems. We note that the current state of practice / art in related fields – such as high-performance micro-electromechanical systems (MEMS) manufacturing, widespread commercialization of multi-chip/die integration of heterogenous elements within the same mechanical packages, and advancements in precision additive manufacturing and computer-aided co-design of electronic and mechanical assemblies – could readily be applied to this problem space to offer compelling solutions.

The sensor assembly should:

- Have an overall outer probe tip shape consistent in proportion with accepted practice for construction of pitot-static tubes
- Fit within a cylindrical volume 0.25 inches in diameter and 5 inches long. Preferably, fit within an objective cylindrical volume 0.125 inches in diameter and 2.5 inches long (or smaller)
- Provide a mating surface / fixturing interface, preferably to a hollow support / extension shaft that adapts to the customer's application (e.g., unmanned aircraft wing, nose, or fuselage mount, wind tunnel fixture, etc.)
- Contain all readout electronics, including but not limited to absolute/ differential pressure / temperature / humidity sensing elements, power / signal conditioning, analog-to-digital conversion, microprocessor, etc.
- Operate off a single, common, coarsely regulated low voltage supply, at low supply current – preferably < 20 mA at 3.3 V ± 0.3 V (not including anti-icing provisions)
- Produce pressure altitude measurements over a full-scale range of at least 1000 to 53,000 feet with an accuracy better than ±10 feet (-1000 to 20,000 feet) ±20 feet (20,000 to 29,0000 feet), ±30 feet (29,000 to 41,000 feet), and ±50 feet (41,000 to 53,000 feet)
- Produce indicated airspeed measurements with an accuracy better than ± 5% of the actual indicated airspeed over the full-scale range from 10 knots to 60 knots (low-speed configuration) or over the full-scale range from 30 knots to 180 knots (high-speed configuration)
- Produce outside air temperature (OAT) measurements over a full-scale range of at least -84 °C to +45 °C with an accuracy better than 1 °C
- Contain design features (e.g., heater, drain holes, coatings) to prevent rain / ice from interfering with proper operation
- Implement a bidirectional digital serial interface capable of supporting multiple addressable sensors on the same bus such as I2C, daisy-chained SPI or UART, CAN, etc.
- Permit addressing of individual sensors (e.g., for configuration / calibration) when sending command or the complete chain (e.g., to poll all sensors for a simultaneous on-demand measurement, or to 'broadcast' a shared configuration parameter)
- Digitally transmit commonly required information (e.g., sensor identification, sensor / correction status, altitude, airspeed, outside air temperature, etc.,) as a single serial data packet
- Transmit and receive data fields as appropriately scaled and signed integers, in binary representation of appropriate bit width, preferably in multiples of 8 bits (one byte)

- Encode / decode multibyte fields with uniform endianness. Endianness may be fixed or selectable by non-volatile configuration parameter.
- Utilize a Fletcher-16 checksum (or any alternative appropriate position-dependent binary checksum) to support the verification of encoded / decoded serial messages
- Respond to serial commands with appropriate acknowledgment / rejection (ACK / NACK) messages
- Provide a mechanism to unambiguously flag transmitted data that may be invalid (e.g., during execution of built-in-test or after detection of an out-of-range condition)
- Provide "factory-programmable" non-volatile storage (e.g., internal sensing element / signal conditioning calibration tables, operating software, and other data as required for operation and evaluation)
- Provide "user-programmable" non-volatile storage for correction coefficients (e.g., sensor installation effects, if known) and other operating parameters (e.g., reference barometric pressure, filtering / smoothing settings, correction types enabled, selection of output units, protocol / bus configurations, etc.)
- Implement a built-in-self-test function, including coverage of hardware, software, and status of non-volatile memory, where feasible
- Provide a method to reset configuration to factory settings
- Support operation in either polled (transmit on demand) or automatic (transmit at a fixed update rate) modes. Preferably, sampling should be time-aligned in either mode, when multiple sensors are daisy chained on the same bus
- Support a standard output data rate of at least 20 Hz. Preferably, higher / lower configurable output data rates may be configurable by the user
- Provide internal analog / digital filtering as required to ensure Nyquist sampling criteria are satisfied at the selected output data rate. Filter designs shall not exhibit overshoot

Note: Digital sensor concepts for measuring aerodynamic parameters typically derived from pitot-static probes using non-pressure based phenomenology (e.g., ultrasonic wave propagation) will be considered.

PHASE I: Define and develop a technical concept that can meet the SDPSS measurement performance and size, weight, and power constraints listed in the Description. Conduct modeling, simulation in order to provide an initial analytical assessment of concept performance. Develop conceptual options for both low-speed and high-speed configurations.
The Phase I Option, if exercised, includes further refinement and/or validation of one conceptual design configuration towards a manufacturable state. This effort may include risk reduction experimentation in a lab environment, in order to address residual feasibility concerns and validate novel aspects of the concept.

PHASE II: Finalize developments of the Phase I SDPSS design and fabricate prototypes for demonstration and validation. Deliver six calibrated prototypes to the government for wind-tunnel verification and/or low-risk flight evaluation (data logging only).
The Phase II Option, if exercised, would mature prototypes further for experimental integration as a primary air data sensor for an unmanned system. Enhancements may include redesign to tailor specifications for the application and/or to meet additional qualifications required for integration (shock, vibe, EMI, etc.).

PHASE III DUAL USE APPLICATIONS: Support the Navy/government to transition the SDPSS technology / units into various unmanned aviation programs within the DoD, with initial emphasis on small aircraft < 55 lbs. Once the technology is proven it may find use a primary or secondary (redundant) air data source on larger and even future manned aircraft.

In the commercial sector, SDPSS is likely to find a market both in civilian unmanned vehicle operations as well as in the general aviation / light sport / experimental aircraft industry due to the reliability and weight savings advantages of a “solid-state” digital air data system.

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KEYWORDS: SENSORS; MEMS; ELECTRONICS; AIRSPEED; ALTITUDE; ALTIMETER; AIR; DATA; PRESSURE; DIGITAL; TRANSDUCER; PITOT; PITOT-STATIC; AIRSPEED INDICATOR; AUTOPILOT; UNMANNED; AIRCRAFT; SAFETY; NAVIGATION; UAS

N24A-T011 TITLE: Corrosion Modeling Analytics and Machine Learning to Promote Corrosion-Informed Design to Reduce Ship Maintenance

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

OBJECTIVE: Develop (1) protocols algorithms to transform various raw data formats into information-rich features for machine learning (ML), and (2) software and modeling tools for ML that will automatically detect patterns in data; and learn and augment from experience and corrosion–informed models the ability to predict optimal materials selection and/or corrosion control measures to reduce Navy ship maintenance.

DESCRIPTION: A number of Navy ship classes face growing maintenance delays and maintenance costs. Some solutions resort to cannibalization of parts: moving them from one ship to keep another one operational. This is a critical issue as Navy ships are getting fewer steaming hours because of growing maintenance delays and costs. Maintenance delays have resulted in some ships deferring maintenance. Over time this situation has resulted in worsening ship conditions and increased costs to repair and sustain ships. In some cases, maintenance has been deferred to the point where ships have been decommissioned several years ahead of their planned service life. With increasing computer capabilities, growing materials databases, increasing computational capabilities, the growing use and power of ML and artificial intelligence, digital engineering can reduce acquisition timelines and cost, permit more rapid system upgrades, and streamline maintenance. In addition to verified corrosion models in relevant operational environments, failure analysis, inspection reports, documented ‘lessons learned’, and the results of past maintenance practices can be incorporated into the materials database.

The challenge of digital engineering for DoD is attaining knowledge-based integration of data sufficient to decide lifecycle issues. Key elements of digital engineering are developing and compiling materials databases and developing relevant corrosion models that can predict materials behavior and operational life in platform systems operating in marine environments. ML is a powerful subset of artificial intelligence (AI) for systems to learn from data, pattern identification, and decision making. Application of ML tools can enable characterization of materials and informed-corrosion behavior in new ship design and inform Navy Maintenance personnel about options for cost-effective materials or corrosion control methods to lessen future ship maintenance. A key challenge in applying ML algorithms to materials science data is that data comes in many formats. Determining how to featurize and utilize different materials data formats so that prior data can be used as training data for ML algorithms can be difficult. Feature engineering, including extraction, transformation, and informed selection, is critical for improved ML accuracy and increase Fleet operational availability.

PHASE I: Define and develop a concept/approach/framework for feature engineering tools to extract critical information related to corrosion and other degradation pathways (e.g., physical, strength, fatigue resistance, etc.) from multiple formats. Key features may also include material properties, chemistry, and processing variables. Include in the concept/approach/framework appropriate identification classifiers and interactions. Assemble verified corrosion models and other descriptive terms for different materials. Develop a Phase II plan. In a Phase I option, if exercised, demonstrate the feasibility of the proposed concept/approach to provide labeled data output for corrosion/corrosion control options.

PHASE II: Develop, demonstrate, and validate a materials database for supervised (e.g., support vector, neural networks) and unsupervised learning algorithms (e.g., cluster analysis) use for corrosion/corrosion control and life prediction. Ensure that the collective database is able to identify prioritization of features whether it be structural, chemical, and physical properties or AM-related processing-microstructure-property phenomena relative to corrosion phenomena.

PHASE III DUAL USE APPLICATIONS: Transition optimized computational/informatics handling engineering tools for commercialization in ML utilization through original equipment manufacturers (OEMs) or other partnering agreements. Demonstrate the technology to DoD warfare centers/production facilities. The design tool is focused on application in a marine environment so offshore structures such as oil and gas platforms could benefit.

Dual use applications could include aircraft, land vehicles, materials processing entities. Commercialization of this technology may be realized via success in predicting materials service life in marine and modified marine environment in ship systems.

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2. Ling, Julia, et al. “Machine Learning for Alloy Composition and Process Optimization”. (Proceedings of ASME Turbo Expo 2018 Turbomachinery Technical Conference and Exposition.) https://arxiv.org/abs/1704.07423
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KEYWORDS: Machine learning; corrosion; modeling; digital engineering; design; maintenance; materials dataset

N24A-T012 TITLE: Scalable High Frequency Transmit/Receive Array for Multiple Unmanned Underwater Vehicle and Torpedo Applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Network Systems-of-Systems; Integrated Sensing and Cyber;Sustainment

OBJECTIVE: Develop a configurable, scalable, adaptable, and affordable High Frequency SONAR array technology based upon efficient and affordable textured ceramic materials to offer benefits of improved performance in more compact form factors.

DESCRIPTION: Textured transduction ceramic materials based on lead magnesium niobate-lead titanate (PMN-PT) are an emerging transduction material with properties and performance characteristics superior to those of legacy lead zirconate titanate (PZT), offer additive manufacturing advantages that translate to unique performance and applications opportunities, and are more affordable than the higher performing and less available single crystal materials. The advent of textured ceramics has proven to be a boon to the Navy in stimulating investments that are affordably and effectively refreshing the critical national infrastructure that is acoustic transduction. The space, weight, power, performance, and cost tradeoff space has been altered by textured ceramic materials in a way that is succeeding in overcoming reluctance to considering the risk and cost of new acoustic transduction devices. On autonomous vehicles, maximum sustained performance at the lowest cost is the objective. Making multiple uses of the same, best array of acoustic sensors within an open architecture communication and control architecture to best and most affordably perform multiple missions is an opportunity large enough to subsume multiple stovepipes in legacy capabilities. While not yet so mature, compositions of textured PZT materials are of interest, but only to the extent that documented experience with the proposed material formulation is cited. Designs appropriate to future multi-mission heavy-weight torpedoes but which can be scaled / configured to meet the HF search and acoustic communications requirements of next generation UUVs and concept for their employment in the performance of a variety of missions including Mine Warfare (MIW), Naval Special Warfare (NSW), and Explosive Ordnance Demolition (EOD), while simultaneously offering higher performance back-fit options are a priority are a principal objective. Government rights to a sensor and array design concept so that stove pipes in both future and legacy systems can be mitigated is another high priority objective.

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 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and 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 level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR 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 during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a scalable HF acoustic transducer concept that is configurable as an acoustic transmit/receive array suited to both legacy acoustic communications and heavyweight torpedo detection and homing applications. Demonstrate a robust, manufacturable, and affordable design for individual transducer elements that are consistent with a scalable array concept that is appropriate for consideration as options for both legacy UUV and heavyweight torpedo applications, but which offer scalable, and configurable future performance improvement and mission capability options.

PHASE II: Construct an HF array of such sensors suitable to some legacy or future application. Evaluate the cost and performance envelope made possible by the innovative application of textured ceramics in some new or existing array concept for which the Navy has government use rights. Alignment of the physical characteristics of the design to a form that can be tested on a UUV or torpedo platform of specific, relevant interest to a transition customer agreeable to collaborative testing is expected. The transition application for the customer / collaborator at Phase II, including perhaps a different or additional transition customer at Phase III, is likely to have corresponding security and export control restrictions.

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

PHASE III DUAL USE APPLICATIONS: Deliver an affordable and fundamentally new performance capability for both commercial and Navy / Marine Corps and commercial high frequency SONAR and for Navy / Marine Corps acoustic communications that could not before have been achieved on the basis of space, weight, and power constraints. Alternatively, the Phase III application might well be one intended to remedy a situation of prohibitive cost for a legacy capability. The transition customer would provide detailed specifications for the transducers and for the array extent and geometry.

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KEYWORDS: open architecture; textured ceramics; acoustic communication; acoustic transducer; acoustic array; high frequency

N24A-T013 TITLE: Adaptive Instructor Aid for Virtual Reality/Augmented Reality Enabled Classroom Training

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software

OBJECTIVE: Develop a system for real-time monitoring of student performance and performance-driven instructional adaptation within an immersive (that is, virtual or augmented reality enabled) training experience.

DESCRIPTION: Virtual Reality (VR) and Augmented Reality (AR) are becoming more common in Navy training as instructional media that provide visually immersive training conditions, both in the classroom for individual training and in team dynamic settings. This has the advantage of exposing the student to visual operational conditions that are motivationally immersive and hard to replicate or train to in purely live training. While VR and AR technologies are modern and alluring, use of these technologies alone does not ensure training effectiveness. Furthermore, their introduction may insulate an instructor from fully observing and adaptively interacting with the student, reducing natural and traditional student/instructor experiences. A body of knowledge in basic research addresses the effective use of VR/AR, including the need to monitor student performance and adapting the pace or content of instructional material based on this [Ref 1]. This STTR topic seeks to develop a VR/AR learning system that adapts to the student based on the competency of the student's performance and yields a learning gain that is significantly better than current training methodologies. Toward this end, the aim is to develop a working prototype and a student performance measurement approach that can be generalized across a range of classroom adaptive training environments where VR and AR could be applied.

PHASE I: Determine a technical approach to monitor competency of student performance while using wearable VR or AR instructional media and use such information to inform and adapt instructional content. Determine the metrics to measure student performance shortfalls, and for assessing system training effectiveness. Include designs of baseline measures that would be administered before training and a comparison measure after introducing this new approach, using any current Navy Use Case. Phase I accomplishments will be presented to cognizant ONR Program Officers for feedback before initiating Phase II activity.

PHASE II: Apply the Phase I approach to a representative Navy classroom training environment where VR and/or AR are, or could be, used. Implement the technical approach in a prototype and collect metrics for baseline comparison. The government will provide a representative Navy VR/AR classrooms environment if the performing team does not have access to or insight into the content and design of Navy-relevant classroom settings.

PHASE III DUAL USE APPLICATIONS: Assess the training value of the approach developed in Phase II, comparing it with VR or AR-based training without the assessment and adaptivity of this approach. If the approach developed is demonstrated to be significantly better in training efficacy (speed and/or level of the students' content mastery) based on criteria agreed on by ONR and Fleet representatives, demonstrate the system to leadership in the Fleet Training Wholeness Program of Record. Commercialization opportunities should be explored in Phase II and pursued in Phase III. Potential markets that would be interested in this technology include aviation, maintenance, law enforcement, and the medical field.

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KEYWORDS: Virtual reality; augmented reality; Adaptive training; Instructional media; immersive environments; classroom training

N24A-T014 TITLE: Technology to Drive Extreme Runtime in Wearable Devices

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Biotechnology; Human-Machine Interfaces; Microelectronics

OBJECTIVE: Develop a software technology to be coupled with an existing hardware technology in the form of a fieldable, wearable device that enables the onboard analyses of sleep and performance indicators that impact militarily relevant performance and reduces both battery consumption and storage requirements.

DESCRIPTION: Wearable devices offer the DoD novel information to support readiness of Service Members, informing health and safety risks [Refs 1-2]. Currently DoD lacks the ability for continuous remote monitoring (e.g. physiological) to inform readiness metrics under austere military conditions due to power supply limitations of commercially available wearable devices. Addressing this gap will support feedback to the individual Service Member for improved individual performance and resilience, personnel wellness across the unit, and ultimately, to inform and support decisions affecting training, readiness, and mission planning [Ref 3].

The objective of this STTR topic is to develop a software application that can be incorporated with existing wearable devices (e.g. Android) to enable continuous remote monitoring in austere military environments. Operational environments that involve movements, such as maritime, where induced environmental motion make detection of activity levels or sleep periods particularly challenging should be addressed in device selection. Devices, at a minimum, should continuously capture heart-rate, heart-rate variability, activity/motion, timing of sleep periods and asleep/awake status across the 24-hour day, for a duration of at least 30 (threshold) or 60 (objective) days without charge.

The software application should provide onboard computing and processing of sleep and fatigue data utilizing emerging commercial applications, such as tinyML, to significantly reduce power consumption and data size. Data should be formatted in a way that can be interpreted and ingested in a database agnostic manner, and support rapid transmission to a local server. Data transmission should be conducted via wireless (e.g. Bluetooth) means. The development of this technology will greatly improve the ability to field wearable devices for long periods of time in disrupted, disconnected, intermittent and low-bandwidth environments; where understanding readiness state is critical, but ability for device recharging may not be operationally feasible.

PHASE I: Define, develop, and demonstrate ability to run software application on a commercially available wearable device that enables initial improvement for reduce power consumption and data size, and a plan for transmitting data wirelessly to local server. Define plan for reaching desired battery life with required data collection (e.g. sleep) measures, and ability to test at multiple milestones within both lab and home/operational environments. Define plan to completely turn off device in emission controlled conditions: manually (Threshold) and remotely (Objective). Phase I will result in a proof of concept for testing/demonstration only, no human subjects testing will occur.

PHASE II: Testing and fielding of software application with at least 50 devices within lab and home/operational environments to support verification and validation testing of power consumption rates, data formatting, and other time synchronization between device and local server. Additional testing for data transfer speeds of sleep start and stop times, and health-related summary and other time series data covering a period of 24-hours to 72-hours between devices and a disconnected database infrastructure. The prototypes applications—that meet the transmission needs, onboard computing, and extended runtimes—will be demonstrated in a military relevant environment. Additionally, the developed application and combined wearable will need to be interoperable with existing DoD wireless infrastructure. The prototype device will need to manage wireless transmission of health and readiness status information over a wireless link while maintaining an extended runtimes; and maintain sufficient on-device memory storage to retain multiple weeks' worth of summary information, processed sleep and performance indicators, and synchronize the saved information to the DoD support infrastructure. Interface specifications will be done in collaboration with Navy/DoD to define and develop appropriate wireless interfaces in existing data infrastructure. Provide a detailed plan that will outline the verification of the wearable device, it's sensing capabilities, communication protocol, and validation of the onboard sleep and performance analyses. The wearable device should provide at a minimum but not limited to, heart-rate, hear-rate variability, activity/motion, and asleep/awake health status information. Details of the device requirements will be provided to the Phase II awardee(s). Provide a detailed plan that will occur for testing and evaluation (to include data type, frequency, and structure).

PHASE III DUAL USE APPLICATIONS: Integrate Phase II prototypes into deployed Naval vessels and transition finalized product to the Naval Surface Force (SUFOR). Plan for longitudinal evaluation of the Phase II prototype devices in an operational environment. This evaluation will consist of a cross comparison of the prototype function across two (or more) ships of different class and where appropriate include Marines and other service members embarked on warships (e.g., Destroyer vs. Amphibious Assault Ship) across the Operational Deployment Cycle/Optimized Fleet Response Plan Cycle. Outline the ability to mass produce, support, and service the developed wearable devices.

Dual uses in the commercial sector include sporting teams, extreme athletes, and emergency services (Fire, EMS).

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KEYWORDS: Physiological monitoring, sleep, fatigue, wearables, human performance, extended battery life

N24A-T015 TITLE: Polarization-enhanced, Long-range, Wide-area, High-resolution Imaging System

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

OBJECTIVE: Develop polarization-based techniques to improve target detection and identification and scene clutter characterization at long-range and over a wide field-of-view.

DESCRIPTION: Detection and identification of small targets at long range on the ocean surface is challenging due to wave clutter, reduced observation time from shadowing, and often poor target contrast. To enhance target detection and identification, the USN seeks to exploit the additional information content provided by polarization. Specifically, 3D polarization imaging has improved significantly in recent years as multiple strategies have been developed to resolve the polar and azimuthal angular ambiguities [Ref 1]. Measurement of polarization often provides increased discrimination of man-made objects from nature backgrounds, while the 3D variant could increase the likelihood of positive identification. Moreover, many new polarization-based techniques have been developed in recent years that could significantly increase performance over the conventional Stokes vector analysis, which alone often yields favorable results, but only for specific applications.

Within the scope of this STTR topic, the USN seeks to develop a 3D polarization imaging system to significantly improve long-range detection and identification of targets in maritime clutter from surface-ship platforms. In principle, all wavelength bands from the UV to mm-wave will be considered, although transmission and depolarization with passage through the atmosphere in the maritime environment should be considered. Novel polarization techniques, such as point-spread-function engineering [Ref 2] or speckle correlation [Ref 3], which could potentially improve depth resolution or sampling rate, are also of interest. The use of multi-point correlation functions, such as the complex degree of mutual polarization [Ref 4] or other polarization correlation functions, would be of interest if these techniques can be used to enhance target identification or discrimination in clutter. In addition to the development of imager hardware, a processing component can be anticipated, which could exploit local measurements of the environment, such as ocean wave power spectra or the air-sea temperature jump, to enable optimization of data acquisition and interpretation [Ref 5].

PHASE I: Develop a preliminary design of hardware and algorithms for a novel polarization-based imaging and sensing system that significantly exceeds the current state-of-the-art and enables improved detection and ID of small targets in a maritime environment at ranges beyond 1 km. Targets of shorter range are not of interest under this topic. Additionally, proposed solutions can explore polarization techniques combined with other techniques to further augment 3D image formation. The design should be supported by ample modelling and simulation results to justify construction in Phase II and by risk mitigation experiments as needed.

PHASE II: Develop a hardware/software realization of the design proposed under Phase I. Laboratory based testing should be completed under the Phase II effort to demonstrate the performance of the system.

PHASE III DUAL USE APPLICATIONS: Refine the design of improved ruggedness, size, weight, and power needs to broadly enable use of the system. Produce a sufficiently rugged system to enable field testing under relevant maritime conditions.

REFERENCES:

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KEYWORDS: infrared imaging; polarization; polarimetric imaging; infrared; IR; electro-optical/infrared; EO/IR; maritime sensing

N24A-T016 TITLE: Plasma Assisted Combustion for Enhanced Performance and Operability in Naval Air Vehicles and Weapons

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

OBJECTIVE: Develop, demonstrate, and validate a novel Plasma Assisted Combustion (PAC) device that can be integrated into future naval air platforms and weapons propulsion systems.

DESCRIPTION: The Office of Naval Research seeks development and demonstration of an innovative PAC system to improve the performance, efficiency, and operability of gas turbine engines in naval aircraft. The primary goal of this STTR topic is to identify and explore advanced combustion technologies that will enable significant improvements in performance, fuel efficiency, operational capabilities, and integration with various fuel types, while maintaining or enhancing reliability, maintainability, and safety. The target application for this technology is gas turbine primary combustors, augmentors, rotating detonation combustors, and inter-turbine burners. A brief description of these devices is provided below:

1. Primary Combustor: The primary combustor is where most of the combustion in a gas turbine occurs. Fuel is injected and ignited at high temperatures and pressures and the products drive the turbine stages of the engine.
2. Augmentor: The augmentor, or afterburner, is used to significantly increase the thrust of military aircraft at the expense of fuel efficiency. Fuel is injected in the exhaust stream and ignited to accelerate the exhaust gas existing the engine. These types of combustors take up a significant amount of volume and weight on military aircraft.
3. Rotating Detonation Combustors (RDCs): RDCs use a continuous detonation wave to burn a fuel-air mixture. The rotating detonation wave enables shorter combustion lengths and the device could theoretically produce a pressure rise, which is beneficial to the engine cycle. These type of devices are often difficult to operate and control.
4. Inter-Turbine Burners (ITBs): In an ITB, fuel is added and combusted between stages of a multi-stage turbine to raise the enthalpy of the flowfield in a compact space. While not as efficient as a primary combustor, the ITB is useful for scenarios where additional thrust is needed (similar to the Augmentor). ITBs are challenging to design because of the aerodynamic and pressure changes caused by turbine stage rotation.

Targeted and controllable combustion in naval aviation gas turbine engines is desirable since they provide thrust over a wide operational envelope for critical mission phases such as takeoff, supersonic cruise, and combat while being weight and volume constrained. Combustor length is typically constrained by the combined resonance time required to atomize, vaporize, mix, heat, and react liquid fuels with oxygen molecules at high flow rates, without blowing the flame out of the desired burn location.

A plasma assisted combustor uses plasma discharges to initiate and stabilize combustion, leading to more efficient fuel burning and improved combustion performance. This innovative technology can potentially lower the ignition temperature while enabling faster and more stable combustion. Additionally, electrically driven and controlled plasma may be used to actively control combustion properties. These improvements could yield significant benefits for naval aircraft including increased operational range, reduced fuel consumption, enhanced mission capabilities, and better component reliability. Specific goals for this effort include:

1. Increased combustion efficiency: Achieve a significant improvement in combustion efficiency relative to traditional combustor designs.
2. Decreased burning length: Decreasing the combustion resonance time will enable shorter combustor designs, which reduce the size and weight of the engine.
3. Improved operational flexibility: Develop a PAC system that can adapt to various operating conditions and fuel types.

4. Acceptable reliability and maintainability: Develop a PAC system that maintains or improves upon the reliability and maintainability of conventional systems, with a focus on minimizing downtime and maintenance costs.
5. Scalable and ready for integration: Design a PAC system that can be readily integrated into future naval aircraft, with the ability to scale the technology for different engine sizes and configurations.

Please note that the Office of Naval Research is specifically interested in liquid Jet fuel PAC solutions for this STTR topic, not gaseous. Although gaseous fuels may be used to minimize risk, they should not be the emphasis of this work.

PHASE I: Conduct a comprehensive feasibility study and develop a conceptual design for the proposed PAC system. Thoroughly explore existing and emerging plasma assisted combustion technologies Assess their applicability to naval aircraft. The research and development efforts in Phase 1 should focus on the following key areas:

1. Literature review and technology assessment: Perform a thorough review of the current state of the art in plasma assisted combustion, including research publications, patents, and ongoing research projects in both academia and industry. Identify and assess the most promising plasma generation methods, plasma-fuel interaction processes, and combustion enhancement techniques that have potential for integration into naval aircraft gas turbine engines
2. Analysis of critical technical challenges: Identify the critical technical challenges associated with developing a PAC system for naval aviation gas turbine engines. These challenges may include, but are not limited to, plasma generation methods, plasma-fuel interaction, combustion stability, integration with engine components and systems, and the ability to adapt to various operating conditions and fuel types. Propose innovative solutions to address these challenges, and evaluate the feasibility of these solutions in the context of the overall PAC system design.
3. Conceptual design: Develop a conceptual design for the liquid Jet fuel PAC system, incorporating the lessons learned from the literature review and technology assessment. The design should clearly illustrate the key components and subsystems of the PAC system, their function and operational requirements. Preliminary engine integration requirements and scaling constraints should also be identified.
4. Preliminary benefits and cost assessment: Quantify the performance benefit and cost impact of using a PAC over existing combustor technology in a Navy-like engine. Among others, the analysis should consider factors such as combustion resonance time, combustion efficiency, operability envelope, fuel consumption, reliability, and maintainability. Please note that performers will need to use their own tools and cycle models to conduct these types of studies.
5. Risk assessment and mitigation: Identify potential risks associated with the development testing, and implementation of the PAC system, including technical, operational, and programmatic risks. Develop a risk mitigation plan that outlines the strategies and measures that will be employed to address these risks throughout the course of the project.
6. Development plan and schedule: Develop a detailed plan and schedule for the subsequent phases of the project, including Phase II (Prototype Development and Preliminary Testing) and Phase III (Full-Scale Testing and Validation). This plan should outline the specific tasks and milestones that will be completed in each phase, the resources and expertise that will be required, and the anticipated timeline for completion.
7. Program cost analysis: Conduct a preliminary cost analysis for the development and testing of the PAC system, including estimates for research and development, prototyping, and testing costs.
8. Close collaboration with original engine manufacturers is highly encouraged starting in Phase I.

Upon completion of Phase I, the resulting feasibility study and conceptual design will serve as the foundation for the subsequent phases of the project, providing a clear roadmap for the development and testing of the PAC system in naval aircraft gas turbine engines.

PHASE II: Develop a prototype PAC system based on the conceptual design from Phase I and conduct preliminary testing to assess its performance, efficiency, and adaptability to various operating conditions and fuel types. Perform design refinement, testing, and optimization, with the goal of addressing the critical technical challenges identified in Phase I and demonstrating the potential operational improvements and benefits of the PAC system. The research and development efforts in Phase II should focus on the following key areas:

1. Detailed design and component selection: Develop a detailed design for the liquid jet fuel PAC system, including the selection of appropriate materials, components, and subsystems that meet the requirements for each test. This design process should involve a thorough evaluation of various plasma generation techniques, plasma-fuel interaction strategies, and combustion enhancement approaches, with the goal of selecting the most promising and feasible options for a Navy PAC system.
2. Prototype fabrication: Fabricate a prototype PAC system based on the detailed design, using advanced manufacturing techniques and materials, as required. Performers are expected to collaborate with engine manufacturers, materials suppliers, and other relevant stakeholders to ensure relevance and facilitate technology transition.
3. Preliminary bench-scale testing: Conduct preliminary bench-scale testing of the prototype PAC system using liquid jet fuels to assess its performance, efficiency, and adaptability to various operating conditions and fuel types.
4. Data analysis and design optimization: Analyze the data collected during the preliminary bench-scale testing to identify any areas of the prototype's design that required refinement or optimization. This analysis should involve a thorough evaluation of the PAC system's performance, efficiency, and adaptability, as well as its overall impact on engine operation, maintenance, and safety. Based on this analysis, refine and optimize the design of the PAC system to address any identified issues and maximize its potential benefits for naval aircraft gas turbine engines.
5. Updated risk assessment and mitigation: Revisit the risk assessment and mitigation plan developed in Phase I, and update it based on the results of the prototype development and preliminary testing. This update should include any new risk mitigation strategies and measures that have been employed during the course of Phase II.
6. Phase III planning: Develop a detailed plan for Phase III (Full-Scale Testing and Validation), outlining the specific tasks, milestones, and resources that will be required to conduct full-scale testing of the optimized PAC system, validate its performance and efficiency improvements, and develop a plan for integrating the system into future naval aircraft gas turbine engines.

Upon completion of Phase II, the resulting optimized prototype PAC system will serve as the basis for the subsequent Phase III, demonstrating the potential benefits and feasibility of implementing this advanced combustion technology in naval aircraft gas turbine engines.

PHASE III DUAL USE APPLICATIONS: Conduct full-scale testing of the optimized PAC system in a relevant engine environment, validating its performance, efficiency, and operability improvements. The research and development efforts in Phase III should focus on the following key areas:

1. Full-scale testing: Conduct full-scale testing of the optimized liquid jet fuel PAC system in a representative engine environment, evaluating its performance under different operating conditions and using various fuel types.
2. Performance validation: Validate the performance, efficiency, and operational improvements achieved by the PAC system through rigorous data analysis. Compare the results with traditional combustor designs to better quantify the benefits and drawbacks of the new technology. Evaluate

the PAC system's capability to meet the predefined goals and requirements established during Phase I and Phase II.

Upon completion of Phase III, the resulting validated PAC system will be ready for detailed engine integration studies and manufacturing readiness level maturation. Ideally, this effort will result in significant combustion performance and operability improvements over the state of the art. Improvements in combustion efficiency, fuel consumption, and operational flexibility make it an attractive solution for commercial aviation. In commercial aviation, fuel efficiency is a critical concern for airlines. Implementing PAC technology in aircraft engines could significantly reduce fuel consumption and emissions, leading to substantial cost savings for airlines and reduced environmental impact. Furthermore, enhanced combustion efficiency and operability could enable the use of alternative and sustainable fuels, supporting the aviation industry's ongoing effort to transition towards more environmentally friendly energy sources. PAC could also improve ground based power generation.

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KEYWORDS: Plasma Assisted Combustor (PAC), Gas Turbine Engines, Combustor, Combustion Efficiency, Fuel Consumption, Plasma, Rotating Detonation, inter turbine burning

N24A-T017 TITLE: Soft Robot for Locomotion in Granular Seabed Media

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

OBJECTIVE: Develop a soft robot capable of untethered, autonomous locomotion within granular media in shallow sea-floor environments.

DESCRIPTION: Expeditionary forces often work within the littoral environment, to include manipulation of soft, murky, and complex seabed. It is common for these seabed environments to prove difficult for sensors to penetrate for a full understanding of the bathymetry and shallow water regime. The ability to utilize a system which, when deployed by a diver, or from an autonomous vehicle, can work within and on the seabed, penetrating the sediment to help expeditionary users better understand the bottom habitat. This STTR topic seeks to develop a soft robot capable of untethered, autonomous locomotion within granular media in shallow sea-floor environments. The robot should be able to operate with an onboard power source and control system that can permit up to 2 hours of movement and 72 hours of stationary sensing. The robot should be capable of movement within submerged sand up to a depth within 1 meters of the sand surface, and horizontal movement up to 10 meters, on a single battery charge.

A proposed operational task for such robots would be surveying underwater soil regions by following movement trajectories that are pre-defined (e.g., a grid trajectory), or sensory feedback determined (e.g., follow path of low soil resistance). This task requires the ability to move in multiple directions and to incorporate sensor feedback into basic control algorithms for robot movement. The specific military impact will be to enable the detection, characterization and possibly neutralization of buried mines on the seafloor, and locate attached buried wires, although these would not be the specific tasks within this STTR topic. There would also be future opportunities for seabed sensing, communication, and ISR roles.

PHASE I: Conduct a study on the feasibility of a biologically inspired power-autonomous vehicle design, with a focus on mobility mechanism and power source. This should draw on prior biological research on subterranean locomotion kinematics, dynamics, and granular-body interactions. Identify the most promising actuation mechanism, including power requirements and expected lifetime. Conduct a design study of the feasibility of different sustainable power sources (e.g., solar, mechanical energy scavenging, microbial fuel cells) and specify the expected mission duration. Identify materials with surfaces that resist fouling. Develop a Phase II plan.

PHASE II: Fully develop and fabricate a prototype, according to the requirements stated in the Description. Evaluate the design via in-water tests conducted in a realistic submerged soil environment, targeting the listed performance objectives, including vertical and horizontal digging range and stiffness gradient sensing, via untethered operations. At a minimum, the prototype testing shall consist of (1) basic operability testing, (2) grid survey, (3) range/endurance trials, and (4) object detection. The awardee may propose other tests needed to demonstrate the benefits of their design perform analyses to establish reliability, identify areas needing further improvement, if necessary, and analyze manufacturing scalability in order to transition the design into a useful product for the Navy.

PHASE III DUAL USE APPLICATIONS: Apply the knowledge gained in Phase II to build a prototype ready for field testing. Test the prototype according to the Phase II test goals.
This technology would have dual use for seabed geotechnical measurements, geology, oceanography, and fisheries.

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KEYWORDS: soft robotics; seabed; granular media; underwater soil; autonomous; locomotion, burrowing

N24A-T018 TITLE: Inert Impulsive Expendable Acoustic Source (IIEAS)

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

OBJECTIVE: Develop an expendable impulsive underwater sound source without explosives or combustible gas packaged in A-size sonobuoy and/or Signal, Underwater Sound (SUS) form factor.

DESCRIPTION: High-energy impulsive underwater acoustic sources such as air-guns, sparkers, or explosive/implosive charges are used for oil and gas exploration, seabed characterization, and underwater target detection. Explosive charges, such as the SUS source, are especially convenient for being compact and mobile for easy deployment by surface or airborne platforms. SUS is routinely used to conduct transmission loss experiments used to determine bottom loss parameters which are used in databases for seabed bottom properties. A typical SUS charge contains the chemical compound trinitrotoluene, TNT; a chemical compound used as an explosive material requiring special handling. However, it's been shown that impulsive sound sources, such as created by the implosion of lightbulbs, can be useful for transmission loss or seabed characterization experiments. This STTR topic seeks development of an impulsive sound source without explosives or combustible gas packaged in A-size sonobuoy and/or SUS form factor.

PHASE I: Develop an impulsive underwater acoustic source concept that does not explosives or combustible gas. The source shall exhibit a Peak Source Level greater than or equal to 190 dB//1µPa@1m at water depths of 10 – 200 m or deeper. Energy Spectral Density should be within +/- 10 dB re 1muPa^2 s/Hz @ 1 m from 30 Hz to greater than or equal to 20 kHz. The concept should describe the mechanistic underpinnings of the source and support it with models and simulations. Simulations should demonstrate the source level and spectral content for as a function of depth in a representative ocean environment.

PHASE II: Develop, build, and demonstrate a hardware version of the source concept resulting from Phase I. The demonstration source does not have to be expendable, but should demonstrate the capabilities for source level and spectral characteristics stated in the requirements. Demonstrate that the impulsive source signature is repeatable and predictable for a given source depth. Develop a capability for triggering the source at a specific depth over the range specified. Develop a plan in consultation with the Navy for demonstrating the source to include compliance with environmental regulations. After demonstrations, develop a design for an expendable version of the source with form factors compatible with A-size sonobuoy and SUS.

PHASE III DUAL USE APPLICATIONS: The expected transition will be an inert impulsive expendable underwater acoustic source that can be used for transmission loss surveys, geotechnical surveys, and other naval or civil applications. The inert nature of the source will make handling much safer than currently used sources. Phase III tasking shall include refining the prototype design and fabrication of a near-final product suitable for testing. Sufficient test articles should be manufactured to establish repeatability of the specified source characteristics. An at-sea experimental test and evaluation plan shall be developed and executed in consultation with the sponsor. Test articles meeting the SUS form factor can be demonstrated by being deployed by hand or with the use of a suitable launcher from the deck of a ship. Test articles meeting the A-size sonobuoy form factor must demonstrate compatibility with standard launch tubes with a test plan developed in consultation with the platform operator. In their final forms, the SUS form factor is expected to be used for operational surveys or in support of basic and applied research. The A-size sonobuoy form factor can be dropped from helicopters for ASW search and or environmental characterization.

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KEYWORDS: Underwater Acoustics; Sound Propagation; Sound Source; Geoacoustic Inversion; Bubble pulse; Implosion

N24A-T019 TITLE: Portable Analytics for Multi-Stage Cyber Attack Investigation

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

OBJECTIVE: Develop forward-deployed portable analytics to automate initial stages of cyber attack investigation in connectivity-disadvantaged tactical platforms. The technology is needed to reconstruct attack stories, distilling the most important related events from vast quantities of low-level system and network data.

DESCRIPTION: As cyber attacks continue to escalate in complexity and Advanced Persistent Threat (APT) actors shift to using low-and-slow multi-stage attacks, cyber intrusion detection has come to be treated as a Big Data problem. Modern approaches require that a wide variety of information and sensor streams come together in an integrated analysis environment, with human and machine analytics combing the data feeds, hunting for needles in the haystack.

However, in connectivity-disadvantaged tactical environments, all of the fine-grained cyber event data (interface calls, low-level system logs, packet captures, event attestation, etc.) generated by a platform's information systems is unable to be streamed back to a centralized repository in a timely manner. This results in limitations for cyber attack investigations: either central analysis relies on incomplete, untimely, or reduced-precision data, or analytics expecting a global picture have to be pushed out to edge nodes, simultaneously reducing their effectiveness and separating them from the cyber hunt experts best equipped to make use of them.

To better address the problem of conducting effective Defensive Cyber Operations (DCO) on systems where connectivity is Denied, Degraded, Intermittent, or Limited (DDIL), new technology is needed to enable a multi-stage forensics approach to cyber event analysis and investigation. To feed later stages of analysis, portable analytics designed to be edge deployed need to be developed that distill the rich, onboard system and network event data, enabling the platform to make the most efficient use of any upstream connection.

The analytics must not rely on having any backhaul connectivity or onboard operator expertise beyond a most basic set of hints such as an operator noticing that a service crashed or that a subsystem was behaving oddly. The analytics should seek out connections and sequences in the system and network data that map to possible attack tactics, techniques, and procedures (TTPs), then bundle relevant data for priority offboarding to a more centralized analysis platform where it could be further triaged.

PHASE I: Define and develop a concept for automated rapid cyber forensics that can enable multi-stage cyber attack investigation and meet the constraints outlined in the Description. Provide a model of how the analytics would feed the cyber event distillation. Phase I Option, if exercised, would develop the initial distillation capability to create the full prototype in Phase II.

PHASE II: Develop a containerized portable analytic capability to validate the concepts defined in Phase I. Demonstrate attack story reconstruction and key data distillation by ingest on several different types of system and network data. The prototype should be deployable on a connectivity-disadvantaged edge node and able to inform a cyber big data platform by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II developed portable analytics prototype to a program as a component to a DCO system. Field containerized analytic with appropriate data ingestors and capability to integrate with existing data fabrics. Commercial use includes cyber security analysis in various sectors such as automotive, IoT, robotics, agricultural, and industrial control.

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KEYWORDS: Cyber, Defensive Cyber Operations, Forensics, Sequence Learning, Situational Awareness, Artificial Intelligence/Machine Learning, AI/ML, Denied, Degraded, Intermittent, or Limited, DDIL

N24A-T020 TITLE: Biological Noise Modeling for Active and Passive Sonar System Performance Predictions

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software

OBJECTIVE: Develop a biologic noise model compatible with Navy standard acoustic propagation packages (CASS and RAM) and highlight existing available and/or lacking biologic diversity density databases. The model should be applicable for both active and passive sonar performance predictions by including both the biologic vocalizations and scattering properties as a function of frequency.

DESCRIPTION: The Department of the Navy (DON) seeks to develop and demonstrate new reliable and computationally efficient biologic noise models for use within sonar performance prediction modeling packages such as CASS-GRAB or RAM-PE. Underwater acoustic energy is often dominated by shipping noise (low frequencies) and wind-wave noise (midrange frequencies (MF)). There are existing noise models and techniques for both of these predominate noise sources. However, in some geographical areas, biologics can be the limiting noise source. This can occur in passive sensing when produce vocalizations in the frequency bands of interest (LF and MF) which can be louder than the other noise sources. For active sonar, scattering from biologics can also cause significant clutter to sonar screens and impact the Pd/Pfa for the system. This STTR topic aims to identify existing, applicable or available biologic diversity density databases, to propose any new data bases that should be considered, select a processing technique in order to determine the statistical representation of noise contribution from biologics vocalization, integrate the developed model into a DON tactical decision aid (TDA), and ultimately have the model accredited for the Oceanographic and Atmospheric Master Library (OAML).

PHASE I: Develop the initial model architecture, conceptual design, and the algorithms necessary to demonstrate a Technical Readiness Level (TRL) of 3. This should include:

- Identification of applicable biologic databases and proposal of any new databases that should be considered
- Selection of processing technique to determine statistical representation of noise contribution from biologics vocalizations to the levels produced, spatial location of sources, and time dependencies (such as diurnal patterns)
- Case example for a representative sonar system

Put forward a model development and validation plan for subsequent phases of the effort.

PHASE II: Further mature biologic noise model based on the Phase I design(s) validated to TRL 5 (Phase II Base), TRL 6 (Phase II Option, if exercised). Validation criteria include required computational load, accuracy, processing time, special and temporal resolution, and compatibility with Navy TDAs. Upon completion of Phase II, the developed model and a technical report outlining function and validation/verification of performance should be delivered to the Department of the Navy.

PHASE III DUAL USE APPLICATIONS: Align Phase III efforts with the program of record to integrate the results of the Phase II work. This includes the productionization of source code, incorporation of algorithms to Navy systems (where feasible), and adjusting model requirements based on needs of the operational environment.

Dual-use applications include coordination with other governmental partners for oceanographic monitoring and data collection (such as National Oceanic and Atmospheric Association (NOAA)) and university partners using data for pedagogical and/or research purposes.

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KEYWORDS: Ocean Acoustics, Marine Biology, Oceanographic Models, Modeling, Tactical Decision Aids, SONAR Systems

N24A-T021 TITLE: Synthetization of Refractory/Transition Metal Diboride & Carbide Precursors for Chemical Vapor Infiltration (CVI) of Ceramic Composites

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

OBJECTIVE: Develop a stable, scalable synthesis route for a refractory diboride precursor suitable for evaporation in a Chemical Vapor Infiltration (CVI) system.

DESCRIPTION: Properties of refractory/transition metal diborides have attractive coating options for extreme applications with melting temperatures above 3200°C, high hardness, and excellent thermal oxidation resistance. Metal diborides such as hafnium, zirconium, tantalum, iridium, etc. have no commercially available single source CVI precursor. Depositing metal diboride via chemical vapor deposition routes such as CVI offer a viable method of integration into Ceramic Matrix Composite (CMCs) with respect to protective interface coatings. Commercial availability of refractory metal boride precursors to support epitaxial deposition is non-existent and development efforts are scarce. This STTR topic aims to develop stable, repeatable and scalable routes for new precursors for integration into existing large scale CVI systems. This research is critical for domestic development of key precursors identified to have the potential for significant advancements in Ultra High Temperature CMC processing.

PHASE I: Demonstrate synthesis route and basic precursor properties (vapor pressure, melting/freezing temperature, density, etc.) using modeling, characterization and experimentation. Determine repeatable and projected scalability of formulation.

PHASE II: Optimize process and demonstrate repeatability. Determine projected scalability of compound formulation. Begin Chemical Vapor Deposition (CVD) deposition studies. Evaluate deposition temperature range for amorphous and crystalline coatings and associated data showing crystallinity, grain size and stoichiometry. Initiate infiltration studies.

PHASE III DUAL USE APPLICATIONS: Continue infiltration studies, modelling the infiltration process to determine optimal conditions (T, P, flow) to optimize densification of fiber preforms. Determine methods and measures to ensure reproducibility for scaling to larger preform sizes. Dual use activities could include commercial access to space components, as well as other high temperature applications in the energy and materials processing communities.

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KEYWORDS: Precursors, coatings, chemical vapor deposition, chemical vapor deposition, organometallics, ceramic matrix composites

N24A-T022 TITLE: Remote Magnetometry with Resonantly Enhanced Multiphoton Ionization (REMPI) Readout

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Quantum Science

OBJECTIVE: Demonstrate atomic magnetometry in air using radar Resonantly Enhanced Multiphoton Ionization (REMPI) readout of 129Xe quantum states.

DESCRIPTION: Remote magnetometry has recently been demonstrated at 100+ kilometers using sodium atoms in the mesosphere [Refs 1,2]. At this high altitude, the naturally occurring alkali atoms are at low pressure making the environment similar to atomic measurements inside of traditional vapor cells. As in conventional atomic magnetometers [Refs 3,4,5], first pumping with circularly polarized light depopulates all but one hyperfine sublevel of the ground state creating a net polarization. Next, the polarized spins precess at the Larmor frequency that is directly proportional to the strength of the magnetic field. The constant of proportionality is the gyromagnetic ratio, which is a known atomic physics constant for a specific atomic isotope. Finally, the atoms fluoresce producing a readout signal. This STTR topic seeks to demonstrate atomic magnetometry with atoms in the air at sea level. Historic work has identified 129Xenon as a naturally occurring species in air with a long nuclear spin lifetime that could be used for magnetometry [Ref 6]. Like other species in the air, the transition energy to the first excited state in xenon is a vacuum ultraviolet (VUV) transition [Refs 7,8,9] but commercially available ultrashort pulse lasers can generate intensities above 1 GW/cm^2 for efficient multi-photon excitation using visible blue light. While the ~100 picosecond time between collisions in air is too short for fluorescence and the xenon concentration is too low for stimulated emission, recent work has used ultrashort pulse lasers to demonstrate Resonance Enhanced Multi-Photon Ionization (REMPI) in air. Thomson scattering of radar off the resulting low-density plasma (i.e., radar REMPI) could remotely readout the ionized electrons for a standoff magnetometry signal [Refs 10,11]. In this method, the laser wavelength provides the selectivity, and the radar intensity determines the sensitivity. Initial proposals should present a specific plan for reading the spin of a hyperfine 129Xe ground state, including the planned energy levels that will be utilized for three-photon radar REMPI.

PHASE I: Demonstrate radar REMPI detection of 129Xe using three-photon excitation in a vapor cell, ideally down to a pressure of 1e11 atoms/cc or show how this sensitivity could be achieved. Assess the time for spin to transfer from an excited electron to the nuclear spin during REMPI readout. Present a plan to demonstrate an all-optical standoff magnetometry measurement in a vapor cell including optical polarization and radar REMPI readout of the 129Xe.

PHASE II: Demonstrate remote magnetometry using radar REMPI readout with 129Xe in a vapor cell [Ref 12]. Publish a journal article ideally demonstrating the measurement in air (with the naturally occurring 129Xe concentration at 23 ppb) or clearly present how a measurement in air could be accomplished.

PHASE III DUAL USE APPLICATIONS: Explore methods to improve the measurement sensitivity, study schemes to increase the pumping efficiency and polarization with pressure broadened lines at atmospheric pressure, theoretically understand the spin transfer time relative to quenching from collisions, and advance methods to decrease the laser energy requirements.
Commercial applications include trace gas detection for air quality monitoring, combustion characterization, and magnetic mapping for geophysical prospecting.

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KEYWORDS: Quantum; atomic; magnetometry; radar; multi-photon; ultrashort pulse laser; trace gas detection; plasma; ionization; remote sensing

N24A-T023 TITLE: Scalable Additive Friction Stir (AFS) for Multi-metal Deposition

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

OBJECTIVE: Develop a portable or scaled-down / aircraft scale sized friction stir deposition system that is able to structurally repair spot sizes or through holes down to 0.25” in diameter on 0.125” thick aluminum, titanium, and high-strength steel.

DESCRIPTION: Rendering forging-like instead of casting-like properties, additive friction stir deposition (AFSD) is an emerging solid-state metal additive manufacturing process uniquely capable of large-scale metal additive manufacturing, cladding, and structural repair. Friction stir deposition systems are able to deposit high-quality aluminum, titanium and high-strength steel alloys, but current commercial systems as supplied by manufacturers like MELD and BOND use tool heads with a large surface area, approximately 1-1.25” in diameter [Ref 1]. This scale is useful for larger volume material deposition but is too large for the repair of most components on Navy and Marine Corps aircraft, which have small, localized damage areas of < 1”. In addition, this large tool geometry requires large backing forces to support a repair, which is likely going to be excessive for thin cross-section aircraft parts, potentially leading to part deformation during deposition [Ref 2]. The currently available systems are also very large and not practical for potential remote or portable use on aircraft.

PHASE I: Develop a concept for a friction stir deposition system that can deposit aluminum, titanium, and high-strength steel in areas < 1 square inch on substrates that are 0.125” thick. Capture relevant machine parameters and deposition data to support modeling/model development; such as high-resolution time-history data of the various parameters. At minimum, establish empirical/curve-fitting formulas to enable structural applications. Prepare a report to ONR and NAWCAD on design(s) and modeling. and prepare a Phase II testing plan.

PHASE II: Construct a prototype friction stir deposition system and assess the material properties, of the deposition of aluminum 7050-T7451, Ti6-4, and AerMet 100 alloys. Assess the properties of repaired 7050-T7451, Ti6-4, and AerMet 100 substrates using feed stock of the same alloys. Provide a report that documents the design of the prototype system, results of system performance, and results of material testing for the three alloys. Provide a Phase III plan to ONR and NAWCAD for prototype evaluation. Provide a prototype friction stir deposition system to NAWCAD for evaluation.

PHASE III DUAL USE APPLICATIONS: Assemble a full friction stir deposition system and demonstrate output meeting key deposition and material parameters, to include at least full mechanical properties related to strength and fatigue. Deliver a full friction stir deposition system to NAWCAD and a comprehensive final report containing the design, deposition, and process and testing data to ONR and NAWCAD.

The development of a scalable or portable AFSD print head with multi-metal capability would be directly applicable to in-situ repair of commercial structures for aviation and other vehicle platforms alike.

REFERENCES:
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2. Yu, Hang Z. “Additive Friction Stir Deposition.” Elsevier, Cambridge, MA, 2022. ISBN:978-0-12-824374-9.

KEYWORDS: Friction stir deposition, aerospace alloys, reduced scale, portable, in-situ, sustainment

N24A-T024 TITLE: Additive Manufacturing of Ferroelectric and/or Ferromagnetic Composite

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Materials; Directed Energy (DE)

OBJECTIVE: Develop a process for additive manufacturing of ferroelectric and/or ferromagnetic composites for High Power Microwave (HPM)applications. The composites should be comprised of at least 50% ferroelectric and/or ferromagnetic material. The final print should be free of large voids (> 1 µm3) and have a shortest dimension of at least one inch. The final sample should be close to final dimensions and have a resolution of < 1mm.

DESCRIPTION: Ferroelectric and ferromagnetic materials are utilized in various ways for HPM development; nonlinear transmission lines (NLTLs), high energy density capacitors, high voltage delay lines, tunable antenna arrays, etc. The development of additive manufacturing and 3D printing has provided inexpensive alternatives to traditional fabrication and prototyping. Currently there are no additive manufacturing processes that provide a prototyping capability for ferroelectric and/or ferromagnetic materials. Currently these ceramic and ferrite materials must be sintered and machined resulting in expensive prototyping and innovation due to material brittleness. Possible solutions include, but are not limited to, Stereolithography (SLA), Fused Deposition Modeling (FDM), and Selective Laser Sintering (SLS).

Production of the materials can be done using any innovative way but must produce a composite with electrical and/or magnetic properties of at least 90% of the ferroelectric and/or ferromagnetic inclusion. Electrical breakdown is a common critical failure mechanism for components in HPM systems that can result when voids are present in the materials. The final prints should be free of all voids greater than 1 µm3.

KEY ADDITIVE MANUFACTURING COMPONENT PARAMETERS
Will be negotiated with each proposal depending on submitted design.
• Smallest print dimension > 1 inch
• Resolution of print < 1 mm
• Material to print ferroelectric and/or ferromagnetic
• Electromagnetic properties = 90% inclusions
• Final dimensions should be = 95% of completed component
o Some post processing is acceptable

PHASE I: Develop design and strategies for an additive manufacturing process of ferroelectric and/or ferromagnetic composites for HPM applications. Perform cost analysis of various options. Determine compatibility with use of ferroelectric and/or ferromagnetic materials. Evaluate sample preparation (whether it is powder, resin, or filament). Evaluate print parameters. Provide a convincing way forward for a Phase II effort.

PHASE II: In consultation and with ONR approval, determine possible limitations of chosen path. Perform prints to evaluate the following parameters
• Permittivity and/or permeability
• Electrical breakdown strength
• Resolution of print
Perform the preliminary work necessary to prepare for high-power testing and characterization in Phase III.

PHASE III DUAL USE APPLICATIONS: In consultation and with ONR approval, proceed to printing multiple structures to be used as NLTLs, capacitors, inductors, tunable metamaterials, and/or delay lines for evaluation. In consultation and with ONR approval, test and characterize at high power. ONR may also dictate the location and government assets used to verify the test and characterization.

REFERENCES:

1. Benford, James; Swegle, John A. and Schamiloglu, Edl. "High Power Microwaves, Third Edition." CRC Press, 2016.
2. "Advances in High Voltage Engineering." IET. ISBN 0852961588, 2004.
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4. Fairbanks, Andrew J.; Darr, Adam M. and Garner, Allen L. "A review of nonlinear transmission line system design." IEEE Access, vol. 8, 2020, pp. 148606-148621.
5. Rangel, Elizete G Lopes; Rossi, José O; Barroso, Joaquim J; Yamasaki, Fernanda S and Schamiloglu, Edl. "Practical constraints on nonlinear transmission lines for RF generation." IEEE Trans. Plasma Sci., vol. 47, no. 1, 2018, pp. 1000-1016.

KEYWORDS: High Power Microwave; HPM weapons; Nonlinear Transmission Lines; NLTLs; Additive Manufacturing; Ferroelectrics; Ferromagnetics