# DEPARTMENT OF THE NAVY (DoN)
# 25.A Small Business Technology Transfer (STTR)
# Proposal Submission Instructions

**IMPORTANT**

- **The following instructions apply to STTR topics only:**
  - **N25A-T001 through N25A-T028**
- Information on the 25.1 SBIR and 25.A STTR Topics Workshop can be found at https://navysbir.com/nw25_1.htm.
- Submitting small business concerns are encouraged to thoroughly review the DoD SBIR/STTR Program Broad Agency Announcement (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 takes precedence over the DoD Instructions posted for this 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.

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 on the DoD SBIR/STTR Innovation Portal (DSIP). Refer to the Proposal Submission section of the DoD SBIR/STTR Program BAA for details. |
| | BAA Open | DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions)<br>Refer to the Proposal Submission 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 | DoN 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 |
|---|---|---|---|
| N25A-T001 to N25A-T006 | Ms. Kristi DePriest | Naval Air Systems Command (NAVAIR) | navair-sbir@us.navy.mil |
| N25A-T007 to N25A-T012 | Mr. Jason Schroepfer | Naval Sea Systems Command (NAVSEA) | NSSC_SBIR.fct@navy.mil |
| N25A-T013 to N25A-T028 | 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); and 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 seven 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:
    - A Phase I proposal template specific to DoN to meet Phase I requirements is available at https://navysbir.com/links_forms.htm.
    - 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. If a value above or below $0.00 is entered in the Cost Sharing field the proposal will be deemed non-compliant and will be REJECTED by DoN.**

- 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 Proposal Preparation Instructions and Requirements 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:

  - 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
  - Details of Request for Discretionary Technical and Business Assistance (TABA), if proposed, is to be included under the Additional Cost Information section if using the DoN Supporting Documents template.
  - 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 Proposal Preparation Instructions and Requirements section of the DoD SBIR/STTR Program BAA for details.

- **Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Volume 7)**. In accordance with Section 4 of the SBIR and STTR Extension Act of 2022 and the SBA SBIR/STTR Policy Directive, the DoD will review all proposals submitted in response to this BAA to assess security risks presented by small business concerns seeking a Federally funded award. Small business concerns must complete the Disclosures of Foreign Affiliations or Relationships to Foreign Countries webform in Volume 7 of the DSIP proposal submission. Please refer to the Proposal Preparation Instructions and Requirements 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 Method of Selection and 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 criterion 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.
  - **Cost Sharing: Cost sharing is not accepted on DoN Phase I proposals. If a value above or below $0.00 is entered in the Cost Sharing field the proposal will be deemed non-compliant and will be REJECTED by DoN.**

- **Company Commercialization Report (Volume 4).** The CCR (Volume 4) will not be evaluated by the DoN nor will it be considered in the 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.

- **Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Volume 7).** Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Volume 7) will be assessed as part of the Due Diligence Program to Assess Security Risks. Refer to the DoD SBIR/STTR Program BAA to ensure compliance with Volume 7 requirements.

## 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 Certifications and Registrations 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, 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 $2,000,000 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 STTR 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 Management Office.

If the TABA request does not include the following items the TABA request will be denied.
- TABA provider(s) (firm name)
- TABA provider(s) point of contact, email address, and phone number
- An explanation of why the TABA provider(s) is uniquely qualified to provide the service
- Tasks the TABA provider(s) will perform (to include the purpose and objective of the assistance)
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must NOT:
- Be subject to any 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 Navy SBIR 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 Navy 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 compliance review of Volume 3, to 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 Additional Considerations, 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. 4021/10 U.S.C. 4022 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 $2,000,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $2,000,000 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.

**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 25.A Topic Index

N25A-T001 TITLE: High-Fidelity Computational Modeling of Fluid-Thermal-Structural Interactions in Hypersonic Air-Breathing Systems

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

OBJECTIVE: Develop robust, accurate, and efficient computational methods for predicting the coupled fluid-thermal-structural response of an air-breathing hypersonic system at moderate hypersonic speeds.

DESCRIPTION: Air-breathing hypersonic systems are typically powered by ramjet or scramjet engines. At hypersonic speeds (i.e., Mach 5+), compression of the air stream is performed without any turbomachinery simply by slowing the oncoming flow through an isentropic (i.e., minimal loss) compression and/or a series of oblique shock waves. For scramjet engines, designing an inlet, which provides uniform flow to the combustor with minimal aerodynamic losses, is critical to obtaining high-engine performance (e.g., high-inlet efficiency, high-combustion efficiency, thrust). In addition to engine performance, the design of scramjet inlets significantly influences engine operability. At off-design conditions, the contraction ratio of the inlet may cause strong shock waves to develop that can prohibit mass flow through the engine and ultimately expel the flow out the front of the engine leading to engine “unstart”. Unstart can be catastrophic to the performance of a hypersonic system. Once an engine has unstarted, it is very difficult, if not impossible, to restart the engine in flight. Furthermore, due to the dynamics of the unstart process, maintaining control of the vehicle can be challenging and often leads to system failure.

In the hypersonic environment, the aerodynamics through the engine become increasingly coupled with the structural and thermal response of the vehicle. Vehicle deformation, both structural deformation and thermal deformation, can have significant impacts on the performance and operability of the propulsion system. To date, conventional design and analysis methodologies utilize isolated assessments of each physics domain (e.g., aerodynamics, structures, and thermodynamics) and do not properly capture the coupled effects between physics domains (e.g., fluid-thermal-structural interaction). If multiphysics interactions are not properly captured and accounted for during the design phase, the resulting hypersonic system may have reduced mission performance or may experience an unstart event leading to system failure.

Improvements in high-fidelity modeling and simulation of the fluid-thermal-structural response of a hypersonic vehicle are desired. The computational methods that are developed should address the impacts of coupling strategies between physics domains on the resultant simulation time and modeling fidelity for air-breathing hypersonic vehicles at moderate hypersonic speeds. The methods and tools shall be validated against experimental data and be capable of accurately accessing engine, air vehicle, and material/structural performance during flight. Any developed methods should be capable of transition and integration into government toolsets.

PHASE I: Develop and implement robust multiphysics coupling methodologies to simulate the coupled fluid-thermal-structural response of a body at moderate hypersonic speeds. Review the robustness, computational cost, and accuracy of coupling strategies for high-fidelity multiphysics simulation. Coordinate with government POCs on interface design to ensure the developed methodology can transition into government toolsets (e.g., CREATE-AV Kestrel). Validate the coupled multiphysics simulation capability against existing experimental data where the coupling of either fluid-structural, fluid-thermal, or fluid-thermal-structural interaction is captured. Assess the accuracy and computational cost of various multiphysics coupling strategies relative to conventional, single-physics analyses. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Demonstrate the coupled multiphysics simulation capability for a Navy-relevant, air-breathing, hypersonic vehicle. Assess the design impacts and improvements realized by the coupled multiphysics simulation capability relative to existing approaches. Further enhance the robustness, accuracy, and efficiency of the methodology. Continue coordination with government POCs to ensure an effective transition to government toolsets. Any developed methodologies should be able to execute on conventional CPU-based high-performance computing (HPC) hardware. Deliver prototype software tools on HPC, and document the mathematical theory, assumptions, and guidance for tool execution. Conduct a training session for potential government users on the new capability.

PHASE III DUAL USE APPLICATIONS: Verification and validation (V&V) of the new methods based on available test data. Methods should be updated based on the V&V effort. Additional analyses should be performed on a Navy relevant configuration. Developed algorithms and code are sufficiently validated to transition to HPCMP CREATE-AV for integration.

With the push for commercial aircraft operating at hypersonic speeds now part of the national discussion, the tools and methods developed under this STTR topic will have utility to the design and development of future commercial hypersonic and reusable space access platforms. Additionally, developments from this work can be applicable to computational analysis of supersonic and subsonic reacting flows.

REFERENCES:
1. Bertin, J. J. and Cummings, R. M. “Critical hypersonic aerothermodynamic phenomena.” Annu. Rev. Fluid Mech., 38(1), 2006, pp. 129-157. https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1007&context=aero_fac
2. Bertin, J. J. “Hypersonic aerothermodynamics.” AIAA, Washington, cop. 1994. https://search.worldcat.org/title/1022808140
3. Heiser, W. H. and Pratt, D. T. “Hypersonic Airbreathing Propulsion.” AIAA, Washington, D.C., 1994. https://search.worldcat.org/title/123496950

KEYWORDS: Hypersonic; Fluid-Thermal-Structural Interaction; Computational Aerothermodynamics; Multidisciplinary Physics-Based Modeling; Digital Engineering; Air-Breathing Hypersonic Vehicle

N25A-T002 TITLE: Lattice-Boltzmann Real-Time Dynamic Interface (LBRDI)

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

OBJECTIVE: Develop an innovative hybrid hardware/software system, based on Lattice-Boltzmann aerodynamic modeling techniques, capable of accurately modeling interactional aerodynamic effects on rotary-wing vehicles in the shipboard environment that is suitable for real-time, blade element-based rotary-wing aircraft flight simulations of urban and shipboard launch and recovery operations.

DESCRIPTION: Rotorcraft operations near obstacles (e.g., buildings, revetments, and ships) are characterized by complex aerodynamic interactions between the flow field created by the passage of air over the obstacle (airwake) and the flow field created by the air vehicle (rotor wake). Typically, real-time piloted simulations use simplified aerodynamic models in order to meet real-time execution requirements. The effects of obstacle proximity and unsteady, non-uniform wind flow (airwake) are accounted for using separate, precomputed models that are superimposed on the rotor inflow model. While this approach works well in many situations, important interactional aerodynamic effects that occur when a rotorcraft is operating in close proximity to obstacles are neglected. This compromise in fidelity is a barrier to using modeling and simulation for launch and recovery envelope development or for pilot shipboard certification. Coupled rotor/obstacle aerodynamics can significantly affect handling qualities; therefore, modeling these effects accurately is essential for predictive ship launch and recovery, and urban environment flight simulations. Interactional aerodynamics can be modeled using high fidelity Navier-Stokes (N-S) computational fluid dynamics (CFD) methods; however, the computations are significantly slower than real time. Lattice-Boltzmann CFD methods (LBM CFD) offer the possibility of calculating the evolving flow field in the loop with the piloted simulation because the equations set is reduced (as compared to N-S), and the algorithms are highly scalable on GPU computer hardware.

This STTR topic seeks to leverage ongoing research related to modeling-coupled aircraft/ship environments with LBM CFD methods to develop and demonstrate an aerodynamic coupling “compute on the fly” flight simulator. A combined hardware/software LBM CFD capability that captures average and standard deviation of rotor thrust to within 90% of N-S CFD and executes at speeds sufficient to model the evolving physics in a real-time piloted simulation environment is sought. The final system must be demonstrated in the Manned Flight Simulator environment at NAVAIR, NAS Patuxent River, Maryland.

PHASE I: Demonstrate accuracy of helicopter rotor thrust prediction for in-ground-effect hover ladder and for stationary hover behind a ship or ship-like structure for no-wind and with-wind conditions by comparing to GFE data. If the model does not execute fast enough to meet real-time simulation requirements, determine technical feasibility and develop a plan to achieve execution speed requirements. Demonstrate execution of LBM CFD integrated into a flight simulation environment for an (auto) piloted rotary-wing vehicle attempting to hold a hover in the wake of a bluff body obstacle. Create a plan to develop and demonstrate a deployable module. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Extend the Phase I approach to model shipboard launch and recovery operations for a single-main-rotor and a multiple-main-rotor aircraft as specified by the Navy Technical Point of Contact (TPOC). Demonstrate desktop (auto-piloted) simulations using contractor or university hardware. Develop and implement an approach to interface with the Controls Analysis and Simulation Test Loop Environment (CASTLE) operating environment. Implement the software and models in the NAS Patuxent River Manned Flight Simulator (MFS) CASTLE environment on a GFI GPU cluster at the MFS. Demonstrate integration of hardware/software system in real-time flight simulation for at least one Navy relevant ship/aircraft combination. Accuracy of the results will be judged through comparisons with GFI experimental and/or high-fidelity, fully coupled, Navier-Stokes CFD simulations. The ship configuration, the aircraft model, and CASTLE will be provided GFI.

PHASE III DUAL USE APPLICATIONS: Enable application for future Navy ship and aircraft configurations by developing methods to expedite new aircraft and ship model development and implementation. Determine and document best practices required to assure accuracy requirements are achieved for new aircraft and ship models.

Developments from this STTR topic are marketable to both commercial and private sectors to improve fidelity of helicopter flight simulators for shipboard, urban environments, and mountainous terrain.

REFERENCES:

1. Syms, G. F. "Simulation of simplified-frigate airwakes using a Lattice-Boltzmann method." Journal of Wind Engineering and Industrial Aerodynamics, 96(6-7), 2008, pp. 1197-1206. https://www.researchgate.net/profile/S-Shukla-3/post/Why-cant-the-lattice-Boltzmann-method-be-used-in-high-Reynolds-number-simulation/attachment/59d6256ac49f478072e9a449/AS%3A272164027076609%401441900368541/download/2007-Simulation+of+simplified-frigate+airwakes+usinga+lattice-Boltzmann+method.zip
2. Ashok, S. G. and Rauleder, J. "NATO generic destroyer moving-ship airwake validation and rotor–ship dynamic interface computations using immersed boundary Lattice–Boltzmann method." Proceedings of the 79th Vertical Flight Society Forum, West Palm Beach, FL. May 2023. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C14&q=NATO+Generic+Destroyer+Moving-Ship+Airwake+Validation+and+Rotor%E2%80%93Ship+Dynamic+Interface+Computations+using+Immersed+Boundary+Lattice%E2%80%93Boltzmann+Method&btnG=
3. Ashok, S. G. and Rauleder, J. "Towards real-time coupled ship–rotorcraft interactional simulations using GPU-accelerated Lattice-Boltzmann method." Proceedings of the 80th Vertical Flight Society Forum, Montréal, Canada, May 2024. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C14&q=Towards+Real-Time+Coupled+Ship%E2%80%93Rotorcraft+Interactional+Simulations+using+GPU-Accelerated+Lattice-Boltzmann+Method&btnG=
4. Forrest, J. S. and Owen, I. "An investigation of ship airwakes using detached-eddy simulation." Computers & Fluids, 39(4), 2010, pp. 656-673. https://www.academia.edu/download/39854358/An_investigation_of_ship_airwakes_using_20151109-9413-136wwwl.pdf
5. Yuan, W., Wall, A. and Lee, R. "Combined numerical and experimental simulations of unsteady ship airwakes." Computers & fluids, 172, 2018, pp. 29-53. https://doi.org/10.1016/j.compfluid.2018.06.006
6. Polsky, S. A.; Wilkinson, C.; Nichols, J.; Ayers, D.; Mercado-Perez, J. and Davis, T. S. "Development and application of the SAFEDI tool for virtual dynamic interface ship airwake analysis." 54th AIAA Aerospace Sciences Meeting, 1771, 2016. https://www.cobaltcfd.com/pdfs/2016/AIAA_2016_1771.pdf
7. Forsythe, J. R.; Lynch, E.; Polsky, S. and Spalart, P. "Coupled flight simulator and CFD calculations of ship airwake using kestrel." 53rd AIAA Aerospace Sciences Meeting, 0556, 2015. https://arc.aiaa.org/doi/pdf/10.2514/6.2015-0556
8. Nichols, J.; Magyar, T. and Schug, E. "The platform-independent aircraft simulation environment at manned flight simulator." AIAA Modeling and Simulation Technologies Conference and Exhibit, 4179, 1998. https://doi.org/10.2514/6.1998-4179

KEYWORDS: Lattice-Boltzmann Methods; LBM; Rotorcraft; Shipboard; Computational Fluid Dynamics; CFD; Flight Simulation; Coupled Aerodynamics; Real-Time; Dynamic Interface; DI; Launch and Recovery Envelopes; LRE

N25A-T003 TITLE: Metamaterial Lens Additive Manufacturing

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

OBJECTIVE: Develop and demonstrate additive manufacturing (AM) processes to produce metamaterial lenses process in Middle Wavelength Infrared (MWIR) (3–5 µm) or Long Wavelength Infrared (LWIR) (8–12 µm) bands derived from full-wave electrodynamic simulation.

DESCRIPTION: Meta-optics present several benefits to modern optical technologies. First, they allow for extreme miniaturization of optical components, reduced size, weight, and power (SWaP) for optical systems. Second, they enable smart functions that are not readily available with conventional optics, such as integrating multiple functions in a single optical element. Third, the nanoscale volume of the resonators offers fast and real-time reconfigurability of optical functions. Most importantly, meta-optic provides a means for the Navy to develop optical components in the MWIR and LWIR, which is not accessible by convectional glass.

With all of the benefits of meta-optics highlighted above, it is a challenge to produce meta-optical components. The current practice of producing meta-optics relies on simulations, creating a mask, using photo-lithography process, and then etching away the final product. This process is time consuming and has significant cost associated with it. Additionally, the small business awardee is relegated to materials that are complementary metal-oxide semiconductor (CMOS) friendly. If there is an error in the design or fabrication cycle the small business awardee must start the whole process from the beginning.
To mitigate the exhaustive development and manufacturing cycle of a meta-optical component, the Navy is seeking an AM solution that would take a meta-optic design and 3D print the final product. The Navy also seeks to work with any material of choice that supports the MWIR and LWIR spectrums. The Navy also seeks to work with multimaterial meta-optic solutions.

Create a meta-optical design using a n ($10 < n < 3$) sided polygon and demonstrate that the simulation produces a 10% diffraction limited lens of focal length 50 mm. Develop a method of preforming AM and simulate the production of meta-optical lens design using the AM process proposed by the awardee. Using the Phase I simulations produce a 25 mm meta-optical lens that is 10% diffraction limited with a focal length of 50 mm using AM process and equipment proposed by the awardee.

PHASE I: Propose a concept for broadband LWIR metalens AM materials that meets the objectives stated in the Description. The concept will include specific prototypes, by which the proposed AM process technology will be demonstrated. These prototypes will subsequently be produced and used (in Phase II) to verify, by testing and analysis, the efficacy of the proposed AM concept. Demonstrate feasibility by a combination of analysis, modelling, simulation, and evaluation of proposed process steps against established manufacturing methods. The Phase I Option, if exercised, will include the initial process specifications, AM equipment requirements, test specifications, and capabilities description to build a prototype AM facility in Phase II. Determine necessary equipment and manufacturing process to fabricate planar optical elements. Produce initial proof-of-concept lenses using the design and manufacturing processes to show viable path to meeting Navy program requirements. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a prototype facility for AM of LWIR metalens. In this context, “facility” refers to the combination of equipment, tooling, and process steps required to demonstrate the end-to-end AM capability provided by the proposer, not the actual physical facility. Demonstration of the AM process (or multiple processes) will be accomplished by fabrication and evaluation of the prototype components and materials identified during Phase I. Multiple prototype components and samples are expected during execution of this Phase as the process development is assumed to be necessarily iterative in nature. However, at the conclusion of Phase II, at least one example of each proposed prototype component or material sample will be delivered to the U.S. Government with no fewer than five total prototype samples delivered overall. Test data will also be delivered with each prototype sample delivered.

PHASE III DUAL USE APPLICATIONS: Provide representative prototype samples using the awardee's AM process to a U.S. Government laboratory and to a U.S. Government depot. Evaluate, by conventional metrology, the innovative optical surface with the flatness as detailed in the Description to ensure the AM process is on par with an optical flatness produced by common practice. Transition the AM process to a U.S. Government laboratory and to a U.S. Government depot.

Perform testing and make improvements to the AM process based upon the U.S. Government's evaluations and results.

Begin producing optical MWIR and LWIR AM components for field testing and use in military systems. Laser manufacturers, camera manufacturers, and imaging technology manufacturers will benefit from this AM technology because they can now specify custom-size optical components with unique MWIR and LWIR transmission profiles that are not currently available with conventional optical processing.

REFERENCES:

1. She, A.; Zhang, S.; Shian, S.; Clarke, D. R. and Capasso, F. "Large area metalenses: design, characterization, and mass manufacturing." Optics express, 26(2), 2018, pp. 1573-1585. https://doi.org/10.1364/OE.26.001573
2. "Low-Loss, Low-Aberration, Numerical Aperture-Matched Microlens Arrays to Improve Coupling Efficiency onto Photonic Imaging Devices.: Navy SBIR 22.1 - Topic N221-079 SSP. SBIR-STTR. https://www.sbir.gov/node/2101805
3. Unal, B. "AFRL-RX-WP-TR-2021-0133: Fundamental limits of nonlinear optical effects for metalens design with high index optical materials." United States Air Force, 2021. https://apps.dtic.mil/sti/pdfs/AD1154169.pdf
4. Benavides-Guerrero, J. A.; Gerlein, L. F.; Trudeau, C.; Banerjee, D.; Guo, X. and Cloutier, S. G. "Synthesis of vacancy-rich titania particles suitable for the additive manufacturing of ceramics." Scientific Reports, 12(1), 15441, 2022. https://doi.org/10.1038/s41598-022-19824-y
5. Bougdid, Y.; Chenard, F.; Sugrim, C.; Kumar, R. and Kar, A. "CO2 Laser Sintering of TiO2 Nanoparticles Thin Films for Improved Transmittance. Lasers in Manufacturing and Materials Processing, 2024, pp. 1-22. https://doi.org/10.1007/s40516-023-00241-6

KEYWORDS: Additive Manufacturing; AM; lens; LWIR; 3D Printing; Material Science; Metallurgy

N25A-T004 TITLE: Material System Design Tool to Enable Functionally Graded Materials

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

OBJECTIVE: Develop an Integrated Computational Material Engineering (ICME)-based material system design tool for multi-material functionally graded materials (FGMs).

DESCRIPTION: Additive manufacturing (AM) is a process of "printing" a 3D solid object from a digital model and enables the production of geometrically complex components that would be too costly, time-consuming, and/or impossible to produce by other manufacturing processes. However, most of the current AM technologies have not yet begun to achieve their full potential. One example of this is the ability to use multiple materials to fabricate components that are multifunctional. Functionally graded materials (FGMs) are materials whose composition (elements and/or phases) or microstructure (grain size, shape, and/or orientation) varies across a volume. The gradient of material properties results in unique mechanical and functional properties.

FGMs can enable multifunctional material systems with multiple functions. Multi-material FGMs can strategically allocate properties such as strength, density, and wear resistance over a single part. For example, wear and corrosive resistant alloys have been placed on tool steel die/mold for performance enhancements to elongate service life [Refs 1–3]. However, current multi-material AM processes produce discrete and relatively thick layers, which make the creation of a smooth gradient challenging. Additionally, while current multi-material AM processes are sufficient for some material combinations (e.g., deposition of stainless steel onto low-carbon steel), other material combinations have poor compatibility (e.g., Ti-6Al-4V and Inconel 718). A combination of material compatibility and residual stresses from processing can result in cracking and delamination of layers. However, a true FGM with gradual transition from one material to the next can mitigate this issue. The results can be further improved if a buffer material is incorporated into the FGM. For example, Thiriet et al. (2019) demonstrated the potential of fabricating an FGM using Ti-6Al-4V and Inconel 718 by using a molybdenum buffer layer [Ref 5]. Therefore, the buffer material selection will be critical for FGM design and fabrication for certain material combinations.

An analytical toolset to design functionally graded material systems is being sought to improve mechanical performance (strength, ductility, fatigue, fracture toughness) and environmental protection (corrosion, wear/fretting) for structural and subsystem components on U.S. Navy and Marine Corps aircraft. More specifically, FGMs are desired to provide transition zones from a substrate material to a desired coating material to reduce stiffness mismatches between the two materials to promote a longer service life via reducing stresses. The ICME-based analytical tool must address material selection by considering the compatibility of material properties, such as thermal expansion coefficients, as well as the need for buffer materials. Material selection must also consider undesirable high-temperature chemical reactions may result in intermetallics that may degrade the mechanical properties of the material system. The analytical tool must also predict the thicknesses of a transition zone for a FGM and any required buffer materials, and must consider different types of gradients (e.g., continuous and discrete gradients). The material system design must also ensure the fulfillment and optimization of application requirements, such as the overall strengths, fatigue, fracture toughness, weight, corrosion resistance, wear resistance, thermal and electrical conductivity, and so forth, of the fabricated FGM part.

PHASE I: Develop, design, and demonstrate feasibility of an ICME-based material system design tool to facilitate the fabrication of multi-material FGMs once the based material and target material(s) are identified. The focus of Phase I must be to explore the feasibility of a robust methodology for designing the proper FGM material system, including all buffer materials. Such an FGM material system design tool must be demonstrated by fabricating at least two different FGM samples with buffer materials. FGM samples must be designed and fabricated to satisfy different and complementary/supplementary functionalities, such as strength, fatigue, fracture toughness, density, corrosion, or wear/fretting resistance, and so forth. The produced FGM samples must be evaluated based on microstructure and mechanical properties, such as hardness and tensile and fatigue strength. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Fully develop and validate the prototype tool with various material systems and applications, including more performance requirements, such as fracture toughness, fatigue resistance, corrosion resistance, and so forth. The design tool must be fully demonstrated with at least five separate FGM examples that are applicable and useful for Navy applications. The developed methodology and tool must be demonstrated for its robustness in handling various applications, including the cases that selected base material and the target material(s) are not non-compatible, thus buffer material(s) is needed. FGM samples must be fabricated and validated through proper testing, including mechanical and environmental testing to validate the multi-functional requirements.

PHASE III DUAL USE APPLICATIONS: Fully develop the FGM design and fabrication tool to produce naval aircraft components that can be integrated into the fleet. Conduct final component level testing to fabricate the FGM parts with geometry and material properties of AM components meeting the Navy's specifications.

The process will be directly applicable to a wide range of AM process applications due to the high amount of usage of AM parts in the commercial/private aerospace industry. The proposed process will allow the industry to apply the benefits of AM technology to many critical aircraft components.

REFERENCES:

1. Riabkina-Fishman, M.; Rabkin, E.; Levin, P.; Frage, N.; Dariel, M. P.; Weisheit, A.; Galun, R. and Mordike, B. L. "Laser produced functionally graded tungsten carbide coatings on M2 high-speed tool steel." Materials Science and Engineering: A, 302(1), 2001, pp. 106-114. https://doi.org/10.1016/S0921-5093(00)01361-7

2. Zhang, X.; Pan, T.; Li, W. and Liou, F. "Experimental characterization of a direct metal deposited cobalt-based alloy on tool steel for component repair." Jom, 71, 2019, pp. 946-955. https://doi.org/10.1007/s11837-018-3221-5

. Cui, C.; Guo, Z.; Liu, Y.; Xie, Q.; Wang, Z.; Hu, J. and Yao, Y. "Characteristics of cobalt-based alloy coating on tool steel prepared by powder feeding laser cladding." Optics & Laser Technology, 39(8), 2007, pp. 1544-1550. https://doi.org/10.1016/j.optlastec.2006.12.005

4. Choi, J. W.; Kim, H. C and Wicker, R. "Multi-material stereolithography." Journal of Materials Processing Technology, 211(3), 2011, pp. 318-328. https://doi.org/10.1016/j.jmatprotec.2010.10.003

5. Thiriet, A.; Schneider-Maunoury, C.; Laheurte, P.; Boisselier, D. and Weiss, L. "Multiscale study of different types of interface of a buffer material in powder-based directed energy deposition: example of Ti6Al4V/Ti6Al4V-Mo/Mo-Inconel 718." Additive Manufacturing, 27, 2019, pp. 118-130. https://doi.org/10.1016/j.addma.2019.02.007

6. Alkunte, Suhas; Fidan, Ismail; Naikwadi, Vivekanand; Gudavasov, Shamil; Ali, Mohammad Alshaikh; Mahmudov, Mushfig; Hasanov, Seymur and Cheepu, Muralimohan. "Advancements and Challenges in Additively Manufactured Functionally Graded Materials: A Comprehensive Review." Journal of Manufacturing and Materials Processing 8, no. 1, 2024: 23. https://doi.org/10.3390/jmmp8010023

7. Fathi, Reham; Wei, Hongyu; Saleh, Bassiouny; Radhika, N.; Jiang, Jinghua; Ma, Aibin; Ahmed, Mahmoud H.; Li, Qin and Ostrikov, Kostya Ken. "Past and present of functionally graded coatings: Advancements and future challenges." Applied Materials Today 26, 2022: 101373. https://doi.org/10.1016/j.apmt.2022.101373

KEYWORDS: Functionally Graded Materials; Additive Manufacturing; Multi-Material Design; High-Fracture Resistance; Integrated Computational Material Engineering; Corrosion

N25A-T005 TITLE: Enhancing Naval Aviation Training Through Advanced Psychological and Physiological Techniques

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Human-Machine Interfaces;Trusted AI and Autonomy

OBJECTIVE: Research, develop, and validate advanced training techniques and technologies that leverage cutting-edge psychological and physiological insights to improve human performance and psychological well-being within naval aviation training environments.

DESCRIPTION: The Navy seeks a multi-disciplinary approach to the design development of novel manned and unmanned pilot operation training solutions drawing upon insights from high-performance domains such as Drone Racing League's [Refs 1–5, and 7]. This civilian population demonstrates exceptional hand-eye coordination, reaction times, and resilience to simulation sickness. These are highly useful traits and skills in naval aviation. Thorough research and examination of the unique physiological and psychological characteristics of individuals excelling in such environments, this effort aims to identify key factors contributing to their success including, but not limited to binocular vision, psychological resilience, and physiological adaptations [Refs 6 and 8].

To address these objectives, the Navy seeks a detailed investigation into the physiological and psychological profiles that distinguish high performers in extreme stress and high-demand environments in the initial phase. This exploration will not only encompass the intrinsic traits and capabilities that facilitate exceptional performance, but also the training methodologies and environmental factors that contribute to knowledge and skill development. The Navy seeks isolation of core components to identify transferable techniques and principles that can be adapted and integrated into naval aviation training programs. The investigation should include advanced data collection methods, such as eye-tracking technology and physiological monitoring, to gain insights into the cognitive and physical processes underlying peak performance and resilience to motion/simulation sickness.

The second phase of the effort will involve the development of a comprehensive training and intervention program, tailored to the specific needs and challenges of naval aviation training. Efforts should consider leveraging digital technologies, including mobile apps and websites, to deliver customized training modules focused on enhancing cognitive flexibility, stress tolerance and resilience, increased human performance in extreme environments, and physiological readiness [Refs 6 and 8]. The interventions will be designed to improve overall human performance and well-being, with a particular focus on mitigating the effects of motion/simulation sickness, a common challenge in aviation training in a manner that addresses human factors considerations [Ref 9]. Efforts should incorporate evidence-based techniques from existing relevant fields such as positive psychology and sports psychology, adapted for the unique context of naval aviation, to foster a positive training environment that supports mental health and peak performance [Refs 10 and 11].

In parallel, efforts should explore methods to establish a predictive model for individual performance variation, integrating a wide range of data points from physiological metrics to lifestyle factors such as diet, sleep, and physical activity. This model will serve as a foundational tool for customizing training approaches to the individual, optimizing learning and performance outcomes. By identifying key predictors of success and areas of potential improvement, the model will enable trainers to tailor interventions more effectively, ensuring that each aviator receives the support and guidance needed to reach their full potential. Findings should be considered for recommendations for selection and training. Finally, the initiative will explore the commercialization potential of the developed training program, considering its applicability not only within the military aviation context, but also in commercial and civilian aerospace sectors. As space travel and commercial aviation continue to evolve, there is a growing demand for training solutions that can prepare individuals for the challenges of these environments, from motion sickness to the psychological stresses of long-duration flights. The project's outcomes could thus have broad implications, offering valuable tools and insights for a wide range of high-stress professions and activities. This multi-faceted approach, combining rigorous research with practical application and commercial potential, positions the initiative to make a significant impact on the effectiveness and well-being of naval aviators and beyond.

PHASE I: Research, develop, and validate the taxonomy detailing the knowledge, skills, attitudes, and individual factors that contribute to high resilience against motion/simulation sickness and peak performance in high-stress environments. This Phase will also investigate the feasibility and alignment of existing interventions from sports psychology and positive psychology for adaptation or integration into naval aviation training solutions. Initial considerations should be made for any software/technology solutions to be in compliance with Risk Management Framework policy and requirements. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Leverage insights from Phase I to develop a comprehensive training program, integrating mobile app or website-based interventions, tailored to enhance the psychological well-being and performance of naval aviators. Include specific training techniques aimed at improving resilience to motion/simulation sickness, enhancing cognitive and physical performance, and promoting psychological health. Considerations should be made for any software/technology solutions to be in compliance with Risk Management Framework policy and requirements.

PHASE III DUAL USE APPLICATIONS: Conduct architecture hardening and engineering documentation to facilitate an Authority to Operate (ATO) approval for software/technology solutions as a standalone package or coordinate with a program to become part of a larger system approved ATO. Transition focused training effectiveness evaluations will offer input for data driven decision making associated with future acquisitions. Continued enhancements to technology may include automated processes for scenario generation, content conversion, sustainment of the system infrastructure, as well as commercialization of the capability to other stakeholders and domains.

Performance in high-stress environments or dynamic individual/team jobs that require increased interaction with remote and/or automated technology continue to increase. As technology adoption in a variety of fields increase, the potential utility of these types of training solutions will increase. In the near-term, commercial aviation offers a highly related domain for consideration of commercialization. The increased feasibility of remote and automated technology integration that impacts the complexity of jobs in homeland security or transportation security may benefit from similar technology. As a variety of commercial applications and domains consider automated human-in-the loop unmanned system integration (e.g., logistics, commercial goods transportation, food delivery, local area transit), considerations will be needed for the selection and training of personnel involved thereby increasing the commercialization applicability of the technology developed under this effort.

REFERENCES:

1. Pfeiffer, C. and Scaramuzza, D. “Human-piloted drone racing: Visual processing and control.” IEEE Robotics and Automation Letters, 6(2), 2021, pp. 3467-3474. IEEE. https://ieeexplore.ieee.org/abstract/document/9372809
2. Song, Y.; Steinweg, M.; Kaufmann, E. and Scaramuzza, D. “Autonomous drone racing with deep reinforcement learning.” 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), September 2021, pp. 1205-1212. https://ieeexplore.ieee.org/abstract/document/9636053
3. Pfeiffer, C. andScaramuzza, D. “Expertise affects drone racing performance.” arXiv preprint arXiv:2109.07307, 2021. https://doi.org/10.48550/arXiv.2109.07307

4. Barin, A.; Dolgov, I. and Toups Dugas, P. O. “Understanding dangerous play: A grounded theory analysis of high-performance drone racing crashes.” Proceedings of the annual symposium on computer-human interaction in play, October 2017, pp. 485-496. https://doi.org/10.1145/3116595.3116611
5. Pfeiffer, C;, Wengeler, S.; Loquercio, A. and Scaramuzza, D. “Visual attention prediction improves performance of autonomous drone racing agents.” Plos one, 17(3), e0264471, 2022. https://doi.org/10.1371/journal.pone.0264471
6. Fraser, W. D. “Stress, cognition, drones, and adaptive tasks.” Aerospace Medicine and Human Performance, 91(4), 2020, pp. 376-378. https://doi.org/10.3357/AMHP.5584.2020
7. Lochtefeld, J.; Schlager, S.; Bryan, S.; Harbour, S. and Colter, J. “Human Vs. Autonomous Agents: Drone racing and Obstacle Avoidance.” 2022 IEEE/AIAA 41st Digital Avionics Systems Conference (DASC), September 2022, pp. 1-5. https://ieeexplore.ieee.org/abstract/document/9925887
8. Memar, A. H. and Esfahani, E. T. “Physiological measures for human performance analysis in human-robot teamwork: Case of tele-exploration.” IEEE access, 6, 2018, pp. 3694-3705. https://ieeexplore.ieee.org/abstract/document/8248746/
9. Stark, B.; Coopmans, C. and Chen, Y. “A framework for analyzing human factors in unmanned aerial systems.” 2012 5th international symposium on resilient control systems, August 2012, pp. 13-18. https://ieeexplore.ieee.org/abstract/document/6309286/
10. Huang, H. M.; Messina, E. and Jacoff, A. “Performance measures framework for unmanned systems (PerMFUS) initial perspective.” Proceedings of the 9th workshop on performance metrics for intelligent systems, September 2009, pp. 65-72. https://dl.acm.org/doi/abs/10.1145/1865909.1865923
11. Freedy, A.; DeVisser, E.; Weltman, G. and Coeyman, N. “Measurement of trust in human-robot collaboration.” 2007 International symposium on collaborative technologies and systems, May 2007, pp. 106-114. https://ieeexplore.ieee.org/abstract/document/4621745/

KEYWORDS: Training; Human Performance; Psychological Well-Being; High-Stress Domains; Resilience; Motion/Simulation Sickness

N25A-T006 TITLE: Reducing the Life Cycle Cost of Automatic Target Recognition Application

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

OBJECTIVE: Utilize advances in 3D deep learning to dramatically lower the cost of developing and maintaining automatic target recognition template databases.

DESCRIPTION: Generating and/or collecting sufficient imagery to train neural-network-based automated ship recognition applications can be extremely costly. For classification purposes, the ships of the world can be adequately represented with approximately 1500 vessel types. Collecting sufficient imagery in situ for that many vessel types over a very wide range of viewing angles or building 3D models of that many vessels is not feasible from a cost and time perspective. Advances in 3D deep learning are revolutionizing computer vision and machine learning ability to synthesize views of complex scenes using only a limited number of input views. Approaches such as neural radiance fields (NeRF) [Ref 1] and Generative Query Networks [Ref 2] are capable of generating high-quality, photorealistic volumetric scenes from multiview input images by incorporating prior knowledge of the world to significantly reduce the input data requirements. Here we seek utilize these classes of techniques with minimal input imagery, potentially diverse in nature, to generate the 3D geometry of targets of interest such as combatant ships from which 2D projections of the target models from arbitrary views can be produced. These 2D dimensionally accurate projections can then be utilized to train radar and electro-optical/infra-red (EO/IR)-based neural-network target recognition applications or populate databases of classification templates for expert-system and/or hybrid artificial intelligence/machine learning (AI/ML) system automatic target recognition applications.

Consideration should be given to the nature and quantity of acceptable inputs. Candidate inputs include, but are not limited to, multiple view optical images or plan and profile view silhouettes. Limited physical dimension information such as vessel overall length from which the dimensions and physical location of other features on the vessel can be computed. Real-time, full-spectrum rendering is required. Comparing real-time sensor data to a target classification database in a tactical situation, for example, demands this. Inputs may require segmentation or other operations to make them suitable for processing. Once the nature of acceptable inputs are determined, the processing should be automated and include accuracy assessments using suitable additional information not included as input. The approach should be directly extendable to other target types such as aircraft. The goal is to make the entire process from input sourcing through 2D projections as efficient as possible in order to dramatically reduce the life cycle costs of these automatic target recognition applications.

PHASE I: Research, evaluate, and develop the overall system approach and architecture. Identify acceptable input requirements to produce the 3D representations and 2D projections. Consideration should be given to options for sourcing suitable inputs. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop the complete processing chain including steps required to prepare inputs. Automate the processing as much as is feasible. Work with the Navy to produce a limited template database and conduct a comprehensive evaluation it being used in existing maritime automatic target recognition applications.

PHASE III DUAL USE APPLICATIONS: Complete the automated processing capability and integrate as a means to train a target recognition application or to generate a feature database for a template-matching algorithm.

The 3D deep learning ability to synthesize views of complex scenes using only a limited number of input views can be utilized for a very wide range of computer vision applications.

REFERENCES:

1. Mindenhall, B.; Srinivasan, P. P.; Tancik, M.; Barron, J. T.; Ramamoorthi, R. and Ng, R. "NeRF: Representing scenes as neural radiance fields for view synthesis (Version 2)." Cornell University, 2020. https://arxiv.org/pdf/2003.08934.pdf

2. Eslami, S. A.; Jimenez Rezende, D.; Besse, F.; Viola, F.; Morcos, A. S.; Garnelo, M.; Ruderman, A.; Rusu, A. A.; Danihelka, I.; Gregor, K.; Reichert, D. P., Buesing, L., Weber, T., Vinyals, O., Rosenbaum, D., Rabinowitz, N., King, H., Hillier, C., … & Hassabis, D. "Neural scene representation and rendering." Science, 360(6394), 2018, pp. 1204-1210. https://www.science.org/doi/10.1126/science.aar6170

KEYWORDS: 3D Learning; Neural Radiance Fields (NeRF); Automatic Target Recognition; Machine Learning; Template Matching; Maritime Situational Awareness

N25A-T007 TITLE: Automated Data Synchronization Across Multiple Databases

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

OBJECTIVE: Develop a software algorithm that provides a capability to automate data synchronization across multiple databases of software defects and problem reports of surface naval platforms.

DESCRIPTION: Databases now use a set of disaggregated decision criteria that do not support collaboration and must be aggregated by the operator to be useful. Current decision support database tools are fixed in time and rely on operators to assess various sources of information to maximize performance over time. Databases to be utilized for tasking and actions are within the maritime, and air and land mission domains and should not be limited in their ability to visually represent multi-unit or multi-domain temporal coordination. The Navy seeks an automated course of action (COA) capability that improves situational understanding using merging, removing, or automating synchronization. New approaches are needed with enhanced methods to support database alignment, clarity, and usability.

The Navy has multiple databases located at various locations. It invests in several different land-based testing facilities for various capabilities. These various sites maintain their own hardware and database configurations for tracking purposes. Many of the databases contain identical or almost identical data with the same intent. The data needing to be automated and synchronized are the various software defects that have been reported and problem reports associated with the various surface navy combat systems baselines or platforms. The duplication of data residing on a host of different databases builds to the unnecessary data redundancies. The redundancies cause searching for information harder by having to eliminate data through comparison with all data that is retrieved. The current process requires manual human labor to catch duplicates through Change Review Board and potential audits. The redundancy in data prevents a common picture of ground truth in reporting defect status and the insufficient process slows down the decision-making actions of stakeholders costing valuable time in a decision-making process. The Navy desires an automated data synchronization capability in real time. It must retrieve information that is then compared with only unique occurrences of the same data which is brought forward as a single source. This will remove redundancies and reduce decision time of stakeholders that drive capability.

The AEGIS combat system databases are comprised of various databases that have various capabilities for controlling components specific to their baseline. The various baselines control specific radars and weapons per their primary and secondary mission areas. The databases in use currently store data for tactical employment and replay capability for reconstruction for mission accomplishment. The databases are engineered to operate independently as stand-alone sources and synchronize interoperate with other databases and combat systems defining the interoperability capability. The various surface naval databases can vary in different ways that may provide difficulty for the sailor to access in a timely manner when comparing different types of data.

The Navy is seeking a software application that can automate and synchronize identical or almost identical data contained on various databases. The solution will enhance capabilities by bringing a complete accessibility to a variety of data from non-similar sources for Surface Navy planning. There are currently no available commercial capabilities that will solve the need for the technology.
One of the key challenges of big data is taking the enormous amounts of data and turning it into useful cognitive information. Although there are no defined limitations to hardware and software for use aboard ships, Navy resource sponsors are seeking to reduce lifecycle costs to support Fleet capability by developing hardware agnostic software and by employing software standards that facilitate updates without significant cost. Currently, the software defects are reported on one database and not synchronized to extend to another database, failing to provide overarching awareness across all

capabilities. Equally, a Test Observation Report (TOR), which is sometimes handwritten during testing and turns into Trouble Reports (TR)/ Problem Reports (PRs), reported on one database may not be shared to another, thus not being universally accessible.

The speed and accuracy of the solution must exceed existing database access performance attributes by 10% or better. The software code should be able to demonstrate the ability to scan or screen the physical copy into editable fields within databases.

For Change Requests (CRs) that need to enter into a defect database, currently a team of individuals manually input the CR data on a weekly basis. Ideally, it would be more efficient to provide a file in a pre-determined format that could then be imparted into the defect database to create the PRs.

To reduce redundancy, it currently requires manual human labor to catch duplicates through the Change Review Board (CRB) and CR review and potentially audits. The solution software application needs to demonstrate the ability to screen through multiple databases and find duplicates based on parameters like change request number, description of the data observed, and PR type; and highlight the potential duplicate so users can take the next step. In addition, the application should be able to prioritize which defects have higher impact and rank them from red to green scale based on priority and safety impact parameters.

PHASE I: Develop a concept for an automated data synchronization algorithm that meets the objectives stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy's need. Feasibility shall be demonstrated by a combination of analysis, modeling, and simulation as stated in the Description. 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 automated data synchronization algorithm based on the results of Phase I. Demonstrate the prototype's functionality to improve situational visualization and situational understanding within a varied database context.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the prototype database software applications to Navy use. The final product will allow for further experimentation and refinement. The prototype database software application will be incorporated into the AEGIS baseline database modernization process. This will consist of integration into a database definition, incorporation of the databases existing and new database capabilities for software defects and problem reports accessibility to support certification.

Database algorithms could provide assistance to additional Department of Defense areas and air traffic controllers in maximizing database capability to prevent future potential collisions.

REFERENCES:

1. GeeksforGeeks. “The Problem of Data Redundancy in Database.” https://www.geeksforgeeks.org/the-problem-of-redundancy-in-database/
2. Kiyavash, Negar. “Database Alignment: Fundamental Limits and Efficient Algorithms.” 21 Oct 2021. https://www.youtube.com/watch?v=pbdXq_XXBbU
3. Silberschatz, Avi; Korth, Hank and Sudarshan, S. “Database System Concepts: Seventh Edition.” Nw York: McGraw-Hill Education, March 2019. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjymJCa5qGFAxXJNGIAHZKUChAQFnoECBEQAQ&url=https%3A%2F%2Fwww.mheducation.com%2Fhighered%2Fproduct%2Fdatabase-system-concepts-silberschatz-korth%2FM9780078022159.html&usg=AOvVaw3kzDHzb0YRbtzgrLYJP5W3&opi=89978449

4. Shmeltzer, Shay and Wells, Joyce. “Agile Development and the Modern Database.” Database Trends & Applications. Vol 32, Issue 4, Aug/Sep2018. https://www.dbta.com/Editorial/News-Flashes/Agile-Development-and-the-Modern-Database-126723.aspx
5. Campos, Luna. “Data Synchronization: What It Is and How to Sync Data for Beginners.” December 05, 2022. HTTPS://BLOG.HUBSPOT.COM/WEBSITE/DATA-SYNCHRONIZATION

KEYWORDS: Multiple Databases; Identical Data; Software Defects; Database Alignment; Automating Synchronization; Data Redundancies

N25A-T008 TITLE: Modeling of Magnetic Properties of High Strength Steels

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

OBJECTIVE: Develop physics-based material models for the understanding and prediction of stress-induced hysteretic magnetic behavior of high strength steels.

DESCRIPTION: The problem of stress-induced hysteretic magnetic behavior of high strength steels is challenging and a pressing one for the Navy. This is because Navy vessels, in general, and submarines, in particular, are subjected to stresses and complex changes in magnetic states that in turn causes their magnetic signature to evolve in a nonlinear, hysteretic fashion. Lack of fundamental understanding of this phenomenon prevents the Navy from designing magnetic signature reduction systems using a rigorous physics-based approach. Consequently, the Navy and industry address this issue by resorting to empirical approaches lacking sufficient physics-based understanding.

Computationally tractable models have been developed for the hysteretic magnetic behavior of steels of interest [Refs 4,5]. The commercial sector addresses this problem, e.g., for the effect of stresses on steels used in motor stators [Ref 5]. However, these models typically do not investigate the impact on the magnetic behavior due to hysteresis induced by large stresses of the order of 100's of mega Pascals (MPa). This effect is of great interest to the Navy.

While investigators have studied the effect of large stresses on hysteretic behavior of steels [Refs 1,2], fundamental understanding of this behavior that can be translated into a robust computational tool is still lacking.

Developing a computationally tractable model that accurately captures the physics is challenging because it involves the interplay of structural, stress, and magnetic properties spanning extremely varied length scales [Ref 3]. Therefore, this STTR topic calls for proposals that emphasize the need for a rigorous understanding of the effect of stress on the hysteretic behavior of high strength steels. Research and development are needed for the following inter-dependent areas:

1. Measurement of magneto-elastic and magneto-thermal hysteresis.
2. Development of both fundamental and phenomenological physics-based models of magneto-elastic and magneto-thermal hysteretic behavior based on measurements.
3. Implementation of the developed models into an efficient computational tool for rapid and robust prediction of magnetic behavior.

Taken together, the measurements, models, and computational predictions will be assessed against measurements and predictions based on physical scale and simple computational models.

PHASE I: Provide a concept of an approach to model the magnetic properties of high strength steels. Ensure that the concept clearly demonstrates how the challenges inherent in the three R&D areas in the Description section above will be addressed. Measure the effectiveness of the feasibility of the concept, e.g., by applying the methodology on idealized and geometrically simple objects such as spheres or shells with magnetically simple properties as test cases to serve as subscale prototypes or surrogates.
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: Build on the results obtained in Phase I to make a more robust framework that will consider the measurements and modeling of simple shapes to develop and implement measurement and computational tools that can be applied to a wide variety of magnetic and stressed environments. These measurement and computational tools will also be applied to objects of increasing geometric complexity.

The results of the application of the above tools will be verified or validated against comparable results obtained on Navy-owned physical scale models. The results of the verification and validation as well the computational tools (prototype) will be delivered to the Navy.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the mature computational tool prototype as well as measurement techniques that have been developed in Phase II for use by the Navy. Routinely validate, test, qualify, and certify the tools for Navy use by a rigorous verification and validation process involving comparisons against physical scale model and full-scale measurements. In addition, the computational and measurement tools will be used for the understanding and characterization of commercial steels that are likely to be used for high-stress and low-ambient magnetic field applications.

REFERENCES:

1. Schneider, Carl S.; Gedney, Stephen D.; Travers, Mark A.; Gedney, Joseph J.; Netzahualcoyotl Ojeda-Nayala; Redmond, Kyle E. and Gomez, Isabella M. “Isotropic Micromagnetic Field Model of Ferromagnetic Stress Effects.” Physica B, 666, 2023, 415120. https://doi.org/10.1016/j.physb.2023.415120
2. Schneider, Carl ;S, Gedney, Stephen D.;, Travers, Mark A.; Gedney, Joseph J. and Redmond, Kyle E. “Measurement and Gaussian Model of Ferromagnetic Viscosity.” Physica B, 635, 2022, 413830. https://doi.org/10.1016/j.physb.2022.413830
3. Hubert, O. “Multiscale Magnetoelastic Modeling of Magnetic Materials Including Isotropic Second Order Effect.” J. Magn. Magn. Mats., 491, 2019, 165564. https://doi.org/10.1016/j.jmmm.2019.165564
4. Chwastek, Krzysztof and Gozdur, Roman. “Towards a unified approach to hysteresis and micromagnetics modeling: A dynamic extension to the Harrison model.” Physica B, 572, 2019, pp. 242-246. https://doi.org/10.1016/j.physb.2019.08.016
5. Cui, Ronggao; Li, Shuhui; Wang, Zhe and Wang, Xinke. “A modified residual stress dependent Jile-Atherton hysteresis model.” J. Magn. Magn. Mats., 465, 2018, pp. 578-584. https://doi.org/10.1016/j.jmmm.2018.06.021

KEYWORDS: Ferromagnetism; Stress; Hysteresis; Isotropic Model; High Strength Steel Measurement; Multi-scale Modeling; Magneto-elastic

N25A-T009 TITLE: Medium Voltage Alternating Current System Grounding Circuit

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

OBJECTIVE: Develop a compact system grounding circuit for Medium Voltage Alternating Current (MVAC) applications between 1 and 15 kV that can operate continuously with a ground fault, is air cooled, works with a ground fault having a direct current (dc) component, dissipates less than 3 kW of heat during a ground fault, and prevents high transient voltage spikes due to intermittent ground faults.

DESCRIPTION: To enable continued operation in the case of a single ground fault, shipboard MVAC power systems typically are high resistance grounded using a grounding transformer and a High Resistance Grounding (HRG) resistor. The HRG circuit ensures line to ground transient voltages during a ground fault (particularly during intermittent ground faults) are not excessive and that under normal operation, the neutral to ground voltage is nearly zero. During a ground fault, the current through the HRG resistor is equal or marginally higher than the capacitive charging current of the system. This current can be on the order of 10 amps and the voltage would be the line to neutral voltage (The line-to-line voltage divided by the square root of three). In a 13.8 kV system, this can result in the HRG resistor dissipating roughly 80 kW. This amount of heat requires special accommodations for heat removal (water cooling for example) that complicate ship integration and drive costs. Alternately, the ground fault must be cleared within a few minutes before the space overheats, possibly impacting the safety of the ship. Details on HRG systems may be found in IEEE Std 45.1 (Recommended Practice for Electrical Installations or Shipboard—Design) and IEEE Std 3003.1 (Recommended Practice for System Grounding of Industrial and Commercial Power Systems).

Continuous operation with a ground fault is required to ensure vital electrical loads such as propulsion and combat systems do not lose power during critical time periods. The goal is to allow for locating and clearing the fault(s) in a non-critical time period. Since the length of time the ship will be in a critical time period is unknown, the HRG system should have the ability to operate continuously.
Another issue is that if a rectifier load is directly attached to the MVAC system, a ground fault on the Direct Current (DC) side of the rectifier can result in a DC current in the grounding transformer; this DC current can result in saturation of the grounding transformer leading to the grounding transformer and resistor overheating and potential catastrophic failure.

Research and Development along with Innovation are required to fulfill the functionality of an HRG circuit while dissipating less than 3 kW, enabling an air-cooled solution with a heat load that can be accommodated by the ship's ventilation system.

In addition to the requirement to limit heat dissipation to 3 kW, the proposed solution should not require more than 2 square meters deck space (threshold) or 1 square meters deck space (objective). The proposed solution should be capable of accommodating 10 Amps (A) of ground current (threshold) or 20 A of ground current (objective). The power quality of the MVAC system should be assumed to be in accordance with MIL-STD-1399-300.2. The shipboard equipment should be shock qualified to Grade A (MIL-DTL-901) and constructed to operate in the shipboard environment (MIL-DTL-917).

The solution may include power electronic devices with advanced controls to achieve the desired properties. Repair parts should be capable of passing through Navy standard hatches 26" x 66" and doors 30" x 60".

This MVAC System Grounding Circuit should be applicable to all shipboard MVAC systems up to 15 kV (both commercial and naval) and terrestrial industrial power systems where high reliability power is required (such as for process controls).

PHASE I: Provide a concept design of an MVAC System Grounding Circuit fulfilling the desired functionality listed in the Description. The feasibility of the MVAC System Grounding Circuit shall be demonstrated through Computer Aided Design (CAD) models and circuit simulation.

The Phase I Option, if exercised, should include the identification of key knowledge gaps and risks, initial design specifications, capabilities description, test plan, and test procedures for a prototype solution in Phase II. The prototype should address the key knowledge gaps and risks. A draft procurement specification for the production system should also be delivered.

PHASE II: Update the initial design specifications (if necessary) developed during the Phase I Option and produce a prototype system for testing in accordance with the test plan and test procedures. Include, if required, component testing to close knowledge gaps prior to updating the design specifications. Conduct the tests and update the system design and draft procurement specification for the production system based on lessons learned from testing. Once all testing has been completed, deliver the prototype system and all design and test report documentation to the Government.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the MVAC System Grounding Circuit for Navy use. Any naval ship with a MVAC distribution system (including CVN-68 class, CVN-78 class, LHD-8, LHA-6 class, DDG-51 flight III, FFG-62, and DDG(X)) is a candidate for transitioning the technology. Any commercial ship with an MVAC distribution system (such as cruise ships, ice breakers, etc.) is also a candidate for technology transition. Any terrestrial process control industrial application (oil refining, plastic production, chemical manufacturing, etc.) also can benefit from this MVAC System Grounding Circuit.

REFERENCES:

1. Bapat, A.; Hanna, R. and Panetta, S. “Advanced concepts in high resistance grounding.” 2015 61st IEEE Pulp and Paper Industry Conference (PCIC), Milwaukee, WI, USA, 2015, pp. 1-9. https://doi.org/10.1109/PPIC.2015.7165854
2. da Costa, L.A.; Mohammadi, Y.; Leborgne, R.C. and da Silva Gazzana, D. "Impact Evaluation of the Neutral-Grounding Resistance on Short-Duration RMS Voltage Variations." 2020 19th International Conference on Harmonics and Quality of Power (ICHQP), Dubai, United Arab Emirates, 2020, pp. 1-6. https://doi.org/10.1109/ICHQP46026.2020.9177891

KEYWORDS: High Resistance Grounding; Medium Voltage Alternating Current; Ground Fault; Grounding Resistor; Grounding Transformer; Power Continuity

N25A-T010 TITLE: Miniaturized Low Frequency Electric Field Sensing for Underwater Applications

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

OBJECTIVE: Develop a novel, low SWaP (space, weight, and power) electric field sensor for installation in maritime environments.

DESCRIPTION: The Navy utilizes electric field sensing to monitor emissions from corrosion protection systems. Electric field measurements in maritime environments are traditionally acquired using pairs of sensitive electrodes separated by a relatively large baseline. State of the art sensing systems that have a direct current (DC) response employ silver chloride electrodes, but these electrodes are susceptible to drift while deployed in maritime environments. An example of current specifications for silver chloride electrode drift and accuracy can be found in the impressed current cathodic protection system military specification: MIL-DTL-23919.

The Navy desires a sensitive, low SWaP electric field sensor with a DC response that is stable while deployed in the ocean. The desired sensor will be expected to:

- Fit into dimensions of: 10 centimeters by 7.5 centimeters by 5 centimeters
- Consume less than 10W of power continuously

The objective is to develop a compact electric field sensor package, fitting into the dimensions listed above, that meets the following sensing requirements:

- High dynamic range: 0.001 to 10000 millivolts per meter
- High accuracy: 0.001 millivolts per meter
- Low frequency: DC through 500 Hz
- Low noise: 0.001 mV/m/rtHz at 1 Hz (Threshold), 10 nV/m/rtHz at 1 Hz (Objective)
- Resist biofouling and operate in conductivities from 0.1 to 10 S/m
- Biaxial or triaxial design
- Orthogonality shall be established to within 1 degree
- Accuracy and dynamic range requirements shall be met for each independent electric field component axis

It is essential that the sensors maintain these accuracies under environmental stresses in the ocean. These conditions include: temperature 0-50 °C, hydrostatic pressure up to 10,000 kPa, total suspended solids of 0-120 mg/L, fouling and biofouling over extended deployment periods.

Advanced technologies for accurate measurement of local electric fields are sought and may include quantum sensing technologies. Technologies can be revolutionary and physical in nature, such as using phase transitions to sense electric fields. Recently, it was demonstrated that the insulator to metal (IMT) transition in perovskite nickelates could be used to sense marine electric fields [Ref 1]. Technologies can also be evolutionary in nature, such as using improved silver chloride chemistry to reduce the accuracy or drift errors resulting in more accurate small scale electric field measurements. Technologies based on existing silver chloride chemistry but using novel, alternate data processing means to achieve desired accuracy will be considered as well.

PHASE I: Develop a concept for compact electric field sensing meeting the accuracy requirements outlined in the Description. Demonstrate the feasibly of the concept to meet the parameters listed in the Description through modeling, simulation, and analysis. 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 two prototypes of the proposed electric field sensor sensors. Demonstrate the prototype's performance under the necessary environmental stresses. Deliver two such packaged sensors for Navy evaluation. The Navy will evaluate the prototypes for all requirements outlined in the Description section in a relevant seawater environment.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology through system integration and qualification testing. Implement cost reduction measures and install sensor at various locations. Demonstrate operation of the sensor package for a minimum of two years through the collection of background electric field data to support long term environmental data collections. Show that the system is able to collect data for magneto telluric surveys.

REFERENCES:

1. Zheng, Z, et al. "Perovskite nickelates as electric-field sensors in salt water." Nature, Vol. 553, Jan 2018, p. 68. https://www.nature.com/articles/nature25008
2. "Reference Cell, Impressed Current Cathodic Protection (ICCP) – Silver-Silver Chloride." MIL-DTL-23919D(SH), 14 April 2020.
3. Constable, S. "Review Paper: Instrumentation for marine magneto telluric and controlled source electromagnetic sounding." Geophysical Prospecting, 61 (Suppl. 1), 2013, pp. 505-532. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2478.2012.01117.x
4. Jau, Y.Y. and Carter, T. "Vapor-Cell-Based Atomic Electrometry for Detection Frequencies below 1 kHz." Phys. Rev. Appl., 13, 5, May 2020, Article 054034. https://journals.aps.org/prapplied/abstract/10.1103/PhysRevApplied.13.054034

KEYWORDS: Underwater Electromagnetic; Compact Ocean Sensing; Electric Field Measurement; Underwater Electromagnetic Measurement Range; Low SWaP; Quantum Sensing

N25A-T011 TITLE: Marine Biofouling Mitigation and Innovative Broad Band Hydrophobic Glass Development

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

OBJECTIVE: Design an innovative approach to reduce or mitigate biofouling on submerged broad band optical head windows.

DESCRIPTION: Biofouling has been a long-lasting problem in a variety of marine systems. Optics and sensors suffer reduced performance and, in some cases, catastrophic failure due to biofouling. No suitable optical surface coating is available to mitigate biofouling and salt mineral depositions. Legacy coating (Ameral) was effective on imaging systems, but Ameral has been discontinued due to environmental and health hazards. A replacement solution (Rain-X) has a short lifetime and requires frequent beam director window cleaning applications. Neither solution is effective for Photonics periscope and Laser applications, since both solutions absorb light and need periodic applications. No current market options combine the required hydrophobicity and broadband anti-reflection (AR) properties when applied to broadband optical surfaces exposed to a marine environment.

Nanostructured materials with super-hydrophobic self-cleaning surfaces, and hyper-branched polymer structures with hydrophilic-ended or activated foulant releasing groups are incorporated in most current coating techniques on the glass or sensors surface. However, advanced nano-structured coatings are usually associated with reduced mechanical properties, sophisticated fabrication processes, and extensive use of chemicals resulting in higher costs and more environmental issues.

The Navy seeks an innovative nanotechnology to mitigate broadband AR coating challenges. In this STTR topic, the Navy is looking for a cost effective and environmentally friendly innovative approach to mitigating biofouling on submerged glass and sensors. The exposed broadband optical surfaces employed are either sapphire, aluminum oxide, spinal, gallium germinate, or Germanium Oxide (GeO) . The proposed innovative technology should address biofouling and salt mineral deposition mitigation. Both an active and passive solution will be considered. Solutions must provide self-cleaning of the optical and sensor surface with ultra hydrophobicity and broadband AR coating.

Proposals will be evaluated on:

1. Nano structured deposition optical surface transmission wavelength from 0.45 to higher than 5 micrometer with greater than 90% transmission and higher than 99% optical transmission between 1 to 1.5 micrometer Wavelength.
2. Nano structure coating on head window will have wave-front error less than wavelength of light/50.
3. Optical Surface size of minimum 12-inch diameter shall not introduce any polarization or birefringence.
4. Surface durability more than 720 hours of continuous operation against any salt/mineral and any marine particle.
5. Optical surface should introduce self-cleaning technology.

PHASE I: Develop a concept to solve the Navy’s biofouling problem on Optical Head Window. Demonstrate the feasibility of the innovative concept to solve or mitigate the Navy’s problem of broad band glass with nano structure for anti-reflection (AR), biofouling and salt mineral deposition mitigation. Deliverable will include the initial modeling of the biofouling mitigation on broadband developed glass optical surface with salt mineral deposition and broad band AR coating. The Phase I Option, if exercised, will include the validation modeling and capabilities description to build a sample prototype optical glass for testing to mitigate biofouling of the proposed broadband glass surface at Phase II.

PHASE II: Develop the biofouling mitigated broadband glass with self-cleaning optical surface for an HEL beam director or Photonics periscope for data collection analysis. Deliver the prototype to the Navy for further evaluation. In Phase II Base the awardee shall demonstrate the broad band glass GeO and its biofouling properties and hydrophobicity. Test of the glass shall be performed inhouse.

The biofouling and salt mineral deposition mitigated broad band HEL window shall support multi kW laser power transmission with self-cleaning surface technology. The wave front error of the biofouling mitigated surface shall not be bigger than optical wavelength/50 of the optical surface. The Bio fouling mitigated surface shall also have higher than 160-degree contact angle with ultra-hydrophobic surface for water shedding and have broadband (visible to Mid wave IR) anti reflection properties.

PHASE III DUAL USE APPLICATIONS: Complete the final design of the biofouling mitigated broad band glass with self-cleaning optical surface. Support the Navy in transitioning the technology to Navy use.

This technology can have application to both DoD and commercial sectors such as ship's hulls, underwater pipes, oceanographic sensors, terrestrial optical sensors and laser systems, drilling equipment, oil platforms, fishing industry, power plants, and aquaculture systems.

REFERENCES:

1. Bixler, G. and Bhushan, B. "Review article: Biofouling: Lessons from nature." The Royal Society Publishing, Philosophical Transactions A, 370 (1967), May 2012, pp. 2381-417. https://www.researchgate.net/publication/224052963_Review_article_Biofouling_Lessons_from_nature

2. El Kheloui, R., Laktib, A., Elmegdar, S., Fayzi, L., Zanane, C., Msanda, F., Cherifi, K., Latrache, H., Mimouni, R., & Hamadi, F. "Anti-adhesion and antibiofilm activities of Lavandula mairei humbert essential oil against Acinetobacter baumannii isolated from hospital intensive care units." Biofouling, Volume 38, Issue 10, 20 Dec 2022, pp. 953–964. https://doi.org/10.1080/08927014.2022.2149326

3. Vasconcelos, B. M., Pereira, A. M. G., Coelho, P. A. T., Cavalcante, R. M. B., Carneiro-Torres, D. S., Bandeira, P. N., da Silva, F. F., Rodrigues, T. H. S., Gomes, G. A., & Carneiro, V. A. "Enhancement of chlorhexidine activity against planktonic and biofilm forms of oral streptococci by two Croton spp. essential oils from the Caatinga biome." Biofouling, Volume 39, Issue 10, 03 Jan 2023, pp. 984-993. https://doi.org/10.1080/08927014.2022.2159393

4. Long, Y., Yu, Y., Yin, X., Li, J., Carlos, C., Du, X., Jiang, Y., & Wang, X.. "Effective anti-biofouling enabled by surface electric disturbance from water wave-driven nanogenerator." Nano Energy, Volume 57, March 2019, pp. 558-565. https://www.sciencedirect.com/science/article/pii/S2211285518309820?via%3Dihub

KEYWORDS: Bio Fouling; Optical head windows; Hydrophobicity; Laser; HEL; AR (Anti reflection coating); Salt-mineral deposition

N25A-T012 TITLE: Medium Voltage Direct Current Protection Relays and Associated Sensors

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

OBJECTIVE: Develop a Fault Protection relay and associated sensors for 1 kV, 6 kV, and 12 kV Medium Voltage Direct Current (MVDC) distribution systems to implement overcurrent and differential / directional protection in both breaker and breakerless architectures.

DESCRIPTION: MVDC systems are an evolution of the DDG 1000 1 kV DC Integrated-Fight-Through-Power (IFTP) system combined with shared and distributed energy storage as well as advanced controls with active state anticipation data linkage between machinery and combat systems. An Integrated Power and Energy System (IPES) offers the potential to provide revolutionary warfighting capability at an affordable cost. An IPES utilizes integrated energy storage and power along with advanced controls to provide a distribution bus suitable for servicing highly dynamic mission loads and propulsion demands while keeping the lights on. Additionally, such a system can enhance survivability, reliability, and flexibility while providing new capabilities such as the ability to quietly maneuver solely on energy storage. Once technically mature, MVDC IPESs are intended for Future Surface Combatants (FSCs) to affordably improve warfighting capability to meet evolving threats over the ship's service life in an agile manner. The Navy is anticipating relying more and more on high power, highly dynamic, and pulsed weapons and sensors on FSCs. Because the need for generator synchronism is eliminated, MVDC is anticipated to be able to support these systems at lower cost, lower weight, and lower space requirements. Details on IPES are provided in the Naval Power & Energy Systems (NPES) Technology Development Roadmap.

One of the key enablers of an MVDC IPES is reliable and affordable MVDC fault protection systems compatible with both breaker and breakerless fault protection strategies [Refs 1-2]. One of the primary functions of a fault protection system is to sense a fault (such as line to line short circuit) and act quickly to localize and initiate isolating the fault. This function may be performed in both circuit breakers and in protection relays. Circuit breakers typically must decide whether to open or close using only locally measured voltages and currents. Also, protection relays can use more remote current and voltage sensors at the edge of a protection zone to determine if a fault has occurred, and if so, if the fault is within the protection zone. The protection relay initiates action to isolate the fault by sending commands to active rectifiers, circuit breakers, and/or disconnect switches. Designs of future MVDC systems are anticipated to require the use of protection relays to achieve power reliability requirements.

In differential protection, the currents on all conductors of the same polarity entering or leaving the protection zone are summed by the protection relay; if they do not sum to zero, then a fault is within the zone. For directional protection, protection relays examine the direction of current flow to determine if a fault is within the zone. One challenge is minimizing false alarms by coordinating multiple current readings when fault currents rise with high di/dt, particularly in a bus topology supporting pulsed power loads. If the current readings do not occur near simultaneously when currents are quickly ramping up, the sum of the current readings may not sum to zero even if the fault is not within the zone. An additional challenge is proving robustness and reliability of MVDC current and voltage sensors.

The Navy seeks protection relay and associated voltage and current sensors to detect a fault, determine if the fault is within the protection zone, and initiate commands to isolate the fault (if the fault is in the protection zone) within 8 microseconds (threshold) and 1 microsecond (objective). These times are to prevent solid state circuit breaker overcurrent protection from activating without coordination with other circuit breakers. The threshold requirement may require insertion of system inductance to slow the current ramp rate; added inductance can result in stability issues that then must be addressed. The protection relay and associated voltage and current sensors should be designed for use in a shipboard environment (as defined in MIL-DTL-917) for a design life of forty years (threshold) or fifty years (objective). If there is a fault within the zone, the protection relay and associated sensors should operate as desired at least 99% of the time (threshold) or 99.9% of the time (objective). The protective relay should experience a false positive (initiating fault protection when no fault is present in the protection zone) on average no more than once every 30,000 operating hours (threshold) or 300,000 operating hours (objective). The protection relay should be able to differentiate between a fault and a pulsed load. Currently this application does not commercially exist.

PHASE I: Provide a concept design of an MVDC Protection Relay and associated sensors fulfilling the desired functionality listed in the Description. The feasibility of the MVDC Protection Relay and associated sensors should be demonstrated through circuit simulation.
The Phase I Option, if exercised, should include the identification of key knowledge gaps and risks, knowledge gap closure plans/risk mitigation steps, initial design specifications, and capabilities description. Provide a Phase II test plan and test procedures for a prototype solution that addresses the key knowledge gaps and risks. Deliver a draft procurement specification for the production system including the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Provide updated initial design specifications (if necessary) developed during the Phase I Option and produce a prototype system for testing in accordance with the test plan and test procedures. Include, if necessary, component testing to close knowledge gaps prior to updating the design specifications. Conduct the tests and update the system design and draft procurement specification for the production system based on lessons learned from testing. Deliver a fully tested prototype system to the Government.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Any naval ship with elements of a MVDC distribution system (including CVN-78 class, DDG-1000 class, DDG-51 flight III, FFG-62, and DDG(X)) is a candidate for transitioning the technology.

In addition to naval warships, MVDC systems using the protection relays are anticipated to apply to commercial ships such as ferries, cruise ships, and ice breakers. Commercial applications are likely to increase in the upcoming years as international treaties enforce lower emissions from commercial ships; MVDC systems enable more efficient operation of diesel generator sets and easier integration of energy storage systems. Any terrestrial process control industrial application (oil refining, plastic production, chemical manufacturing, etc.) or renewal energy system employing MVDC could also benefit from the protection relay and associated sensors.

REFERENCES:
1. Doerry, Norbert H. and Amy Jr., John V. “Medium Voltage Direct Current (MVDC) Fault Detection, Localization, and Isolation." SNAME Maritime Convention 2022, Houston TX, Sept 27-29, 2022.
http://doerry.org/norbert/papers/SNAME-SMC-2022-073.pdf
2. Doerry, Norbert and Amy Jr., John V. "System Inductance for MVDC Circuit Breakers." IEEE Virtual ESTS 2021, July 27-August 6, 2021.
http://doerry.org/norbert/papers/20210601%20MVDC%20system%20inductance%20Doerry%20Amy.pdf
3. 2019 Naval Power and Energy System (NPES) Technology Development Roadmap.
https://www.navsea.navy.mil/Resources/NPES-Tech-Development-Roadmap/

KEYWORDS: Medium Voltage Direct Current; Fault Protection Relay; Current Sensor; Fault Detection and Localization; Differential Protection; Directional Protection

N25A-T013 TITLE: Vitrimer Patches to Repair Composite Parts with a Complex Shape in a Contested Environment

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

OBJECTIVE: Determine the feasibility of using vitrimer repair patches for repairing composite damage on a contoured surface in a contested environment.

DESCRIPTION: Repairing composites damaged on a contour is always a challenge. This is especially true when the fleet is forward deployed and operates in a contested environment. Usual go-to repair is a wet-layup patch. However, using wet layup patches results in a strength knockdown. The Navy is seeking a robust vitrimer resin based solution that can be deployed with the fleet and will be used to perform repairs in the theater, that will restore the full strength of the composite part.

Vitrimers are a relatively new class of resins developed over the last decade which has dynamic chemistry in which covalent bonds are exchanged and rearranged by providing stimuli such as heat. Referred to as “reversible thermosets,” these polymers have thermoset properties below the glass transition temperature (Tg) yet behave like a thermoplastic at elevated temperatures, above the Tg. Tg can currently be tailored between 80° C to 180° C. However, the chemistry and the resulting Tg are an area of active research. Kits can be developed as flat patches and contoured to shape as needed in the theater. These contoured patches can be cured on the part or secondarily bonded using traditional epoxy vitrimer/epoxy based resins. These late resins can provide bond strength at least as good or better than traditional epoxy adhesives but also can be cleanly removed as needed by applying heat.

PHASE I: Identify suitable vitrimer resin pre-pregs and demonstrate its feasibility to be used for repair. Through suitable experimental campaign, map its formability and mechanical properties. In Phase I any limitations in obtaining tight tolerances and any property degradation during reforming the vitrimer patches should be identified. Potential methods to join it to a carbon/epoxy part should also be identified and its feasibility established. The feasibility study should be completed at the end of the Phase I base as the down select will be made before the Phase I option is exercised.

PHASE II: Using the results from Phase I, develop repair kits. Identify a control surface and an access panel. With TPOC input design and create damage on the parts. Repair the damage using the Vitrimer patches. Examine the quality of the patches through non-destructive inspection (NDI). Determine the strength of the patches through testing.

At this point NAVAIR depots are expected to be involved to inform the team of the needs for repairs. Using this information as well as results from the program, design and produce prototype repair kits and demonstrate it at a Navy depot.

PHASE III DUAL USE APPLICATIONS: The primary transition goal is NAVAIR depots. While interest is from PEO(A) the solution applies to all aircraft with composites.

In addition to repairs, vitrimer resins have great potential in manufacturing complex production parts. In addition to the aviation industry there is also interest in vitrimers by the automotive industry, urban mobility industry, and high performance sport industry.

Vitrimer composites are environmentally friendly and recyclable. Thus it has great potential as environmentally benign replacements for thermoset composite parts.

REFERENCES:

1. Sloan, Jeff. “Vitrimers: The reprocessable thermoset.” CompositesWorld, September 28, 2020. https://www.compositesworld.com/articles/vitrimers-the-reprocessable-thermoset
2. Gardiner, Ginger. “Reprocessable, repairable and recyclable epoxy resins for composites.” CompositesWorld, May 24,2021. https://www.compositesworld.com/articles/reprocessable-repairable-and-recyclable-epoxy-resins-for-composites.
3. Yang, Yang; Xu, Yanshuang; Ji, Yan and Wei, Yen. "Functional Epoxy Vitrimers and Composites." Progress in Materials Science, Vol. 120, 2021/07/01: 100710. . https://www.sciencedirect.com/science/article/pii/S0079642520300748
4. Chen, Mao; Zhou, Lin; Chen, Zhongtao; Zhang, Yinyu; Xiao, Peishang; Yu, Shujun; Wu, Yeping and Zhao, Xiuli. "Multi-Functional Epoxy Vitrimers: Controllable Dynamic Properties, Multiple-Stimuli Response, Crack-Healing and Fracture-Welding." Composites Science and Technology, 221, 2022/04/12: 109364. . https://www.sciencedirect.com/science/article/pii/S0266353822001063

KEYWORDS: Vitrimer; Composite Repair; Wet Patch Layup; contested environment; depot repair; kits; recyclable

N25A-T014 TITLE: Removable Smart Tooling for High Temperature Composite Fabrication

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

OBJECTIVE: Develop removable tooling to produce complex contours by Automated Tape Placement (ATP) and Automated Fiber Placement (AFP) for thermoplastic composite parts.

DESCRIPTION: Recent developments in ATP and AFP have revolutionized the composites industry. They have enabled affordable automated production with high dimensional tolerances. ATP/AFP operations often use a tool over which the material is laid. A removable tool allows for manufacture of complex parts in one operation rather having to make multiple parts and joining them secondarily. Such tooling remains a challenge as it needs to maintain its dimension and strength throughout the layup and consolidation process.

Two promising technologies that can be leveraged in this STTR topic are washout tools and the melt tools. In the first washout material is manually poured into tooling and allowed to harden. Once the part is laid up on the tool and consolidated, usually water is used to washout the tool. There are now washout material available that can operate at up to 370 °C which is sufficient for thermoplastics. However, additional work is needed to improve dimensional tolerances and develop it to a point that it can be used as an ATP/AFP tool. The second candidate technology is the meltout tooling. In this process the tool is molded using Resin Transfer Molding (RTM). Once the part is consolidated it is removed by heating. The challenge for this technology is that it currently uses materials that cannot be used at temperatures needed for thermoplastic manufacturing. Thus material discovery and/or development is needed to meet the topic objective.

The program should produce the tooling such that it is highly repeatable (tolerances of +0.005” on thickness and +0.010” on everything else), is low cost considering both materials and forming process ($40-$50/part of size 1.5” x 12”x 0.5”), does not require an oven post cure, has thermal shock and impact resistance equal to ceramics, and requires minimal processing time. The material should be capable of being used in autoclave processing with typical processing conditions of 350°F temperature and 100 psi pressure. In addition, the material used for the tooling should be environmentally friendly and should not create a hazardous waste stream.

The washout tooling must also provide the appropriate characteristics required for the production of high performance composite structures. In addition to the above mentioned tolerances, it is important that the tooling produces the finished part with the appropriate dimensions. This requires that the washout tooling have the appropriate Coefficient of Thermal Expansion (CTE) such that a finished part meet the tolerances required for the processed component. It should be noted that carbon/Polyetherketoneketone (PEKK) tape will be one of the materials that the washout tooling will be required to be compatible with.

PHASE I: Develop and demonstrate material and handling properties to produce proof of concept specimens with properties suitable for use in removable smart tooling applications, as detailed above. Demonstrate that the tooling material can be easily removed after a component has been processed at 700° F. Finally, demonstrate that the tooling material can be stored under ambient conditions.

PHASE II: Develop and demonstrate a repeatable process whereby the awardee can produce a soluble rectangular mandrel with dimensions of approximately 1.5” x 12” x 0.5” with tolerances of +0.005” on thickness and +0.010” on everything else. These parts must also demonstrate that they are capable of handling the processing conditions typical of tape placement. In addition, they need to demonstrate that the process is scalable to 2” x 20” x 0.5”. Demonstrate the ability to develop and demonstrate the process for manufacturing the removable tooling with more complex shapes, as determined by the topic sponsor.

The shape can include rectangular sections that are out of plane, or circular sections with jogs and protrusions, or foil shapes with complex curvature. Scale up the processing to be able to produce mandrels with planar dimensions of a minimum 12” x 24“. Demonstrate that the manufactured component meets the dimensional tolerances established by the Technical Point of Contact (TPOC).

PHASE III DUAL USE APPLICATIONS: Perform a functional demonstration to DoD stakeholders arranged by the Navy team. Help transition the technology to a DoD original equipment manufacturer. While focused on thermoplastic the tooling will also be useful for thermoset AFP and ATP. The commercial aircraft industry would benefit significantly from low cost tooling material that allows for the fabrication of reproducible low cost composite parts by reducing the part count for complex shaped components. The tooling can also be used in naval platforms (ships, subs) which could benefit from reduced part count and complex composite components.

REFERENCES:

1. Black, Sara. “New options for trapped tooling.” CompositesWorld, July 1, 2011. http://www.compositesworld.com/articles/new-options-for-trapped-tooling
2. Oromiehie, Ebrahim; Gain, Asit Gain and Prusty, B. Gangadhara. "Processing parameter optimisation for automated fibre placement (AFP) manufactured thermoplastic composites.” Composite Structures, Volume 272, 15 September 2021, 114223. ISSN 0263-8223. https://doi.org/10.1016/j.compstruct.2021.114223


KEYWORDS: Removable tooling; Washable tooling; melt tooling; composites manufacturing; thermoplastic composite; low cost manufacturing; complex shapes

N25A-T015 TITLE: Lateral Shear and Strain Sensor for the Ocean Environment

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

OBJECTIVE: Develop a sensor to advance our capability of measuring finescale (1-10 m) lateral gradients in ocean velocity for environmental sensing of anisotropic turbulence. The sensor should be capable of direct measurement of lateral gradient fields within this scale range. While deployment via a ship is appropriate for the initial design phase, the design should consider future deployments on autonomous or moored platforms.

DESCRIPTION: Direct measurement of ocean turbulence depends on sampling of quantities at length scales where universal scaling laws hold. These measurements are typically made in the vertical over regimes that are thought to be isotropic (invariant with rotation), homogeneous (invariant in space), and stationary (invariant in time). In the stratified ocean, the assumption of isotropy breaks down when the vertical scale of turbulent overturns is suppressed by the fluid's stabilizing stratification. In contrast, horizontal shear is unrestrained and turbulent eddies persist. This anisotropic turbulence regime resides in between spatial scales dominated by internal gravity waves in the open ocean and the inertial subrange of isotropic turbulence [Ref 1]. It is characterized by what have been termed 'pancake' eddies or vortical motion as turbulent vortices have a 'flattened' aspect ratio in the vertical.

Direct measurement of velocity fluctuations over this spatial range are exceedingly rare as most existing Commercial off-the-shelf (COTS) sensors offer either a fixed volume or vertical profile of velocity. The Navy seeks development of a sensor capable of direct measurement of lateral velocity gradients over spatial ranges of order 1-10 meters. The Navy is agnostic to the approach, which may be acoustic [Ref 2], optical [Ref 3], or some alternative platform [Ref 4]. Proposed designs should either sample the lateral velocity vector while resolving differences over the scale of 1 m or measure lateral shear/strain directly on scales of at least 1 meter. The sensor should be capable of 1) resolving gradients of 0.0001 1/s (implying a noise floor below this value) and 2) distinguishing lateral motions from platform tilt either through motion correction or direct sensing. While deployment via a ship is appropriate for the initial design phase, the sensor should ultimately be deployable on autonomous or moored platforms.

PHASE I: Identify a design concept for a sensor along with the hardware components that can meet the stated requirements. Develop a concept for onboard and offline software processing. Develop a detailed power budget for the sensor. A detailed analysis for strengths and weaknesses of the proposed design should be included in Phase I, considerations should include resolution and range tradeoffs, endurance determined by power and storage needs, and physical footprint of the sensor. After assessment of strengths and weaknesses a final design review should be completed.

PHASE II: Develop and test a prototype system. Complete analysis of the performance of the system. Report on results. Perform multi-stage testing, allowing for redesign between tests with initial tests in a surrogate ocean environment (e.g., lake or tank) and final testing in the ocean under controlled conditions (e.g., coastal bay). Both hardware and software systems should be developed and tested during Phase II. Field testing in Phase II will constrain the parameter space under which the system is operationally capable for the Navy.

PHASE III DUAL USE APPLICATIONS: Support the transition to Navy use. This technology has potential use in DoD and commercial applications that require current velocity information at small scales (1-10 m). Possible applications include monitoring of contaminants shed from wind/wave farms and other offshore structures, monitoring fluxes for marine carbon dioxide removal (mCDR) development, and navigation of UUVs.

REFERENCES:
Basic theory
1.Kunze, Eric. "A unified model spectrum for anisotropic stratified and isotropic turbulence in the ocean and atmosphere." Journal of Physical Oceanography, 49.2, 2019, pp. 385-407.
Acoustic application
2. Smith, Jerome A.; Pinkel, Robert and Goldin, Michael A. "A vertical slice of acoustic intensity and velocity [2-D images of waves and turbulence]."2015 IEEE/OES Eleventh Current, Waves and Turbulence Measurement (CWTM), St. Petersburg, FL, 2015.
Optical application
3. Steinbuck, Jonah V., et al. "An autonomous open-ocean stereoscopic PIV profiler." Journal of Atmospheric and Oceanic Technology, 27.8, 2010, pp. 1362-1380.
Direct vorticity measurement
4. Sanford, Thomas B., et al. "An electromagnetic vorticity and velocity sensor for observing finescale kinetic fluctuations in the ocean." Journal of Atmospheric and Oceanic Technology, 16.11, 1999, pp. 1647-1667.
Atmospheric application
5. Palmer, R et al. "A Primer on Phased Array Radar Technology for the Atmospheric Sciences." Bull. Amer. Meteor. Soc., 103, 110, 2022, pp. E2391–E2416. https://doi.org/10.1175/BAMS-D-21-0172.1

KEYWORDS: stratified turbulence, anisotropic turbulence, ocean sensing, vorticity, lateral shear, lateral strain

N25A-T016 TITLE: Persistent Airborne Counter Unmanned Aerial System Surveillance

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

OBJECTIVE: Develop and demonstrate an innovative airborne counter-unmanned aerial system (C-UAS) concept that balances sensing performance and host unmanned airborne platform capabilities supporting persistent surveillance with overall system size, weight, power, and cost (SWAP-C).

DESCRIPTION: The Navy seeks an airborne C-UAS system capable of providing persistent coverage around either Naval ships or forward operating bases (FOBs). Such an airborne system could provide extended coverage beyond that possible from fixed surface sensors and enable the host platform to pursue intruders in an effort to locate launch and recovery locations. Significant investments have been made by the Department of Defense (DoD) and the Department of Homeland Security (DHS) in the development of ground/surface-based sensing systems. Group 2 and 3 UAS technology has matured significantly with long endurance systems widely available. Some of these systems are capable of being launched and recovered from small deck ships. Leveraging knowledge of these existing technologies, the Navy is seeking airborne C-UAS concepts that best balances sensing performance which includes detection and tracking performance against Group 1 through 3 intruders, means to mitigate false alarms, volume coverage and revisit rates with SWAP-C to provide persistence long-endurance coverage and the ability to pursue intruding UAS. Consideration should be given to common sensing systems including radar, radio frequency analyzers, acoustic and optical systems either alone or in combination on the host platform. The maximum sensor package SWaP allocation for group 3 UAS should not exceed 50 lbs, 750 watts and if pod mounted should be less than 12” in diameter and 60 inches long.

PHASE I: Complete a comprehensive analysis and trade-off study of sensor modality and performance with UAS host platform capabilities and SWAP-C. The analysis and study should address the nature of the C-UAS threat for both FOBs and Naval ships (both in-port and underway), sensing system considerations and performance assessment, and integration approaches on candidate host UASs. The study should recommend a sensor and platform solution to be develop and demonstrated in Phase II.

PHASE II: Develop and demonstrate a prototype of the recommended solution to achieve the capabilities analyzed in Phase I. The demonstration may be conducted on a surrogate platform with commercially available sensors if it can be shown that a feasible (in terms of cost, time and risk) path exists leading to a mature deployable system.

PHASE III DUAL USE APPLICATIONS: Work with UAS platform and sensor equipment manufacturers to fully integrate and mature the airborne C-UAS. The technology is suitable for a wide range of facility protection and airspace monitoring for civil applications.

REFERENCES:

1. “Department of Defense Counter-Unmanned Aircraft Systems.” Congressional Research Service, April 17, 2023
2. Koebler, J. “Report: Chinese drone ‘swarms’ designed to attack American aircraft carriers.” U. S. News & World Report, March 14, 2013.

KEYWORDS: Counter-Unmanned Aerial Systems; Radar, Acoustic, Optical, Group 2 and 3 UAS; radio frequency analyzer

N25A-T017 TITLE: Mattresses for Improved Sleep Quality (MISQ)

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

OBJECTIVE: Improve shipboard mattresses while meeting required Navy standards (MIL-PRF-32568) to improve sleep quality and enable increases in morale, reductions in fatigue/incident risk, and enhancement of resiliency. No human testing to be completed in Phase I.

DESCRIPTION: Insufficient sleep quality and quantity degrade health and performance outcomes. This is particularly problematic in high-risk occupations where long hours of continuous operations along with circadian rhythm disruption negatively affect sleep quality and quantity and in turn increase the probability of mishaps and mistakes to occur; for example, fatigue was a contributory factor in the two deadly mishaps in 2017 with the USS Fitzgerald and USS McCain. Research focused on exploring the operational factors driving Sailor fatigue found that uncomfortable mattresses are a key contributor negatively impacting sleep quality and quantity [Refs 1,2]. In addition, the Government Accountability Office also identified poor mattress quality as a key factor for addressing fatigue in the Navy [Ref 3]. The objective of this STTR topic is to develop an enhanced mattress for Sailors and Marines aboard Naval vessels to increase comfort and sleep, and ultimately lead to improvements in sleep quality/quantity and reductions in fatigue and operational risks. Innovative mattress technologies must comply with current berthing area dimensional requirements and standards (i.e., fire-proofing, floatation, etc.) outlined in MIL-PRF-32568. Mattress testing (e.g., ASTM E1590) needs be conducted in compliance with MIL-PRF-32568. The enhanced mattresses must demonstrate improved comfort, as subjectively rated by Sailors; and improved sleep quantity and quantity, as objectively defined by gold standard sleep assessment techniques in lab and shipboard-based settings (e.g., polysomnography/ electroencephalography, wearable devices, and subjective assessments) when compared to current shipboard mattresses.

To develop these mattresses and ensure that they provide a higher level of comfort and ultimately sleep quality/quantity, the proposer should partner with an academic and/or clinical institution that has experience in performing evaluations and human sleep research studies. The proposer should work with the academic/clinical institution to ensure there is a valid and reliable improvement in comfort and sleep quality/quantity using the newly developed prototype mattresses over the currently deployed standard shipboard mattresses. It is expected that mattresses will be examined initially in a lab-based setting and then in a shipboard environment once all necessary standards and regulations have been addressed; and demonstrate improvements in comfort and sleep quality.

PHASE I: Define and develop an enhanced shipboard mattress prototype model/concept which meets the dimensional and safety requirements for placement aboard Naval vessels (MIL-PRF-32568); and provide the theoretical justifications for why new mattresses will improve comfort and sleep quality/quantity over the current standard shipboard legacy mattresses. Determine feasibility of scalability of incorporating the new enhanced mattress across the Fleet to replace the legacy mattresses. Required Phase I deliverables to include, but are not limited to, enhanced shipboard mattress concept including planned materials, costs, manufacturing logistics, planned testing (e.g., ASTM E1590), and planned partnership with academic/clinical institution.

The academic/clinical institutional partner should work with the small business to develop a plan for human subjects testing that would take place in subsequent award phases. The deliverables from the small business and academic institution partnership should describe the means and methods to ensure valid and reliable assessment of the mattress performance compared to the legacy mattresses; these are to include but are not limited to: targeted sample population for testing, lab space for testing, IRB and research protocol preparation, and analytical methods.

PHASE II: Develop and limited production of prototype enhanced mattresses that meet the dimensional, safety, and improved comfortability aspects defined in Phase I and the Description. The enhanced mattress should be developed and validated for improving sleep quality and quantity via standard sleep assessments in partnership with the academic/clinical institution (e.g., polysomnography, other wearable devices, subjective ratings). The prototype should be capable of being deployed aboard Naval vessels at the end of Phase II. Prototypes need be tested for compliance with Navy standards (e.g., ASTM E1590) in Phase II prior to deployment aboard ships. The deliverables from the Phase II are to include, but are not limited to: 12 prototype mattresses (6 of which are to be provided to the Navy for testing) and 6 of which can be used by the small business and academic/clinical partner to conduct internal testing outlined in the Phase I deliverables. Three (3) initial prototype mattresses should be delivered to the Navy within 3 months of Phase II award; with the additional 9 to be completed for the Navy within 6 months of award. Human testing should be completed and reported on within the second 6 months of the award (12 months after award).

PHASE III DUAL USE APPLICATIONS: Focus on refining the product for transition and integration into the U.S. Navy surface fleet. This is to include preparations for scaling production of the enhanced mattresses and obtaining required certifications/accreditations for deployment to surface ships. In partnership with the small business, the Navy will integrate the Phase II developed enhanced shipboard mattress as a production product into deployed Naval vessels and transition finalized product to Naval Surface Force. Aim at scaling the production mattresses to commercial markets (e.g., recreational vehicles, garrison bunks). Continued research and development to ensure wide scale acceptance for increased sleep metrics is to be conducted simultaneously.

The final product to be delivered to the Navy should meet all dimensional and safety requirements as specified (MIL-PRF-32568), while also demonstrating increased comfort and sleep quality/ quantity for the users over previous Navy bedding.

REFERENCES:

1. Russell, DW; Markwald, RR and Jameson, JT. “Self-reported sleep and sleep deficiency: Results from a large initiative of sailors attached to U.S. Navy warships.” Journal of Sleep Research 2021; 30(6): e13397. https://pubmed.ncbi.nlm.nih.gov/34187090/
2. Matsangas, P. and Shattuck, NL. “Habitability in berthing compartments and well-being of sailors working on US Navy surface ships.” Human Factors, May pp. 2021; 63(3): 462-73. https://pubmed.ncbi.nlm.nih.gov/32109155/
3. Government Accountability Office. “Navy Readiness: Challenges to Addressing Sailor Fatigue in the Surface Fleet Continue.” GAO-24-106819, 2023. https://www.gao.gov/products/gao-24-106819

KEYWORDS: Sleep; fatigue; performance; mattress; berthing; comfort

N25A-T018 TITLE: High-Power Microwave Phase Shifter

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

OBJECTIVE: Develop a high-power phase shifter and feed network in X-band capable of withstanding peak powers of above 100 MW and pulse durations of threshold of at least 10 ns with an objective of 200ns. The phase shifter ideally would be capable of operating within a fraction of a frequency band aligned to available waveguide, have insertion loss of < 0.5 dB with 0 – 360° phase control. The device should be sealed sufficient to maintain high vacuum which would be maintained by pumps located elsewhere along the connecting waveguides. The device should have a tuning agility to move across 180 degrees in less than 100 ms and have a tuning resolution better than 1 degree.

DESCRIPTION: Microwave phase shifters are commonly used for phase steering arrayed antennas but do not operate at the typical peak powers seen in High Power Microwave (HPM) systems. HPM sources may produce output powers of several GW which can be divided and fed to an arrayed antenna network. These sources are typically operated at high vacuum (< 10-5 torr) along with the output antenna and waveguide networks for insulation purposes. At such vacuum levels, field stresses up to 80 MV/m are tolerable for the short durations produced by these source technologies.

HPM sources in this regime have bandwidths less than 1% of the center frequency for any output pulse and 3 dB pulse widths less than 50 ns. In some instances, multiple or tunable sources may be used which have varying output frequencies from shot to shot, each with the sub 1% bandwidth.
HPM systems in this regime typically operate with maximum repetition frequencies of a 10s to 100s of Hz for burst durations around a second. If the tuning agility is sufficiently fast, it may be possible to adjust the phase of the antenna elements from shot to shot within a burst.

Based on these considerations, the following design requirements should be considered for the phase shifter:

- Input Power: 100 MW or greater
- Pulse duration: 10 ns to 200 ns
- Operational frequency: X-Band
- Bandwidth: 1% or more of design frequency
- Vacuum: < 10-5 torr
- Tuning resolution: < 1 degree
- Tuning agility: 1.8 degree / ms
- Phase control range: 0-360 degree
- Insertion loss of < 0.5 dB
- Minimize electrical scale of the component
- Minimize cost per device

PHASE I: Develop and numerically simulate a design demonstrating the performance capabilities of the phase shifter that meet the requirements above. Build scaled proof-of-concept hardware to validate modeling. Provide a plan for the Phase II effort.

PHASE II: In consultation with ONR, proceed to fabrication of a phase shifter to be tested at full power using government provided source hardware. In addition to single element testing construct a sub array of as few as 16 elements for testing of steering capability. Document the performance and design of the developed hardware and sub array.

PHASE III DUAL USE APPLICATIONS: HPM weapons of both defensive and offensive designs could utilize a developed phase shifter to integrate on a number of candidate platforms. In addition, HPM technology is also usable in high-power radar and the Electronic Attack (EA) subsystems for Electronic Warfare (EW). In consultation and with ONR approval, proceed to building multiple phase shifters to integrate into a full phased steered HPM system utilizing an arrayed antenna provided by the government. Implement a control system to coordinate the phase shifters. Extensive commercial applications include phased array antennas for radar systems, satellite communications and 5G networks with additional applications in test/measurement equipment for RF systems and medical devices.

REFERENCES:


Changing Waveguide Side Wall Dimensions

1. Zhuang, QQ.; Yan, F.; Jiang, Z.; Liu, M.; Xiong, Z. and Yan, C. "Study and Design of A Contracting Waveguide Phase Shifter for S-band High-Power Microwave Applications." 2019 IEEE 2nd International Conference on Electronics Technology (ICET), Chengdu, China, 2019, pp. 162-165. doi: 10.1109/ELTECH.2019.8839350
2. Yang, Y. -M.; Yuan, C. W.; Cheng, C. X. and Qian, B. L. "Ku-Band Rectangular Waveguide Wide Side Dimension Adjustable Phase Shifter." IEEE Transactions on Plasma Science, vol. 43, no. 5, May 2015, pp. 1666-1669. doi: 10.1109/TPS.2014.2370074
3. Yang, Y. -M.; Yuan, C. W. and Qian, B. L. "A Novel Phase Shifter for Ku-Band High-Power Microwave Applications." IEEE Transactions on Plasma Science, vol. 42, no. 1, Jan. 2014, pp. 51-54. doi: 10.1109/TPS.2013.2288946

Reflector-Based Phase Shifter (3 types seen)

4. Liu, A.; Lu, J.; Tan, P. K.; Gan, T. H. and Sow, S. M. "A Compact Waveguide-Based Reflection-Type Phase Shifter." 2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI), Singapore, Singapore, 2021, pp. 1633-1634. doi: 10.1109/APS/URSI47566.2021.9704049
5. Chang, C. et al. "A New Compact High-Power Microwave Phase Shifter." IEEE Transactions on Microwave Theory and Techniques, vol. 63, no. 6, June 2015, pp. 1875-1882. doi: 10.1109/TMTT.2015.2423281
6. Guo, L. t.; Chang, C.; Huang, W. h.; Sun, J. and Liu, Y.s. "Design of a novel phase shifter for high power microwave applications." 2015 IEEE International Vacuum Electronics Conference (IVEC), Beijing, China, 2015, pp. 1-2. doi: 10.1109/IVEC.2015.7223835
7. Choi, J. -H. and Kim, Y. -H. "A High-Power Waveguide Phase Shifter With Periodic RF Chokes for Subgigawatt NanopulseTransmission." IEEE Transactions on Plasma Science, vol. 44, no. 10, Oct. 2016, pp. 2307-2313. doi: 10.1109/TPS.2016.2600032

Phase Shifters Leveraging Polarization (includes Refs 4-6 above)

8. Zhao, X. -L.; Yuan, C. W.; Liu, L.; Peng, S. R.; Bai, Z. and Cai, D. "GW TEM-Mode Phase Shifter for High-Power Microwave Applications." IEEE Transactions on Plasma Science, vol. 44, no. 3, March 2016, pp. 268-272. doi: 10.1109/TPS.2016.2523122

Movable Gaps/Holes/Objects in Waveguide

9. Wang, E.; Yang, J. and Zaman, A. U. "An E-band Reconfigurable Phase Shifter Based on Gap Waveguide." 2022 16th European Conference on Antennas and Propagation (EuCAP), Madrid, Spain, 2022, pp. 1-3. doi: 10.23919/EuCAP53622.2022.9769484
10. Palomares-Caballero, Á.; Alex-Amor, A.; Padilla, P. and Valenzuela-Valdés, J. F. "Reconfigurable Phase Shifter in Waveguide Technology Based on Glide-Symmetric Holey Structures." 2021 15th European Conference on Antennas and Propagation (EuCAP), Dusseldorf, Germany, 2021, pp. 1-4.
11. Zhang, Q.; Yuan, C. and Liu, L. "Studies on mechanical tunable waveguide phase shifters for phased-array antenna applications." 2016 IEEE International Symposium on Phased Array Systems and Technology (PAST), Waltham, MA, USA, 2016, pp. 1-3.

12. Yokokawa, K. et al. "Study on reconfigurable corrugated waveguide using moveable shorting plate." 2017 IEEE Conference on Antenna Measurements & Applications (CAMA), Tsukuba, Japan, 2017, pp. 49-50.
13. Ghasemi, A. and Laurin, J. J. "X-band waveguide phase shifter using rotating dielectric slab," 2016 IEEE International Symposium on Antennas and Propagation (APSURSI), Fajardo, PR, USA, 2016, pp. 1139-1140.

KEYWORDS: High Power Microwave; HPM; Microwave; Phase shifter; Electromagnetic; Beam-steering; Antenna

N25A-T019 TITLE: Passive Automatic Dependent Surveillance-Broadcast Validation to Support Collision Avoidance During Missions Requiring Emissions Control

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

OBJECTIVE: Develop a passive means to validate Automatic Dependent Surveillance-Broadcast (ADS-B) tracks that is suitable for aircraft operating with no radio frequency emissions.

DESCRIPTION: The Navy desires a system that validates ADS-B independently of any active sensors. The use case for this STTR topic is a large U.S. military Unmanned Aircraft System (UAS) engaged in operations not conducted under International Civil Aviation Organization (ICAO) flight procedures. Procedures exist for military aircraft operations in international airspace consistent with the Convention on International Civil Aviation [Ref 1]. When following ICAO flight procedures is not practical and compatible with the mission, U.S. military aircraft must operate with due regard for the safety of all other aircraft including civilian aircraft consistent with DoDI 4540.01 [Ref 2]. Such a case might arise, for example, when the mission necessitates that radio frequency emissions be minimized or eliminated altogether.

The UAS commander must utilize all available resources and information in assessing an acceptable level of risk before conducting such operations [Ref 2]. At present, there is no technology by which a UAS might passively validate ADS-B tracks broadcast by other aircraft. The goal of this STTR topic is to create that technology and make new information available.

ADS-B is an aviation surveillance technology in which an aircraft periodically broadcasts its position and other related data, enabling it to be tracked. It consists of two distinct functions. "ADS-B Out" and "ADS-B In". "ADS-B Out" is active; it periodically broadcasts track information like identity, position, and velocity. "ADS-B In" is passive; it receives and processes "ADS-B Out" information transmitted by other aircraft [Ref 3]. Civilian flights in oceanic airspace must be conducted under Instrument Flight Rule procedures when operating at or above Flight Level 055 within the New York, Oakland, and Anchorage Oceanic Flight Information Regions. ADS-B is required under these rules. Oakland Center covers 18.7 million square miles of the Pacific Ocean, roughly 9.5% of the Earth's total surface area, making this the largest Area Control Center in the world by controlled surface area [Ref 4].

ADS-B tracks received by the UAS “ADS-B In” receiver inform collision avoidance maneuvers. Independent validation of the received data is necessary to prevent the UAS from responding to spoofed or erroneous tracks. In a permissive environment, Traffic Alert and Collision Avoidance System (TCAS) and radar could be acceptable means for validating ADS-B. Both of those are active so neither work when UAS operates under emission control. UAS with SIGNIT could conceivably validate the track’s relative bearing against the direction of arrival of the “ADS-B Out” broadcast but not all UAS have such systems. Modifying the ADS-B receiver to measure angle of arrival is cost prohibitive.

Comparing observed changes in received signal strength over time to the expected changes corresponding to changing distances between aircraft seems a promising approach to passively validating “ADS-B In.” This is a variation of the approach in Reference 5 that estimates distance to the other aircraft but needs an initial calibration. The Navy desires to determine whether the change in received signal strength correlates to the propagation path change over time, so the initial calibration might not be needed. Reference 6 shows that the propagation path loss agrees with free-space propagation. That experimental effort included a method to remove the effect of the alternate transmission from the two transponder antennas on the aircraft of interest. Reference 7 demonstrates a means to remove co-channel interference that degrades the signal strength measurement accuracy.

PHASE I: Plan and execute a series of experiments to passively validate "ADS-B In" by correlating changes in reported separation with actual changes in received signal strength. Take received signal strength's natural variability into consideration. While these experiments can be conducted with the receiver located on the ground consideration should be given to how the results may differ when implemented on aircraft.

PHASE II: Design and build a system that implements the techniques of Phase I and complies with flight critical software safety requirements. Conduct airborne experiments that demonstrate performance of the approach sufficient to certify that the system meets the requirement for independent validation.

PHASE III DUAL USE APPLICATIONS: Mature the capability sufficiently to transition as a software upgrade to airborne ADS-B system processing hardware. The technology is directly applicable to use by civil aviation particularly low-SWaP UAS incapable of supporting an active surveillance capability.

REFERENCES:


1. "Convention on International Civil Aviation." https://www.icao.int/publications/pages/doc7300.aspx
2. "DoDI 4540.01, 02 June 2015, Incorporating Change 1 22 May 2017
3. "Automatic Dependent Surveillance – Broadcast." Wikipedia. https://en.wikipedia.org/wiki/Automatic_Dependent_Surveillance%E2%80%93Broadcast
4. "ENR 7. Oceanic Operations. ENR 7.1. General Procedures." FAA Air Traffic Publications. https://www.faa.gov/air_traffic/publications/atpubs/aip_html/part2_enr_section_7.1.html
5. Naganawa, Junichi and Miyazaki, Hiromi. "Aircraft–Receiver Distance Estimation Using ADS-B Signal Strength for Position Verification Application." 2021 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), Honolulu, HI, USA, 2021, pp. 178-183. doi: 10.1109/APWC52648.2021.9539711
6. Naganawa, Junichi et al. "Evaluating Path Loss by Extended Squitter Signals for Aeronautical Surveillance." IEEE Antennas and Wireless Propagation Letters, vol. 16, 2017, pp. 1353-1356. doi: 10.1109/LAWP.2016.2635157
7. Naganawa, Junichi et al. "A Method for Accurate ADS-B Signal Strength Measurement Under Co-Channel Interference." 2018 Asia-Pacific Microwave Conference (APMC), Kyoto, Japan, 2018, pp. 354-356. doi: 10.23919/APMC.2018.8617413


KEYWORDS: Airspace access; Automatic Dependent Surveillance-Broadcast; ADS-B; emissions control; collision avoidance, safe separation; unmanned aerial systems; UAS

N25A-T020 TITLE: Generation of Infrared Synthetic Data for System Training and Testing

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

OBJECTIVE: Develop and demonstrate synthetic generation of infrared imagery in a realistic ocean background for objects and vessels on the ocean surface in order to improve operator training and testing of infrared camera systems.

DESCRIPTION: There are a wide variety of high quality camera systems for examining the ocean surface from platforms in the air, sea surface or elsewhere. Synthesis of electro-optic data in the visible spectrum for such systems is a well-developed field and represented in many government-owner and commercially available software tools, particularly in the game industry. Products such as Unreal Engine, Unity and Blender provide tools for 3D image creation in a virtual world that captures physically realistic details of optical effects. The Navy seeks analogous solutions that operate in infrared bands such that imagery from infrared camera systems can be generated for purposes of operator training, system testing, and related applications. Proposals should address the commonly available infrared camera resolutions and consider the effects of all physically relevant infrared phenomena. These include, but are not limited to scattering, emissions sources, and environmental conditions from wind and the ocean.

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.

PHASE I: Identify a modeling approach for infrared spectrum imagery generation whose implementation can be justified on the basis of physical/optical realism, environmental effects, and in a computational feasibility. Analyze key design considerations assuming a commercially available electro-optic/infrared camera system of at least 640x480 pixel resolution. Assess the strengths and weaknesses of the proposed approach and report results for the solution to be developed in Phase II.

PHASE II: Develop and test a prototype for the proposed approach. Complete preliminary performance testing using open source surrogate data examples. Apply the prototypic software to generation of data given specifications provided by the Navy for up to 10 example objects on the ocean surface. It is possible, but not certain that the Phase II work will involve classified information.
It is possible that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Phase III work will extensively test the prototype fabricated in Phase II and examine results under day and night conditions and well as performance in suboptimal environments and conditions. Potential dual use applications for this technology reside with automation of thermal sensing and imaging systems that require data for model training and system validation. In particular, sensors for evaluating structural heat loss in buildings and vehicles would benefit as well as automatic airborne sensing for search and rescue missions.

REFERENCES:
1. "FREE FLIR Thermal Dataset for Algorithm Training." FLIR Systems, Inc. https://www.flir.com/oem/adas/adas-dataset-form/
2. Aguerre, Jose and Fernandez, Eduardo. "ThRend: a ray tracing module for infrared rendering of urban scenes." Proceedings of Building Simulation 2021: 17th Conference of IBPSA.
3. Suffern, K. (2016). "Ray Tracing from the Ground Up." A K Peters/CRC Press, April 2016.
4. Horton, Travis & Oline, Alice & Hauser, Nan & Khan, Ming & Laute, Amelie & Stoller, Alyssa & Tison, Katherine & Zawar-Reza, Peyman. (2017). "Thermal Imaging and Biometrical Thermography of Humpback Whales." Frontiers in Marine Science, Volume 4, 20 December 2017.
5. "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

KEYWORDS: synthetic data, imagery, infrared, simulation

N25A-T021 TITLE: Non-Wearable and Off-Engine Jet Noise Reduction

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

OBJECTIVE: Develop and demonstrate a non-wearable, off-engine, jet noise reduction (JNR) solution that is capable of significantly reducing afterburning turbofan/turbojet jet noise levels during testing, ground and test cell operations, and take-off and landing events, thereby reducing the negative health and environmental impacts associated with jet noise.

DESCRIPTION: The U.S. Navy seeks a non-wearable, off-engine JNR solution to address the significant noise generated by afterburning jet engines during ground and indoor testing, aircraft taxiing, takeoff, and landing operations. Current state-of-the-art noise reduction technologies consist of:

- Barriers and headsets that attenuate and reflect sound
- Active sound sources that reduce noise through destructive interference
- A combination of the previous two principles

Engine mounted noise reduction technologies have been explored in the past, but such state-of-the-art solutions for tactical aircraft tend to negatively impact thrust performance while providing little noise reduction benefit for low bypass turbofan and turbojets, which makes them undesirable in a military application. Passive and Active Noise Control (ANC) equipped headsets are known to significantly reduce perceived jet noise levels, but they are insufficient for mitigating the sound emanating from modern afterburning engines. Further headset noise reduction can be accomplished through more invasive earpieces, but they come with other challenges. To further reduce perceived jet noise levels, the Navy is interested in non-wearable, off-engine, jet noise reduction technologies that complement the benefits of modern headset. This STTR topic focuses on:

- Developing advanced noise reduction techniques that can be implemented off-engine and benefit a broad coverage area
- Delivering a flexible solution that addresses the noise signatures of various U.S. Navy jet engines
- Developing a system that delivers noise reduction at the necessary amplitudes and frequency ranges needed to be effective
- Ensuring compactness and compatibility with current operating environments, minimizing need for infrastructure modifications
- Creating a solution that is energy efficient to minimize the burden of powering the system during extended operations
- Utilizing robust, durable technologies that can survive the harsh thermal, acoustic, vibratory, corrosive, and EMF environment of an aircraft carrier

Solutions should aim to:

- Achieving significant noise reduction (10dB+ desired) in the audible frequency range, especially at frequencies below 5kHz
- Providing tonal and broadband noise reduction

The resulting technology should:

- Function effectively at relevant distances from the jet engine exhaust centerline
- Be compact, lightweight, and portable to minimize impact on fleet operations.
- Be easily deployable, requiring a reasonable amount of time for setup and activation in various environments
- Operate reliably for extended periods of time in a typical Naval operating environment, which may consist of extreme weather and highly corrosive conditions
- Have broad application across engine operating range at various power levels
- Be responsive to rapid changes in engine power or acoustic disturbances

• Be responsive to changing noise source positions and environmental factors that influence acoustic propagation
• Ensure that noise is not increased beyond acceptable levels in an undesirable location

Example candidate technologies may include, but are not limited to:
• Off-Aircraft, distributed sound generators that synchronize with jet noise to destructively interfere at desired locations
• On-Aircraft, but off-engine, distributed sound generators that destructively interfere with jet noise
• Temporary fluid-based barriers, such as water/bubbly water curtains, that significantly attenuate/reflect/scatter jet noise with minimal impact to personnel/aircraft mobility. These fluid-based barriers should be sufficiently far from the jet plume to avoid interaction.

Please note that the Navy is not interested in the following types of technologies for this topic:
• Passive or dynamic solid barriers
• Passive or active noise cancelling headsets/headphones
• On-aircraft water injection system that interact with jet plume
• Engine, or nozzle, mounted flow actuators, tabs, or chevrons

PHASE I: Determine the feasibility and develop a concept for a non-wearable, off-engine jet noise reduction prototype system. The awardee will be expected to perform modeling and simulation to identify and design an innovative approach that meets the specified noise reduction, operational range, portability, and durability requirements. Phase I efforts should include the following:
1) Define and develop a detailed concept for the noise reduction system, including the underlying hardware, sensors, software, methodologies, and their integration.
2) Perform modeling and simulation to demonstrate the feasibility of the proposed concept in achieving the desired noise reduction within the specified parameters.
3) Develop a preliminary design for the prototype system, outlining key components, system architecture, and expected performance.
4) Provide a detailed report summarizing the concept development, feasibility analysis, and preliminary design. This report should include:
a) Technical approach and innovation,
b) Simulation results and analysis,
c) Design specifications and proposed materials/components, and
d) Implementation plan for Phase 2, including a projected timeline, milestones, and budget estimates.

The Phase I effort should culminate in a proof-of-concept demonstration, through simulation or fundamental testing, that substantiates the proposed technology’s potential and justifies further investment in Phase II.

PHASE II: Develop, demonstrate, and validate a fully functional prototype of the non-wearable, off-engine, jet noise reduction solution based on the concept and feasibility analysis conducted in Phase I.

Phase II efforts should include the following:
1) Use the results from Phase I to design and fabricate a prototype system that meets the specified noise reduction, operational range, portability, and durability requirements.
2) Conduct testing to validate the performance of the prototype in reducing jet engine noise. Testing should first be carried out in a controlled environment and later in a realistic environment. The demonstration should showcase the system’s effectiveness, ease of use, and operational reliability.

3) Provide detailed documentation of the prototype development efforts including hardware/software design, performance models, and simulation/test results.
4) Deliver a final report summarizing the development, demonstration, and validation of the prototype.
Phase II efforts should result in a validated prototype that demonstrates the capability to significantly reduce jet noise in a broad defined area.

PHASE III DUAL USE APPLICATIONS: Focus on the commercialization and deployment of the proposed technology within the U.S. Navy and other potential defense and civilian applications. The technology will become fully operational, validated, and production ready in Phase III and will be capable of significantly reducing jet noise levels during ground and indoor testing, aircraft taxiing, takeoff, and landing operations. The primary use cases for this technology beyond Phase II will be at Navy jet engine test facilities, on naval aircraft carriers and at Naval bases where jet noise is a significant concern. This technology has significant commercialization potential because it is applicable to commercial test facilities and airports as well. This technology could also be beneficial for powerplants and other industrial applications that use gas turbine engines.

REFERENCES:
1. Elliott S. J. and Nelson, P. A. "Active noise control." IEEE Signal Processing Magazine, vol. 10, no. 4, Oct. 1993, pp. 12-35. doi: 10.1109/79.248551.
2. Kuo S. M. and Morgan, D. R. "Active noise control: a tutorial review." Proceedings of the IEEE, vol. 87, no. 6, June 1999, pp. 943-973. doi: 10.1109/5.763310.
3. Stevens, J. C. and Ahuja, K. K. “Recent advances in active noise control.” AIAA journal, 29(7), 1991, pp. 1058-1067.
4. Hobbs, C.; Karantonis, K. and Sharp, B. “Active reduction of airport noise.” INTER-NOISE and NOISE-CON Congress and Conference Proceedings, Vol. 2000, No. 6, August 2000, pp. 2014-2020.

KEYWORDS: Jet Noise, Jet Noise Reduction, Active Noise Cancellation, Destructive Interference, Barriers, Noise Curtain, Turbofan, Turbojet, Gas Turbine, US Navy Carrier, US Navy Bases, Jet Engine Test Facilities

N25A-T022 TITLE: Photonic Bump Bonds

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Materials;Microelectronics;Space Technology

OBJECTIVE: Develop an enabler of heterogeneous photonic integrated circuits (PICs), the photonic equivalent of an electrical bump bond.

DESCRIPTION: Most radio frequency (RF) photonic components are created in the plane of the thin film substrate in order, or in part, to allow structures to be large in at least 1 dimension to compensate for, e.g., low electron-photon coupling. For optimum performance of any photonic circuit, the constituent components are best made in the material that individually optimizes their performance. Thus, the PIC of greatest application relevance requires moving the optical beams carrying the signals of interest between different chiplets of different chemical composition, lattice structure/spacing, and sometimes different substrates. Various methodologies are at modest TRL levels to interconnect such edge (of chiplet) emitting species including butt free space coupling, microlens, photonic wire bonds, V-grove alignment, and tapered transitions. However, the optical modes are generally very compact within the launching and receiving waveguide structures, so sub-micron 3D alignment of the 2 sides is crucial to the optical insertion loss. The tendency for most epoxy glues holding actual fibers in place to change shape and size (hence torques on fibers) when cured or subjected to temperature excursions is a major issue. Thus, routinely getting the per facet optical loss down below 0.1 dB is so far illusive. However, in the case of VCSELs, which emit light perpendicular to the substrate, the commercial market for high bandwidth data flow through arrays of fibers has driven the development of an interposer technology which can today yield the desired 0.1 dB loss per facet metric. This STTR topic seeks the development of a technique for planar photonic devices to turn their output beams from the in plane to vertical direction so that they can be packaged together in 3D manner, ideally from bumps located within the body of the chiplets, not just along its edges. Such bumps would allow the highest possible performance component chiplets to be combined into the smallest possible finished die, minimizing the discrepancy between today's extremely dense digital circuits and photonics. The same sort of bumps should be used to provide the multi-chip wiring module using low loss SiN waveguides and normal CMOS interconnects and wiring structures.

PHASE I: During the base, the right angle turn method described in the proposal shall be developed, at least by simulation, to the point where the technical risk of failure is arguably low. A first experimental demonstration is preferred. The non-SiP component can be of any type of functionality, so little effort shall be expended on improving its internal operation. However, the test plan included in the original proposal must explain how the performance of the joint will be quantitively measured. Write the preliminary Phase II proposal. During the Phase I option, if exercised, complete the proof-of-concept demonstration and negotiate the Phase II contract using a technically detailed proposal and clear work plan.

PHASE II: Work to improve the performance and reliability of the demonstrated link method(s). That is, work to improve the yield of joints with insertion losses of less than 0.1 dB, with threshold performance of >85% and objective level of >97% yield. Invent and demonstrate a way to achieve self-alignment of the mating structures. Deliver test articles to government for verification of performance claims.

PHASE III DUAL USE APPLICATIONS: Demonstrate the utility of this packaging technology by integrating a heterogeneous PIC having more than 5 optical components made from more than 2 different materials and relevance to a military function.

Development of a packaging technology with substantially improved internal integration losses will allow planar RF photonic circuits to be sold in a wider array of settings than currently possible. Attention will then be focused on what functional performance the rf photonic circuit can provide, not have to continuously fight with excessively large noise figures created by the floor of the end-to-end insertion losses.

REFERENCES:

1. Samtec. “Optics”. https://www.samtec.com/optics/#development-platforms
2. Lomonte, E.; Stappers, M.; Krämer, L. et al. “Scalable and efficient grating couplers on low-index photonic platforms enabled by cryogenic deep silicon etching.” Sci Rep 14, 4256 (2024). https://doi.org/10.1038/s41598-024-53975-4
3. Tamir, T. and Peng, S.T. “Analysis and design of grating couplers.” Appl. Phys. 14, pp. 235-254 (1977). https://doi.org/10.1007/BF00882729
4. Dirk TAILLAERT, et al. “Grating Couplers for Coupling between Optical Fibers and Nanophotonic Waveguides.” Japanese Journal of Applied Physics, Vol. 45, No. 8A, 2006, pp. 6071-6077

KEYWORDS: bump bonds; vertical packaging; heterogeneous integration; 3D packaging; self-alignment; body pads

N25A-T023 TITLE: Robotic Manipulation Learning for Repair of Marine Diesel Engines

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software;Human-Machine Interfaces;Trusted AI and Autonomy

OBJECTIVE: Develop autonomous robotic manipulation capabilities using artificial intelligence (AI) to repair and maintain marine diesel engines operating during long missions without human intervention. The overall objective of this topic is to provide the means to extend the duration of missions with uncrewed surface vessels and to provide greater assurance of mission completion.

DESCRIPTION: The Navy is developing a family of uncrewed surface vessels. Current designs utilize marine diesel engines for propulsion. These vessels are expected to conduct autonomous operations on long distance missions without sailors being placed aboard to maintain equipment. It would be desirable to have robotic systems onboard capable of inspection and basic maintenance tasks to enable these vessels to achieve the mission objective area. Due to bandwidth limitations, the ability to conduct teleoperated robotic manipulation is unlikely. There have been recent advances in AI and machine learning (ML) for robotic manipulation that exploit copious internet online video manipulation examples or learning from human demonstration, combined with foundation models and reinforcement learning to achieve autonomous manipulation. However, the manipulation tasks selected are often pick and place, or typical kitchen tasks. There is a need to transfer ML for manipulation to the more demanding tasks involved in equipment maintenance, which often involve tool use, significant torques, deformable (soft/squishy) object handling, difficult to access locations on equipment, or bimanual manipulations. This STTR topic focuses on manipulation, not on robotic locomotion. Maintaining marine diesel engines to sustain fully operational status involves a number of manipulation and inspection tasks. These manipulations include valve opening, rotation or depression of switches, rotation, removal or replacement of lids, adding fluids, adding or removing rubber gaskets and washers, catching liquids in containers, and tightening/untightening bolts, and reattaching loose components. Recent advances in computer vision have been made for object identification that will be needed for both manipulation and inspection. Inspection tasks include checking for deformations, cracks, leaks and loose components (brackets, bolts, hangers), recognition of warning lights, and reading gauges or status message text. This topic seeks the development of robotic manipulation technology capable of such tasks. This would include machine vision, robotic arms, and end effectors, with possible tool attachments. Operation at sea presents mechanical stability challenges, so design concepts are needed that would allow the robotic assembly to be stabilized, yet reach the essential engine components from the appropriate perspective. This could include sliding on a frame around the engine, or locomotion on a stable base.

PHASE I: Develop a design for robotic manipulation capable of the basic tasks involved in diesel engine maintenance, exploiting emerging research on ML of dexterous manipulation. This ML can be based on databases of video for engine repair manipulation tasks or on learning from human demonstration with reinforcement learning. The robotic manipulation concept includes designs or identification of robotic arms, end effectors, stable base and sensors for machine vision. Design a frame or base and means of shifting the position of the arm(s) to reach different areas of a diesel engine. Assess the feasibility of tool use, or end effector adaptations to accomplish basic elements of engine maintenance. Identify suitable cameras and machine vision processors capable of inspections that support diesel engine maintenance. Assess the feasibility of tactile or torque sensing to enable closed loop control of manipulators. The overall approach chosen should be mindful of the ultimate goal of autonomous manipulation, without teleoperation.

PHASE II: Develop prototype hardware and software to validate the concepts developed in Phase I. This can include commercial off-the-shelf (COTS) robotic components. Demonstrate the learning and execution of maintenance relevant robotic manipulation tasks on a diesel engine, or close surrogate.

Possible tasks include valve opening, rotation or depression of switches, rotation, removal or replacement of lids, adding fluids, adding or removing rubber gaskets and washers, catching liquids in containers, and tightening/untightening bolts, and reattaching loose components. While the training of this system can involve teleoperation, the final demonstration should show autonomous manipulation to execute the sample tasks. Develop a prototype machine vision system to work with the robotic manipulators for basic inspection tasks and for closed loop control of the manipulation task.

PHASE III DUAL USE APPLICATIONS: Demonstrate and evaluate the robotic manipulation technology at a Naval LBES facility with marine diesel engines and on board a Navy uncrewed surface vessel with a marine diesel powerplant in coordination with PMS 406.
This technology has strong commercial potential since many commercial vessels use marine diesel engines. This technology would also be applicable to fleets of trucks using diesel engines.

REFERENCES:

1. Spencer, J.; Choudhury, S.; Barnes, M.; Schmittle, M.; Chiang, M.; Ramadge, P. and Srinivasa, S.S. “Expert intervention
learning: An online framework for robot learning from explicit and implicit human feedback.” Autonomous Robots, Volume 46, Issue 1, 2022, pp. 99-113. https://dl.acm.org/doi/10.1007/s10514-021-10006-9
2. Levine, S.; Kumar, A.; Tucker, G. and Fu, J. “Offline reinforcement learning: Tutorial, review, and perspectives on open problems.” arXiv preprint. arXiv:2005.01643, 2020.2021202220232024
3. Deshpande, Abhay; Ke, Liyiming; Pfeifer, Quinn; Gupta, Abhishek and Srinivasa, Siddhartha S. “Data Efficient Behavior Cloning for Fine Manipulation via Continuity-based Corrective Labels.” IEEE/RSJ International Conference on Intelligent Robots and Systems, 2024. https://arxiv.org/abs/2405.19307v2
4. Zhao, Tony Z.; Kumar, Vikash; Levine, Sergey and Finn, Chelsea. “Learning Fine-Grained Bimanual Manipulation with Low-Cost Hardware.” https://doi.org/10.48550/arXiv.2304.13705
5. Bahl, Shikhar; Mendonca, Russell; Chen, Lili; Jain, Unnat and Pathak, Deepak. "Affordances from Human Videos as a Versatile Representation for Robotics." CVPR 2023. https://arxiv.org/abs/2304.08488
6. Arunachalam, Sridhar Pandian; Silwal, Sneha; Evans, Ben and Pinto, Lerrel. “Dexterous Imitation Made Easy: A Learning-Based Framework for Efficient Dexterous Manipulation.” ICRA 20. https://arxiv.org/abs/2203.13251


KEYWORDS: Robotics; manipulation; maintenance; machine learning; diesel engines; machine vision

N25A-T024 TITLE: In-situ Seabed Physical Properties Probe (ISPPP)

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

OBJECTIVE: Develop a probe to rapidly gather in-situ data on physical properties of seabed and shallow sub-subsurface sediments in either a tethered (reusable) or expendable form factor.

DESCRIPTION: Characterization of sediments on the seabed and in the shallow-subsurface is a vital requirement for research, offshore infrastructure development, acoustic propagation measurements, and target detection. Traditional methods of characterizing these sediments usually require shipboard sample collection and laboratory testing or specialized in-situ testing equipment requiring complex handling and data processing steps. Free-fall penetrometers, acoustic probes, and environmental sampling sensors are routinely deployed individually to estimate the physical properties of seabed sediments for use in geologic and geophysical assessment of seabed character, geoacoustic inversions, and transmission/bottom loss calculation; however, the time required for sample collection or in-situ measurement to data availability prohibits the utilization of these data in dynamic seabed environments. These instruments are also rarely used together, from autonomous platforms, or in expendable form factors. This STTR topic seeks development of an in-situ seabed physical properties probe to provide rapid seabed and shallow sub-surface sediment characterization in a tethered or expendable form factor.

PHASE I: Develop a concept for a seabed sediment physical properties probe capable of measuring/estimating environmental parameters (e.g., temperature, salinity) in the water column and seabed/sub-seabed (pore water), sediment sound speed, and sediment strength properties (e.g., undrained shear strength, friction angle and cohesion), with reporting of estimated seabed/shallow sub-surface character (e.g., sound speed ratio, grain size, porosity). Describe the mechanistic underpinnings of the probe and support it with models and simulations. Simulations should demonstrate the measurement resolution and uncertainty in sediment classification as a function of penetrated sediment depth in a representative ocean environment. The conceptual design should operate at ocean depths up to or greater than 4000m.

PHASE II: Develop, build, and demonstrate a hardware version of the probe based on the Phase I concept. The demonstration probe does not have to be expendable but should demonstrate the capabilities for acquisition and transmission of the sediment characteristics/physical properties stated in the requirements. Demonstrate that the probe is capable of penetrating the seabed and providing measurements at accurate sub-surface depths. Develop a capability for operation across a range of ocean depths and seabed types, with accurate measurement geo-positioning. Develop a plan in consultation with the Navy for demonstrating the probe to include compliance with environmental regulations. After demonstrations, develop a design for a tethered (reusable) version deployable from autonomous platforms or an expendable version of the probe with compact form factors that can communicate with remote receivers.

PHASE III DUAL USE APPLICATIONS: The expected transition will be a tethered or expendable acoustic in-situ measurement probe that can be used for seabed characterization and geotechnical surveys for naval or civil applications (e.g., reconnaissance geotechnical surveys, post-disaster seabed stability assessment, seabed AUV survey groundtruth measurements). The tethered version can be deployed from autonomous vehicles. The expendable version can be deployed by hand or with use of a launcher from the deck of a ship for operational surveys or in support of basic and applied research.

REFERENCES:
1. Ballard, M.S.; Lee, K.M.; McNeese, A.R.; Wilson, P.S. and Goff, J.A. “Development of a system for in situ measurements of geoacoustic properties during sediment coring.” Proceedings of Meetings on Acoustics, Vol. 26, No. 1, May 2026. AIP Publishing.
2. Jaber, R. and Stark, N. “Geotechnical Properties from Portable Free Fall Penetrometer Measurements in Coastal Environments.” Journal of Geotechnical and Geoenvironmental Engineering, 149(12), 2023, p.04023120.

KEYWORDS: Underwater Acoustics; seabed characterization; physical properties; Geoacoustic Inversion; geotechnical survey; sediment

N25A-T025 TITLE: Expendable Air-sea Profiling Observations in Hazardous Weather Conditions

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

OBJECTIVE: Develop an improved lower atmospheric observing capability that is hardened for hazardous weather environments to better capture vertical, horizontal, and temporal variations in atmospheric profiles of dynamics and thermodynamics to the air-sea interface compared to standard radiosonde profiling.

DESCRIPTION: Accurate assessment of the environment is a critical prerequisite for forecasting future environmental states and decision making from those forecasts. Remote and hazardous operating environments are among the most challenging to observe and constrain in a forecast system. Understanding and analyzing hazardous weather conditions, such as convective precipitation and tropical cyclones, as well as complex air-sea interactions such as sea ice formation and break-up in marginal ice zones, remain particularly difficult. Although recent initiatives have aimed to enhance the quality and accuracy of environmental observations (see References), operational meteorological and oceanographic (METOC) agencies still rely heavily on legacy profiling and remote sensing techniques. There is often insufficient quantity of observations due to cost per unit as well as quality of data due to the operating environment difficulties on the sensors. This STTR topic aims to build on these recent efforts by developing advanced observing technologies that can provide higher-quality data, complementing existing METOC systems in challenging environments.

This STTR topic solicits novel research for the development of a robust technological candidate aimed at improving expendable profiling of air-sea phenomena in hazardous weather conditions. In particular, a compact, easily deployable, and competitively priced alternative to radiosondes is sought that will provide a higher quantity and quality of air-sea interface related observations in areas such as tropical cyclones and polar lows where more precise information of dynamic and thermodynamic properties such as surface drag and fluxes can be constrained. Proposed work should clearly indicate where the effort will expand beyond current radiosonde capability in one or more of the following: spatial observations, temporal observations, sampling rate, price per unit, durability in hazardous conditions, uncertainty characterization, and ability to target/collocate with other observational platforms. The performer should also aim for a production schedule that allows for the prototyping dozens or even hundreds of units during the validation phase, with the potential to scale up to larger operational thresholds for commercialization or transition.

PHASE I: Determine technical feasibility for improved expendable in-situ profiling observations in hazardous weather conditions of dynamics and thermodynamics influenced by air-sea interactions. Perform background review of strengths and limitations of current observing platforms with an emphasis on measurement uncertainties and logistical challenges. From related operational and research work in this area, identify and design an improved concept of measurement techniques that include novel approaches to addressing the limitations identified in the review. Where appropriate, perform a comparative analysis with current state-of-the-art platforms (such as radiosondes or well calibrated remote sensing) including uncertainty specifications and real-world results from validated field efforts. Required Phase I deliverables will include a report on the state of the science, an overview of previous/current concepts of operations and their accuracy, and the proposed engineering, hardware, software, and/or platform upgrades that will enhance precision, accuracy, and/or quantity of air-sea in-situ observations in challenging environmental conditions. In particular, reporting must include a discussion of how the proposed effort will uniquely enable new environmental observations as compared to radiosondes and must include a comparison of strengths/weaknesses in cost, longevity, sampling rate, and spatial/temporal coverage.

PHASE II: Using results from the Phase I, proposed effort should develop, fabricate, demonstrate, validate, and iterate on expendable profiling technology. Work in the Phase II should particularly focus on calibration and demonstration of improved observational accuracy in hazardous weather conditions. Multiple development spirals of improved engineering prototypes and real-world demonstration in conjunction with currently used sensing technologies are needed to understand sensor characteristics and robustness in desired conditions. To the extent possible, technology deployment should leverage existing systems for ground, ship, and/or aircraft-based delivery mechanisms, thereby supporting comparative calibration/validation metrics and facilitating transition from a prototype to operational system. Part of this effort must also include data ingest and assimilation into operational forecast models with a comparative analysis of added value and analysis/forecast improvement. Phase II work should use multiple prototype demonstration efforts to refine and focus innovative measurement aspects and improve data measurement quality, in addition to refining the concept of operations and solidifying the observational niche of the proposed technology.

PHASE III DUAL USE APPLICATIONS: Phase III work should build upon the previous prototyping and demonstrations to effectively prove the operational concept and mature the technology into a new expendable profiling platform that can be commercialized. The technology must be calibrated and validated in real world conditions and compared to observations that are currently used in an operational meteorology and oceanography environment, such as in-situ stationary platforms, other expendable data, and remote sensing. The expected state of the technology should be a system that can deploy and track observations in real-time of expendable sensors from ground, ship and/or via aircraft. Success rate must match that of currently operational radiosonde technology, with improvements in specific hazardous weather conditions (such as tropical cyclones, polar lows, heavy convective precipitation, large wave events) with a demonstrated decrease in failure rates and modes. Final transition/commercialization will entail regular production of well characterized sensors that can be deployed operationally and in field missions for targeted air-sea profiling observations to be transmitted and used in real-time for environmental forecast and analysis.

REFERENCES:

1. Nelson, T. C.; Harrison, L. and Corbosiero, K. L. “Temporal and Spatial Autocorrelations from Expendable Digital Dropsondes (XDDs) in Tropical Cyclones.” J. Atmos. Oceanic Technol., 37, 2020, pp. 381-399. https://doi.org/10.1175/JTECH-D-19-0032.1
2. Cione, J. J. et al. “Eye of the Storm: Observing Hurricanes with a Small Unmanned Aircraft System.” Bull. Amer. Meteor. Soc., 101, 2020, pp, E186-E205. https://doi.org/10.1175/BAMS-D-19-0169.1
3. Lee, Craig M. et al. "Emerging technologies and approaches for in situ, autonomous observing in the Arctic." Oceanography 35.3/4, 2022, pp. 210-221. https://www.jstor.org/stable/27182719
4. Holbach, Heather M. et al. "Recent advancements in aircraft and in situ observations of tropical cyclones." Tropical Cyclone Research and Review 12.2, 2023, pp. 81-99. https://doi.org/10.1016/j.tcrr.2023.06.001
5. Poulsen, Ebbe et al. "Uncrewed aerial vehicle with onboard winch system for rapid, cost-effective, and safe oceanographic profiling in hazardous and inaccessible areas." HardwareX 18, e00518, 2024. https://doi.org/10.1016/j.ohx.2024.e00518
6. Abdunabiev, Shahbozbek et al. "Validation and traceability of miniaturized multi-parameter cluster radiosondes used for atmospheric observations." Measurement 224, January 2024, 113879. https://doi.org/10.1016/j.measurement.2023.113879


KEYWORDS: Radiosonde; expendable; profile; meteorological and oceanographic; METOC; meteorology; oceanography; autonomous; temperature; humidity; wind; flux; marine atmospheric boundary layer; tropical cyclone; polar low

N25A-T026 TITLE: Automatic Readiness and Training Systems Enhanced with Artificial Intelligence, Machine Learning, and Optimization

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

OBJECTIVE: Develop an automated, artificially intelligence-enhanced system for scalable effective training and monitoring of skilled physical tasks. Proposed solution should be demonstrated in a domain of interest to the Department of Defense such as maintenance, operation of military equipment, surgery, manufacturing, or medical tests.

DESCRIPTION: Ensuring the readiness of the military requires the execution of a large number of skilled physical tasks in a variety of areas such as aircraft maintenance, operation of detection systems, medical care, production of advanced materials or equipment, and medical tests. Thus, it is critical to train and certify personnel to perform these tasks and to provide monitoring that supports ongoing quality improvement, through both individual feedback on performance and data collection for optimizing how the task is performed. The training environments range from centralized facilities to infrastructure-poor and geographically isolated locations with limited network connectivity.

Historically, training and performance feedback has been provided via direct supervision of trainees by experts. This approach is limited by the number of qualified experts available and the geographical location of trainees. A single expert can train and supervise a limited number of personnel at a time and must travel to the trainees' location. This prevents rapidly scaling capabilities relying on skilled physical tasks. When the experts available are too few to provide adequate ongoing supervision, it can also result in low-quality work-product. Moreover, recording data on how the work is performed can be time consuming, requiring tradeoffs between data collection and the amount of work accomplished. Finally, when experts leave their roles, knowledge is lost regarding how to perform specific tasks. While some training can be provided via written documents and videos alone without direct supervision, the quality of this training is low and such methods do not provide effective supervision or data collection.

The Navy seeks an approach for scalable effective training and monitoring of physical tasks that are mission critical and require extended concentration. This approach should be able to rapidly train and monitor thousands of personnel across many geographical areas with only one expert. It should use video and audio inputs to automatically record and process information about the work done to support individual feedback, optimization, and integration with other efforts that would benefit from information about work status. User input should not be required. It is envisioned that artificial intelligence and machine learning will play a key role in this approach as recent advances in these areas are poised to support automating many of the tasks that have historically been performed by individual experts.

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.

PHASE I: Provide a viable concept with detailed methodology to address the general training problem in the Description. A specific area of training in a domain of interest to the Department of Defense should also be identified, perform testing, and provide preliminary results. The concept should be generalizable beyond one specific area of training.

PHASE II: Develop a prototype for testing, demonstrating, and validating that the method improves performance for novice individuals on a specific area of training. Depending on the specific area chosen, this could result in the some of the work being classified.

It is probable that the work under this effort will be classified under Phase II (see the Description section for details).

PHASE III DUAL USE APPLICATIONS: Transition the prototype to a mature capability that will be used for a broad range of different areas of training.

The ideal end-state should be usable on handheld devices to leverage the video and audio technology there to provide input to the automated system, which would allow for feedback. Industrial and government sectors are expected to procure varying levels of this technology depending on the level of sophistication required by their training requirements.

REFERENCES:


1. Banerjee, A. et al. "AI Enabled Tutor for Accessible Training." Artificial Intelligence in Education, Vol. 12163, 2020, pp. 29-42. doi 10.1007/978-3-030-52237-7_3
2. Yazdi, M. "Acquiring and Sharing Tacit Knowledge in Failure Diagnosis Analysis." Journal of Failure Analysis and Prevention, Vol 19(2), 2019, pp, 369-386. doi.org/10.1007/s11668-024-01904-y
3. Yilmaz, R; Bakhaidar, M and Del Maestro, RF. "Real-Time multifaceted artificial intelligence vs In-Person instruction in teaching surgical technical skills: a randomized controlled trial." Scientific Reports, 14(1), 2024. doi.org/10.1038/s41598-024-65716-8
4. Brooks Babin, LisaRe and Garven, Alice J. (Sena). "Tacit Knowledge Cultivation as an Essential Component of Developing Experts: A Literature Review." Journal of Military Learning, April 2019. https://www.armyupress.army.mil/Journals/Journal-of-Military-Learning/Journal-of-Military-Learning-Archives/JML-Apr-2019/Babin-Garvin-Tacit-Knowledge/
5. "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


KEYWORDS: Artificial intelligence; machine learning; applied optimization; training

N25A-T027 TITLE: Dynamic Thermal Management Suit

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

OBJECTIVE: Develop and demonstrate a suit to be worn to protect an individual from thermal exposures in water (28-99°F) diving, capable of maintaining individual at a core body temperature of 95-99°F and maintaining the temperature of diver's extremities above 53.6°F. Suit shall be designed using new approaches and materials, that can insulate an individual submerged in water from hypo and hyperthermia. The system should work in helmeted or unhelmeted and in tethered and untethered conditions. The system should be capable of functioning in a highly contaminated environment.

DESCRIPTION: Thermal management in an aqueous environment places a significant challenge for human physiology due to the high thermal conductance of water versus air. Most locations in which military divers must dive require thermal protection. There is not currently a rugged, reliable system that can maintain normal physiologic temperature for the diver.

There are several engineering challenges. First in an untethered system the diver must carry any power source. Second, there is a specific requirement to keep the extremities warm enough to maintain manual dexterity. Third a tube suit or other wet suit materials compress at depth resulting in reduced insulation. Prior attempts have resulted in bulky designs that are difficult to both put on, take off and impedes mobility. Fourth and finally, when using a tethered system there may be heat loss/gain due to traversing the length of the tether resulting in reduced cooling or heating for the diver.

Consideration should be given to an innovative dynamic approach (e.g., additive manufacturing, metamaterials, bio-inspired hydrophobic gels) that shields the body from direct contact and allows the diver to maintain a normal body temperature. Innovative solutions that are dynamic and can adjust to cold and hot environments are most desirable. Mobility, and don and doff times should be comparable or better to those of current wetsuits.

PHASE I: Define and develop a design for a thermal-protective diving suit that is capable of use in a great range of water temperatures (28-99°F) and maintains an internal temperature that maintains a healthy core body temperature (95-99°F) and a temperature of > 53.6°F in the extremities for a 10-hour threshold duration. Prepare designs that are sufficiently detailed to specify all materials needed, their availability, how they will be implemented, and the overall thermal suit thickness. Specify how the design buffers the external water temperature to the body and will adapt in changing conditions. The suit material, its seams (both intergarment and at wrists, neck, and feet), and any closing mechanisms must stand up to typical underwater diver activities and approximately 100 dives. The design created in Phase I should lead to plans to build a prototype unit in Phase II.

Human factor and human subject testing are critical in follow-on Phases of this topic. Please carefully review the requirements of approval for proposals that include testing of human subject and compliance with Institutional Review Board (IRB): https://www.nre.navy.mil/work-with-us/how-to-apply/compliance-and-protections/research-protections. IRB approval is needed prior to award of Phase II. Performers must submit a proposal for IRB approval during Phase I.

PHASE II: Develop, fabricate, lab-test (in variable conditions), and provide two suits/systems for form, fit, and function evaluation by operational Navy divers in maritime environments. Within the period of performance, revise the design and refabricate an additional 10 units based on feedback.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to operational use, support the Navy for test, validation, and qualification of the system for use by military divers, and develop commercial variants suitable for commercial, scientific, and recreational divers. Create a marketing plan for reaching civilian users and mass production, to bring the per unit cost down to under five hundred dollars.

REFERENCES:

1. Piantadosi, C. A.; Ball, D. J.; Nuckols, M. L. and Thalmann, E. D. "Manned Evaluation of the NCSC Diver Thermal Protection (DTP) Passive System Prototype." US Naval Experimental Diving Unit Technical Report (NEDU-13-79), 1979. http://archive.rubicon-foundation.org/xmlui/bitstream/handle/123456789/3356/NEDU_1979_13.pdf?sequence=1

2. Bardi, Jason S. "How Does Fur Keep Animals Warm in Cold Water?" American Physical Society, College Park, MD, November 23, 2015. https://www.aps.org/units/dfd/pressroom/news/2015/upload/7pr-animals2015.pdf

3. Nuckols, M.L. "Analytical modeling of a diver dry suit enhanced with micro-encapsulated phase change materials." Ocean Engineering, Volume 26, Issue 6, 1999, pp. 547-564. ISSN 0029-8018, https://doi.org/10.1016/S0029-8018(98)00001-8 https://www.sciencedirect.com/science/article/pii/S0029801898000018

KEYWORDS: Diving, Wetsuit, Drysuit, Hypothermia, Hyperthermia, Personal Protective Equipment, PPE

N25A-T028 TITLE: Rapid Cryogenic Cooling of Superconducting Systems

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

OBJECTIVE: Develop a novel process, technique, or material for rapidly cooling a large thermal mass or distributed thermal load from room temperatures down to cryogenic temperatures to enable operation of a superconducting system within roughly 24 hours as compared to several days.

DESCRIPTION: High-temperature superconducting (HTS) magnet systems are being developed by the Navy for the minesweeping mission. These large-diameter magnets (on the order of 2 m) utilize standard heat exchanger technology with circulating cryogenic helium to distribute cooling throughout the magnet and may take several days to achieve operational temperatures. The Navy is also pursuing HTS degaussing systems which have a more distributed load and use circulating cryogenic helium in a cryostat. It is desired to reduce the time to cool down the system to operational temperatures so that the Navy's mission can be completed with reduced operational timelines. Future potential applications of HTS technologies include motors, generators, cables, etc., and the issue of cool down can be an important consideration in the viability of these concepts.

Heat pipes, often used for cooling electronics, utilize the phase change of a working fluid to dramatically boost the heat transfer across the length of the pipe. Unfortunately, this working fluid must be "tuned" to a particular temperature range as once the fluid freezes, the heat exchange benefit is lost. For cryogenic temperatures, Nitrogen has been explored; however, this limits the cold side temperature to 63 K. Many HTS Systems utilize colder temperatures to increase the ampacity of the wire or compensate for lost ampacity due to magnetic interaction with the material. In these situations, 55 K or below is a relatively common target temperature.

This STTR topic seeks to develop a cryogenic cooling method, and/or heat exchanger technology, capable of dramatically reducing the cooling time to improve operational readiness of Naval HTS systems. The proposed solution should be applicable to rapidly cool down a superconducting magnet that has a large thermal mass on the order of 2,000 lbs from room temperature to around 40-50 K by either direct conduction, or convection with a heat exchanger and circulating helium cryogenic gas. Additionally, there will be further consideration given to proposed solutions that can provide rapid cooling to a more distributed heat load as in a long length cryostat on the order of 600 ft containing HTS wires (HTS cable) with helium gas flowing within the cryostat at roughly 10-15 g/s.

The desire is to apply the rapid cooling method to either application to reduce the temperature from 300 K to below 50 K in as short of a time as possible. Ideally the time to cool will be within a 24 hr period. During this time, it is expected that there will be power available. The use of alternate cryogens such as liquid nitrogen may be considered but it should be noted that liquid nitrogen alone will not achieve the desired temperatures below 50 K. The use of toxic or flammable cryogens or cryogenic materials will most likely not be considered due to safety issues with using or handling these materials. Finally, the proposed solution should also include any auxiliary hardware that would be necessary such as helium circulators, heat exchangers, and cryorefrigerators.

PHASE I: Define and develop concepts for rapid cryogenic cooling. Determine the technical feasibility of the concepts meeting the desired performance specifications. Perform an analysis via modeling, experimentation, etc. Identify characteristics of the technology and nominal performance. Upon identification of a feasible solution, perform a cost estimate, for both prototype development and full-scale production. The Phase I Option, if exercised, includes a detailed design and specifications to build a prototype during a Phase II effort.

PHASE II: Develop, demonstrate, and validate a functional prototype of a rapid cryogenic cooling method and/or heat exchanger with characterization of key performance metrics at the proposer's facility or other suitable test center identified by the awardee. Establish cool down curves for various cryogenic temperature gradients with a representative thermal mass. Deliver the Phase II prototype to the Navy for further testing, or integration into a larger system.

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II developed cryogenic cooling method and/or heat exchanger into a military or commercial superconducting system to achieve lower operational employment timelines and demonstrate ability to transition the technology. If successful demonstration of the technology is achieved, the transition of the development will lead to lower operational employment timelines for superconducting systems. This will enhance Fleet readiness when deploying superconducting systems in the field. There are several superconducting systems that are currently being transitioned to the Fleet and this technology may be implemented in future upgrades.
Applications in the commercial sector may include superconducting systems being developed for the wind power generation market, resilient power grid, superconducting propulsions for aviation, or existing medical devices such as MRIs.

REFERENCES:

1. Green, Michael. "Methods of speeding up the cool-down of superconducting magnets that are cooled using Small coolers at temperatures below 30 K." OP Conference Series: Materials Science and Engineering, Volume 1240, Advances in Cryogenic Engineering: Proceedings of the Cryogenic Engineering Conference (CEC) 2021, 19-23 July 2021, Virtual Conference, USA. 10.1088/1757-899X/1240/1/012139
2. Kwon, Daniel and Sedwick, Raymond. "Cryogenic Heat Pipe for Cooling High-Temperature Superconducting Coils." Cryogenics, 23, 2009, pp. 514-523. 10.1016/j.cryogenics.2009.07.005
3. Bai, Lizhan; Zhang, Lianpei; Lin, Guiping; He, Jiang and Wen, Dong-sheng. "Development of cryogenic loop heat pipes: A review and comparative analysis." Applied Thermal Engineering, 89, 2015, pp.180-191. 10.1016/j.applthermaleng.2015.06.010
4."Magnetic and Acoustic Generation Next Unmanned Superconducting Sweep (MAGNUSS)." ONR Special Notice N00014-21-S-SN12, 2021. https://sam.gov/opp/ddd803b6d03e42e9b6dbcde611800317/view
5. "High Temperature Superconducting Degaussing System." US Patent Number US 7,451,719 B1, November 2008.


KEYWORDS: Cryogenic Temperature; Heat Exchanger; Rapid Cool Down; Cryogenic Cooling; Superconducting Systems; Cryogenic Thermal Mass; Heat Removal