DEPARTMENT OF THE NAVY (DON)
24.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

IMPORTANT

- **The following instructions apply to topics:**
  - **N241-001 through N241-069**

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

- The information provided in the DON Proposal Submission Instructions document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).

- **DON Phase I Technical Volume (Volume 2) page limit is not to exceed 10 pages.**

- Proposing small business concerns that are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF) or any combination of these are eligible to submit proposals in response to DON topics advertised in this BAA. Information on Majority Ownership in Part and certification requirements at time of submission for these proposing small business concerns are detailed in the section titled ADDITIONAL SUBMISSION CONSIDERATIONS.

- Phase I Technical Volume (Volume 2) and Supporting Documents (Volume 5) templates, specific to DON topics, are available at https://www.navysbir.com/links_forms.htm.

- The DON provides notice that Basic Ordering Agreements (BOAs) may be used for Phase I awards, and BOAs or Other Transaction Agreements (OTAs) may be used for Phase II awards.

- This BAA is issued under regulations set forth in Federal Acquisition Regulation (FAR) 35.016 and awards will be made under “other competitive procedures”. The policies and procedures of FAR Subpart 15.3 shall not apply to this BAA, except as specifically referenced in it. All procedures are at the sole discretion of the Government as set forth in this BAA. Submission of a proposal in response to this BAA constitutes the express acknowledgement to that effect by the proposing small business concern.

INTRODUCTION

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

The Director of the DON SBIR/STTR Programs is Mr. Robert Smith. For questions regarding this BAA, use the information in Table 1 to determine who to contact for what types of questions.

TABLE 1: POINTS OF CONTACT FOR QUESTIONS REGARDING THIS BAA

Type of Question	**When**	**Contact Information**
Program and administrative	Always	Navy SBIR/STTR Program Management Office usn.pentagon.cnr-arlington-va.mbx.navy-sbir-sttr@us.navy.mil or appropriate Program Manager listed in Table 2 (below)
Topic-specific technical questions	BAA Pre-release	Technical Point of Contact (TPOC) listed in each topic. Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
	BAA Open	DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions) Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
Electronic submission to the DoD SBIR/STTR Innovation Portal (DSIP)	Always	DSIP Support via email at dodsbirsupport@reisystems.com
Navy-specific BAA instructions and forms	Always	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
N241-001 to N241-004	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	sbir.admin@usmc.mil
N241-005 to N241-021	Ms. Kristi DePriest	Naval Air Systems Command (NAVAIR)	navair-sbir@us.navy.mil
N241-022 to N241-053	Mr. Jason Schroepfer	Naval Sea Systems Command (NAVSEA)	NSSC_SBIR.fct@navy.mil
N241-054 to N241-067	Ms. Lore-Anne Ponirakis	Office of Naval Research (ONR)	usn.pentagon.cnr-arlington-va.mbx.onr-sbir-sttr@us.navy.mil
N241-068 to N241-069	Mr. Jon M. Aspinwall III (Acting)	Strategic Systems Programs (SSP)	ssp.sbir@ssp.navy.mil

PHASE I SUBMISSION INSTRUCTIONS

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

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

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

Proposal Volumes. The following six volumes are required.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR Program BAA.

- **Technical Proposal (Volume 2)**
  - Technical Proposal (Volume 2) must meet the following requirements or the proposal will be REJECTED:
    - Not to exceed ten (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 ten-page limit of Volume 2, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified. Phase I Options are exercised upon selection for Phase II.
    - Work proposed for the Phase I Base must be exactly six (6) months.
    - Work proposed for the Phase I Option must be exactly six (6) months.

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

- **Cost Volume (Volume 3).**

- Cost Volume (Volume 3) must meet the following requirements or the proposal will be REJECTED:
  - The Phase I Base amount must not exceed $140,000.
  - Phase I Option amount must not exceed $100,000.
  - Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.
  - For Phase I, a minimum of two-thirds of the work is performed by the proposing small business concern. The two-thirds percentage of work requirement must be met in the Base costs as well as in the Option costs. DON will not accept deviations from the minimum percentage of work requirements for Phase I. The percentage of work is measured by both direct and indirect costs. To calculate the minimum percentage of work 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 subcontractor percentage is calculated by taking the sum of all costs attributable to the subcontractor (Total Subcontractor Costs (TSC)) 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.
    - Subcontractor Costs (numerator for subcontractor calculation):
      - Total Subcontractor Costs (TSC)
    - Total Cost (i.e., Total Cost before Profit Rate is applied, denominator for either calculation)
  - Cost Sharing: Cost sharing is not accepted on DON Phase I proposals.

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

- **Company Commercialization Report (Volume 4)**. DoD collects and uses Volume 4 and DSIP requires Volume 4 for proposal submission. Please refer to the Phase I Proposal section of the

DoD SBIR/STTR Program BAA for details to ensure compliance with DSIP Volume 4 requirements.

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

  All proposing small business concerns must review and submit the following items, as applicable:

  - **Telecommunications Equipment Certification.** Required for all proposing small business concerns. The DoD must comply with Section 889(a)(1)(B) of the FY2019 National Defense Authorization Act (NDAA) and is working to reduce or eliminate contracts, or extending or renewing a contract with an entity that uses any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As such, all proposing small business concerns must include as a part of their submission a written certification in response to the clauses (DFAR clauses 252.204-7016, 252.204-7018, and subpart 204.21). The written certification can be found in Attachment 1 of the DoD SBIR/STTR Program BAA. This certification must be signed by the authorized company representative and is to be uploaded as a separate PDF file in Volume 5. Failure to submit the required certification as a part of the proposal submission process will be cause for rejection of the proposal submission without evaluation. Please refer to the instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
  - **Disclosures of Foreign Affiliations or Relationships to Foreign Countries.** Each proposing small business concern is required to complete Attachment 2 of this BAA, "Disclosures of Foreign Affiliations or Relationships to Foreign Countries" and upload the form to Volume 5, Supporting Documents. Please refer to the following sections of the DoD SBIR/STTR Program BAA for details:
    - Program Description
    - Proposal Fundamentals
    - Phase I Proposal
    - Attachment 2
  - **Certification Regarding Disclosure of Funding Sources.** Each proposing small business concern must comply with Section 223(a) of the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021. The disclosure and certification must be made by completing Attachment 4, Disclosure of Funding Sources, and uploading to Volume 5, Supporting Documents. Please refer to the following sections of the DoD SBIR/STTR Program BAA for details:
    - Phase I Proposal
    - Attachment 4
  - **Majority Ownership in Part.** Proposing small business concerns which are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, are eligible to submit proposals in response to DON topics advertised within this BAA. Complete certification as detailed under ADDITIONAL SUBMISSION CONSIDERATIONS.

  - Additional information:
    - Proposing small business concerns may include the following administrative materials in Supporting Documents (Volume 5); a template is available at

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

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

PHASE I EVALUATION AND SELECTION

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

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

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

- **Technical Volume (Volume 2).** The DON will evaluate and select Phase I proposals using the evaluation criteria specified in the Phase I Proposal Evaluation Criteria section of the DoD SBIR/STTR Program BAA, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. The information considered for this decision will come from Volume 2. This is not a FAR Part 15 evaluation and proposals will not be compared to one another. Cost is not an evaluation criteria and will not be considered during the evaluation process; the DON will only do a compliance review of Volume 3. Due to limited funding, the DON reserves the right to limit the number of awards under any topic.

  The Technical Volume (Volume 2) will undergo a compliance review (prior to evaluation) to verify the proposing small business concern has met the following requirements or the proposal will be REJECTED:
  - Not to exceed ten (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; a minimum of two-thirds of the work is performed by the proposing small business concern. The two-thirds percentage of work requirement must be met in the Base costs as well as in the Option costs. DON will not accept deviations from the minimum percentage of work requirements for Phase I.
  - Cost Sharing: Cost sharing is not accepted on DON Phase I proposals.

- **Company Commercialization Report (CCR) (Volume 4).** The CCR (Volume 4) will not be evaluated by the Navy nor will it be considered in the Navy's award decision. However, all proposing small business concerns must refer to the DoD SBIR/STTR Program BAA to ensure compliance with DSIP Volume 4 requirements.

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

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

ADDITIONAL SUBMISSION CONSIDERATIONS

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

Due Diligence Program to Assess Security Risks. The SBIR and STTR Extension Act of 2022 (Pub. L. 117-183) requires the Department of Defense, in coordination with the Small Business Administration, to establish and implement a due diligence program to assess security risks presented by small business concerns seeking a Federally-funded award. Please review the Program Description section of the DoD SBIR/STTR Program BAA for details on how DoD will assess security risks presented by small business concerns. The Due Diligence Program to Assess Security Risks will be implemented for all Phases.

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

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

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

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

TABA must <u>NOT</u>:

- Be subject to any indirect costs, profit, or fee by the SBIR proposing small business concern
- Propose a TABA provider that is the SBIR proposing small business concern
- Propose a TABA provider that is an affiliate of the SBIR proposing small business concern
- Propose a TABA provider that is an investor of the SBIR 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 <u>NOT</u> exceed:

- Phase I: A total of $6,500
- Phase II: A total of $25,000 per award, not to exceed $50,000 per Phase II project

If a proposing small business concern requests and is awarded TABA in a Phase II contract, the proposing small business concern will be eliminated from participating in the DON SBIR/STTR Transition Program

(STP), the DON Forum for SBIR/STTR Transition (FST), and any other Phase II assistance the DON provides directly to awardees.

All Phase II awardees not receiving funds for TABA in their awards must participate in the virtual 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.

Majority Ownership in Part. Proposing small business concerns that are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, **are eligible** to submit proposals in response to DON topics advertised within this BAA.

For proposing small business concerns that are a member of this ownership class the following must be satisfied for proposals to be accepted and evaluated:

a. Prior to submitting a proposal, small business concerns must register with the SBA Company Registry Database.
b. The proposing small business concern within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. A copy of the SBIR VC Certification can be found on https://navysbir.com/links_forms.htm. Include the SBIR VC Certification in the Supporting Documents (Volume 5).
c. Should a proposing small business concern become a member of this ownership class after submitting its proposal and prior to any receipt of a funding agreement, the proposing small business concern must immediately notify the Contracting Officer, register in the appropriate SBA database, and submit the required certification which can be found on https://navysbir.com/links_forms.htm.

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 concern 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 Proposal Fundamentals, for Phase II awards the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

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

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

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

Days From Start of Base Award or Option Payment Amount

15 Days	50% of Total Base or Option
90 Days	35% of Total Base or Option
180 Days	15% of Total Base or Option

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

PHASE II GUIDELINES

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

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

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

PHASE III GUIDELINES

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

Navy SBIR 24.1 Topic Index

N241-047	[DON has removed topic N241-047 from the 24.1 SBIR BAA]
N241-048	Virtualized Naval Tactical Data System Interfaces over Ethernet
N241-049	Shipboard Proof Testing Apparatus for Field-Expedient Parts
N241-050	Forces Afloat Man Overboard Persons in the Water (PIWs) Recovery
N241-051	Enhanced Radome Design
N241-052	Energy Harvesting for Underwater Persistent Systems
N241-053	Additively Manufactured Polymer Tooling for Rubber Compression Molding
N241-054	Probabilistic Forecasts of High Impact Weather on Medium Range to Subseasonal Timescales using Artificial Intelligence
N241-055	Generative Text Engine for Form Completion
N241-056	Autonomous, Mission-based Traffic Engineering
N241-057	Networking Platform for Real-time Communication of Personnel Health Status and Location during Shipboard Emergencies
N241-058	Multi-Sensor Prototype for Non-Destructive Corrosion Evaluation and Characterization
N241-059	Wideband Interference Suppression
N241-060	Ultra-High Reliable and Efficient Unmanned Surface Vessel (USV) Modular Generator System
N241-061	Multi-variable Unmanned Anti-Submarine Warfare (ASW) system assessment and optimization toolkit
N241-062	Innovative Low Profile, Foldable, High Power Microwave Antenna
N241-063	Naval Shipboard Embedded Battery Containment System
N241-064	Advanced Wearable Integration and Synchronization Hub (AWISH)
N241-065	Advanced Nondestructive Inspection System for Detection and Characterization of Corrosion under Thick Coatings
N241-066	Laser Magazine
N241-067	Common Software Platform for Learning-based Robots
N241-068	Fast Micro-Electromechanical Systems (MEMS) Shutters for Stellar Sensing Applications

N241-069 Deterministic Precision Machining of Miniature Optics in Hard Ceramics

N241-001 TITLE: Durable Wheel End Drive for Amphibious Vehicles

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

OBJECTIVE: Design and develop a new or improved drive axle for the Amphibious Combat Vehicle with greater durability when subjected to operation in an amphibious environment.

DESCRIPTION: The United States Marine Corps is fielding the Amphibious Combat Vehicle (ACV) designed to operate over harsh off-road terrain and in oceans and rivers. The ACV currently uses traditional Constant Velocity (CV) Joints on the wheel end drives that require excessive maintenance because they develop holes and tears in the inside and outside CV Boots. The Marine Corps is interested in innovative approaches to develop a more durable wheel end drive. The design must protect the current CV Boots, replace the Boot with a more durable material, or redesign the wheel end drive joint so that it does not require a grease filled boot covered joint.

Proposed concepts should:

- Address the ability to function in extreme operating environments which include but are not limited to -40 degrees Fahrenheit (°F) to +120°F, hot desert blowing sand, full salt water immersion, operation to and from the beach in surf zones up to 6 foot Significant Breaker Height (SBH) and mud (soft soil of 30 Rating Cone Index (RCI)) which includes suspended abrasive items such as rocks, gravel, sand, and coral.
- Allow for terrain traverse with combined 3 g-force (G) vertical and 0.7 G horizontal load on suspension station, racking load at diagonal corners for 1 G vertical load, North Atlantic Treaty Organization (NATO) tree impact (5" tree at 32 kilometers per hour (kph)-8365 pound equivalent static load), and fatigue loads for 30 year vehicle life.
- Allow for a maximum of 4,350 newton-meters (NM) of torque, a maximum angle of 40 degrees (short duration), and a maximum rotation speed of 2,682 RPM.
- Support steering in the forward and reverse directions on 40% side slopes and ascending, descending, starting, and stopping on a dry hard surfaced longitudinal slope up to and including 60% grade in both forward and reverse direction.

PHASE I: Design a more durable wheel end drive in consideration of the operating environment in which the drive system will be exposed. Demonstrate, via modeling or testing, the feasibility of the concept(s) in meeting Marine Corps' needs and establish that the concept can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and analytical modeling as appropriate. Provide a Phase II development plan with performance goals and key technical milestones that will address technical risk reduction.

PHASE II: Develop a scaled prototype for evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals established for the Marine Corps' amphibious vehicles. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters. Evaluation results will be used to refine the prototype into a design that will meet Marine Corps requirements. Working with the Marine Corps, prepare a Phase III development plan to detail the strategy for transitioning the technology for Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the durable wheel end drive system for Marine Corps use. Working with the Marine Corps, integrate the prototype wheel end drive system into a vehicle for evaluation to determine its effectiveness in an operationally relevant environment. Provide support to the Marine Corps during test and validation to certify and qualify the system for Marine Corps use. Develop manufacturing plans and capabilities to produce the system for both military and commercial markets.

This technology is directly applicable to large military vehicles such as the Marine Corps ACV. Successful development and characterization of a durable wheel end drive system has direct application to various military and commercial applications such as amphibious rescue vehicles. Reductions of weight and complexity in the suspension can be of substantial value.

REFERENCES:

1. MIL-STD-810G Environmental Test Methods and Engineering Guidelines. http://www.everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810_13751/
2. MIL-STD-889B Dissimilar Metals.http://www.everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL_STD_889B_955/
3. Description of a flex joint/Giubo. https://en.wikipedia.org/wiki/Giubo

KEYWORDS: Provide a minimum of six key words separated by semicolons. Drive; axle; constant velocity joint (CV Joint); boot, Giubo; amphibious

N241-002 TITLE: Medical Echelon of Care Conceptual Models for Wargaming

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

OBJECTIVE: Develop Medical Echelon of Care models for wargaming, sufficient to withstand review board scrutiny to support model verification, validation, and accreditation, as required. The focus is on developing and implementing the models referenced herein, not on the underlying mechanics of the Program Manager Wargaming Capability (PM WGC) materiel solution simulation framework.

DESCRIPTION: This SBIR topic addresses two parametrics of interest for future inclusion in the Neller Wargaming and Analysis Center (NWAC), formerly the Marine Corps Wargaming and Analysis Center (MCWAC). Both parametrics are related to medical echelon of care. In the table below, the two major parametrics considered are “Echelon of care” and “Time requirements between echelons of care”. The specific conceptual model requirements are listed for each parametric.

ID	JCA	Parametric	Parametric Description	Conceptual Model Requirement
L4	Logistics	Echelon of care	Represent the different classes of casualties and echelons of care	Represent **entity-level casualties** including time of injury, class of injury (per International Classification of Diseases, 9th Revision (ICD-9)), location, detailed injury information, rate of recovery, and return to combat effectiveness.
L5	Logistics	Echelon of care	Represent the different classes of casualties and echelons of care	Simulate application of the six echelons of care per Fleet Medical Pocket Reference of 2016.
L6	Logistics	Echelon of care	Represent the different classes of casualties and echelons of care	Output updates to casualty status based on care and movement: location, detailed injury information, rate of recovery, and return to combat effectiveness.
L7	Logistics	Time requirements between echelons of care	Represent the time to transition a casualty from one echelon of care to another	Output time and location of entities as they transition echelons of care.
L31	Logistics	Maneuvering shock trauma team with vehicle capabilities, resuscitation capabilities, and a shock trauma bay with blood supplies and independent power supply.	Represent a maneuvering shock trauma team.	Simulate specific trauma services provided by shock trauma teams.

L32	Logistics	Maneuvering shock trauma team with vehicle capabilities, resuscitation capabilities, and a shock trauma bay with blood supplies and independent power supply.	Represent a maneuvering shock trauma team.	Simulate movement of casualties as enabled by shock trauma team transportation capabilities.
L33	Logistics	Maneuvering shock trauma team with vehicle capabilities, resuscitation capabilities, and a shock trauma bay with blood supplies and independent power supply.	Represent a maneuvering shock trauma team.	Represent shock trauma team levels of supply.
L34	Logistics	Maneuvering shock trauma team with vehicle capabilities, resuscitation capabilities, and a shock trauma bay with blood supplies and independent power supply.	Represent a maneuvering shock trauma team.	Modify casualty survival rate based on trauma team actions.
L35	Logistics	Maneuvering shock trauma team with vehicle capabilities, resuscitation capabilities, and a shock trauma bay with blood supplies and independent power supply.	Represent a maneuvering shock trauma team.	Represent location of shock trauma teams.
L36	Logistics	Medical facilities.	Represent casualty survival rate based on trauma team actions.	Modify casualty survival rate based on surgical capacity of medical facilities.
L37	Logistics	Medical facilities.	Represent number of surgeons at medical facilities.	Represent the surgical capacity of medical facilities by number of surgeons.
L38	Logistics	Medical facilities.	Represent capabilities at medical facilities.	Identify medical facility capabilities in accordance with Fleet Medical Pocket Reference of 2016.

The purpose of the models is to support realistic evaluation of medical support systems within USMC future concept and capability development and Operational Plan assessment wargames. The prototype would provide medical treatment simulation from time of injury to return to combat effectiveness via the various echelons of care.

Some examples under the above headings include, but are not limited to:

- Establish baseline performance characteristics of existing medical support systems under a given scenario.
- Model novel ways of treating/transporting/managing Marine casualties occurring in austere environments within challenging operating environments, with imposed limitations on naval medical support.
- Model the complex relationships between location and type of injury, types of medical transport available, location and capabilities of the various echelons of care available, eventual return to combat effectiveness, and associated critical time and resource metrics.

Full satisfaction of each conceptual model requirement is the end goal, however partial solutions will be considered. This topic specifically focuses on developing the mathematical, algorithmic, and data aspects of the conceptual models. The mechanism by which these conceptual models would be integrated with existing wargaming kinetic models resident within the NWAC is not the focus. Documentation of the conceptual models with Cameo Systems Modeler (Cameo/SysML) is desirable, but not necessarily a strict requirement, if another representation is more suitable [Ref 2].

PHASE I: Develop concepts for an improved representation of medical echelon of care in wargaming M&S that meets the requirements described above. Demonstrate the feasibility of the concepts in meeting Marine Corps needs and establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by evaluation of the plan of attack for the development effort including data availability. Provide a Phase II development plan with performance goals and key technical milestones, and that addresses technical risk reduction.

PHASE II: Develop prototype conceptual models. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for medical echelon of care M&S. System performance will be demonstrated through prototype evaluation over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps requirements. Prepare a Phase III development plan to transition the technology to Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Develop medical echelon of care conceptual models for evaluation to determine effectiveness in an operationally relevant environment within the NWAC. Support the Marine Corps for M&S Verification, Validation, and Accreditation (VV&A) to certify and qualify the system for Marine Corps use.

The conceptual models described herein are not only a high priority within the Marine Corps [Refs 1, 3], but are equally applicable across the Services, to support not only wargaming, but also analysis, training, and experimentation. Successfully developed conceptual models would likely be of great interest across these communities. DoD components and prime contractors are in need of accurate medical casualty/echelon of care simulation representation to support gap analysis and solution assessment. Potential civilian applications include emergency medicine and care after the emergency room.

REFERENCES:

1. “Commandant’s Planning Guidance.” 38th Commandant of the Marine Corps, 2019. http://www.marines.mil/Portals/1/Publications/Commandant's%20Planning%20Guidance_2019.pdf?ver=2019-07-17-090732-937
2. “IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)”, IEEE Standard 1730-2022, https://standards.ieee.org/ieee/1730/10715/
3. “Force Design 2030 Annual Update, June 2023. 38th Commandant of the Marine Corps. https://www.marines.mil/Portals/1/Docs/Force_Design_2030_Annual_Update_June_2023.pdf

KEYWORDS: MCWAC; NWAC; USMC; M&S; Modeling and Simulation; medical; conceptual model; analysis; Neller Center; wargaming; Force Design;

N241-003 TITLE: Lower-Cost Textiles for Dismounted Signature Management

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

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

OBJECTIVE: Develop novel approach(es) to textile solution(s) in Marine Pattern (MARPAT) camouflage that lower the cost, increase the manufacturability/scalability, increase the lifecycle, increase ability to launder, and increase the wearability over current signature management textiles. This effort shall apply the developed concept(s) to a Flame Retardant (FR) textile. The textile/material solution(s) developed in this effort are intended to be used in a tactical environment to reduce individual dismounted Marine signature, applicable to a suite of items, in the Infrared Spectrum (IR) from Near Infrared (NIR) through to Long Wave Infrared (LWIR). The intent of this capability is to degrade the ability of adversaries to detect, identify, and recognize a Marine, increasing Marine lethality and survivability in a sensor contested environment.

DESCRIPTION: Detection, recognition, identification, and targeting of dismounted warfighters is a critical variable in past and future fights. Currently dismounted infantry and infantry-like Marines are at an increased risk from various IR imagers from the ground and air. Publicly accessible information and videos on recent events (i.e., the Ukraine-Russia conflict) have demonstrated how accessible and proliferated a variety of sensors are due to recent technological advancements in detector technology. The 2016 Marine Corps Operating Concept cites a '"Battle of signatures" where "Tomorrow's fights will involve conditions in which "to be detected is to be targeted is to be killed." Adversaries will routinely net together sensors, spies, Unmanned Aircraft Systems (UAS), and space imagery to form sophisticated "ISR-strike systems" that are able to locate, track, target, and attack an opposing force… No matter the means of detection, unmanaged signatures will increasingly become a critical vulnerability… Defensively, our units will need to adapt how they fight, emphasizing emissions control and other means of signature management to increase their survivability." [Ref 4]

The current combat ensemble provides visual (VIS) and Near Infrared (NIR) signature mitigation. Current VIS is provided in MARPAT with a digital pattern breakup by utilizing four (4) distinct colors in two (2) color-way patterns, Woodland and Desert, for use in their respective environments. NIR signature management (typically defined as 700-1,000 nanometers) is achieved through the camouflage pattern, breakup, and pigments of the dyestuffs. Near-term improvements and updates to military textiles with Short Wave Infrared (SWIR) (most typically defined as 1,000-1,700 nanometers with some emerging devices seen in the upper ranges of 1,700-2,500 nanometers) mitigation through adjustments in dyestuffs are being evaluated for adoption; these values are ITAR restricted and will be made available to Phase I awardees. Current Marine Corps clothing and equipment items do not have Midwave Infrared (MWIR) (typically defined as 3-5 micrometer wavelength) or LWIR (typically defined as 8-14 micrometer wavelength) signature mitigation. LWIR imaging sensors based on uncooled microbolometer technology are a particularly pervasive threat as costs associated with such systems continue to go down, while the performance of commercial systems available worldwide are competitive with military-grade capabilities. The intent for this SBIR topic is to explore the development of novel lower-cost textile(s) that incorporate(s) current signature mitigation from VIS to NIR, tentative requirements for SWIR, and a significant increase over current capabilities in MWIR and LWIR signature mitigation. The textile(s) developed in this effort should focus on reducing the probability in identification (of a user), reducing the range of detection, and/or reducing targeting accuracy if detected through NIR, SWIR, MWIR, and LWIR sensors. While there are limited commercially available fabrics that mitigate signature from VIS to LWIR, these fabrics are often cost ineffective for the general Marine infantry. Another disadvantage of some current commercial or developmental technologies is overall low comfort or wearability, due to retention of heat, from a user perspective. Additionally, many of these commercial technologies have a short lifespan or use, and must be stored, cared for, and laundered in certain manners. Finally, the existing technologies and current developmental efforts have been developed for Army use, in Operational Camouflage Pattern (OCP), and not focused on MARPAT. The intent of the effort is to address the described issues and produce a material/textile solution(s) for tactical use that mitigate individual signature in VIS-LWIR with a reduction in cost, increased wearability, focus on development of MARPAT camouflage solutions, increase ease of storage/transportation, and increase lifecycle use when compared to current commercially available solutions. A textile with such attributes should be perceived as a piece of protective equipment, providing a capability for the Marine force to operate in austere environments undetected.

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 MCSC in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop new and novel concepts to address the cost reduction of Signature Mitigating textile(s) through use of (but not limited to) different materials, additives, applications, finishes, formation and/or manufacturing methods, in Woodland and Desert MARPAT. Vendors shall not be limited in types of materials, structures, additives, and/or finishes and are encouraged to explore innovative or unconventional ideas and methods for textile(s). Consider scalability, launderability, storage and logistical considerations, lifecycle use, general wearability, and function for use in a range of climatic environments to develop successful novel methodologies and concepts for lower-cost signature mitigating textile(s). Proposed textiles may be reversible for multi-use. Provide a theoretical (written) concept for Desert MARPAT and Woodland MARPAT.

Phase I deliverables will include production and delivery of fabric swatch(es)/sample(s) of the most promising concept(s) down selected from the various conceptual approaches- emphasizing quality of solutions rather than quantity. The end state for Phase I will be a physical material/textile sample(s), (a minimum of twelve-by-twelve inch, 12in x 12in, but preferably larger) that mitigates VIS-LWIR signature. The physical sample shall be one of the following: solid color, Operational Camouflage Patter (OCP), Desert or Woodland in Woodland MARPAT. No new or alternative digital camouflage patterns shall be developed for this effort. If not demonstrated in a physical sample, a, with a theoretical (written) concept shall be provided for Woodland and Desert MARPAT. Vendors shall explore and identify any visual (color) tradeoffs or trade space associated with Woodland MARPAT when intersected with success in the NIR, SWIR, MWIR, or LWIR ranges. Phase I deliverables shall also provide a written report detailing ways to optimize and further development in the Phase I Option or a Phase II potential effort. If I Phase I Option is exercised, further develop the most promising textile(s) and conceptualize several end item configurations (in the form of drawings) to be considered for prototypes in Phase II.

The Phase I effort will not require access to classified information. Controlled Unclassified Information (CUI) may be provided to vendors upon award of Phase I.

PHASE II: Explore the novel Phase I technology(s) and/or alternative proposed concept(s) to mature a lower-cost (compared to what is currently commercially available) Woodland and Desert MARPAT signature mitigating textile for use in an operationally relevant environment on a dismounted Marine. Snow MARPAT may be considered in this Phase. These textile(s) proposed may be refined to areas of interest which include, but not limited to, overgarments/ponchos, personnel covers, and personal hide sites. Concepts should consider multi-functionality of the textile(s) to reduce the burden of number, size, and weight to the Marine. Further refine visual appearance; tune NIR and SWIR values to meet current and potential future USMC requirements (available with a signed NDA), further develop MWIR and LWIR signature mitigation, reduce cost, increase wearability, decrease or address logistical/transportation/storage concerns, and increase lifecycle and explore launderability of proposed textiles. Textile(s) matured in Phase II must be practical for a dismounted infantry Marine to wear, use, transport, and care for. Practical for a dismounted infantry Marine can be defined as creating no to minimal (maximum of 16 oz/sq yd for the textile, objective under 7 oz/sq yd) additional burden in terms of weight as well as the textile must function (in terms of use) in all weather and not be damaged by elements (rain, hail, snow, etc), and the care/ transportation of the textile (must be packable in a deployers bag, must be able to be stored in non-climate controlled facilities during travel to and from facilities, must be launderable if necessary). CUI and classified metrics, additional data, and further description to needs may be provided to the vendor upon award of Phase II.

Examine the application of concepts to substrates, including those with Flame Resistant (FR) performance, with delivery of a minimum of one (1) developmental swatch (minimum of twelve-by-twelve inch, 12in x 12in) of a FR signature mitigating textile. Phase II deliverables will also include textile testing on proposed fabric solution(s) to include but not limited to the tests defined in Table 1. Phase II will result in the delivery of fifty to one hundred (50-100) yards of each non-FR textile concept (minimum of one (1)) demonstrating a minimum of two of the Marine Corps camouflages (Woodland, Desert, and Snow MARPAT). In addition to the textile yardage, submit three (3) prototypes utilizing the proposed fabric(s) in an existing military baseline configuration. Baseline patterns for this configuration will be provided for fabrication of prototypes upon award. In addition to the baseline prototypes, propose novel end items, fabrication, or applications in the Phase II report. Deliver a concise brief, unclassified, brief that explains the high-level principles of how their technology meets the user's operational and maintenances needs.

If exercised, Phase II Option shall further refine the textiles, including the FR capability if warranted, and prototypes in the form of: IR capabilities, cost, scalability, launderability, storage and logistical considerations, lifecycle use, general wearability, and function for use in a range of climatic environments. If warranted, develop other substrate(s) that could be applied to other areas of interest such as combat uniforms, armor and load carriage, outerwear, or cold weather gear.

Test Type	Test Method
Break Strength	ASTM D 5034
Tear Strength	ASTM D 1424
Weight	ASTM D 3776

Air Permeability	ASTM D737
Dry Time	MM-TS-07 (AATCC)
Colorfastness to Light	AATCC TM16 A or E
Colorfastness to Laundering	AATCC TM61 test 1A
Colorfastness to Crocking	AATCC TM8
Colorfastness to Perspiration	AATCC TM15
Toxicity Reference	MIL-PRF-32679 Table I or MIL-PRF-43637F 3.13 available via ASSIST
pH	AATCC TM81- Reference MIL-PRF-32679 Table I or MIL-PRF-43637F 3.12 available via ASSIST
Dimensional Stability Report after Laundering:	according to AATCC 135
Launderability at 0, 1, 5, 10, 15, 20, and 25 cycles (document with written report and photos)	AATCC 135, settings to be determined by vendor dependent on application
Hemispherical Directional Reflectometry (HDR) or Delta T	Use a SOC-100 HDR or spectrophotometer with black body and calibrated sensor (report calculation methods) *This test(s) is optional, but encouraged*

For vendors awareness, the Phase II and III efforts will likely require secure access, and the contractor will need to be prepared for personnel and facility certification for secure access.

Work produced in Phase II may become classified. See note in the Description.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the textile(s) and technology(s) for Marine Corps use in the Program Manager Infantry Weapons (PM IW) teams (Individual Armor and Clothing and Equipment). Transition the developed processes and novel textile(s) though a multitude applicable end item forms. Continue to improve manufacturing processes, supply chain robustness and availability, lower cost through economies of scale on developed textile(s), Continue to expand technology to additional substrates, including those with FR capabilities. Assist in development of briefings or trainings on technology and use of items, understandable and digestible at the lowest level. Information regarding specific textiles and items for transition will be provided upon award.
These processes and textile(s) can be transitioned to all other services for their signature management programs as applicable. The technology and processes developed in this SBIR could be used in programs outside of Clothing & Equipment and may be applicable to other portfolio's such as Land Systems. A successful signature mitigating textile(s) with a lower cost would be applicable to all individual 'kit' and would dramatically change Warfighters ability to operate undetected in a contested environment.

REFERENCES:
1. "Changes to Camouflage Spectral Reflectance Requirements Session #18: SWIR Values." JAPBI Brief -7 November 2019, p. 6. https://www.dla.mil/Portals/104/Documents/TroopSupport/CloTex/Changes%20to%20Camo.pdf?ver=2019-11-21-111440-410
2. Olsen, Frode Berg. "Methods for Evaluating Thermal Camouflage." RTO-MP-SCI-145 - RTO SCI Symposium "Sensors and Sensor Denial by Camouflage, Concealment, and Deception." Brussels, Belgium, 19-20 April 2004. https://www.sto.nato.int/publications/STO%20Meeting%20Proceedings/RTO-MP-SCI-145/MP-SCI-145-16.pdf
3. "Camouflage U.S. Marine corps utility uniform: pattern, fabric, and design Patent US6805957B1. https://patents.google.com/patent/US6805957B1/en

4. "Marine Corps Operating Concept How an Expeditionary Force Operates in the 21st Century." Department of the Navy, Headquarters United States Marine Corps, September 2016, p. 10. https://www.mcwl.marines.mil/Portals/34/Images/MarineCorpsOperatingConceptSept2016.pdf

KEYWORDS: Signature; Signature Management; Sensors; Materials; Textiles; Clothing and Equipment; Protective Clothing; Dismounted Signature; Infrared

N241-004 TITLE: Atmospheric Water Generation – On The Move (AWG-OTM)

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

OBJECTIVE: Develop an Atmospheric Water Generation – On The Move (AWG-OTM) system in a form factor to occupy a limited footprint within the cargo space of a Utility Lightweight Tactical Vehicle (ULTV) and Joint Light Tactical Vehicle (JLTV) with the ability to scale to support other operational units in multiple operational environments. The system shall be required to leverage Onboard Vehicle Power (OVP) or alternative power sources (e.g., solar or wind power generation) to produce 24 gallons of potable water over a period of 24 hours. The developed system shall incorporate the ability to "add-on" modules to separately purify and treat water from raw and brackish sources.

DESCRIPTION: The USMC currently requires a portable, compact means to generate potable water at the point of need, with or without a water source, to sustain small teams for an extended duration in austere environments. As part of its future force modernization efforts, the Marine Corps seeks to deploy small, disaggregated units to locations where access to life-sustaining resources like water will be limited or unavailable. These units are to specifically support the U.S. Marine Corps' Expeditionary Advanced Base Operations (EABO) a form of expeditionary warfare that involves the employment of mobile, low-signature, naval expeditionary forces that operate from a series of austere, temporary locations.

Definitions:
Systems must meet Threshold requirements = (T)
It is highly desirable the system meet Objective requirements = (O)

- Support an operational unit of four personnel (T=O)
- Operate at a low temperature of 40°F (T); 35°F (O)
- Produce NLT 12 gallons of potable water over a 12-hour period with a relative humidity range of 30-99% (T); 20-99% (O)
- Can be powered by on-board vehicle power systems (T), or alternative energy sources (e.g., solar, batteries) (O), ensuring average and peak power draw does not exceed vehicle power requirements
- Ensure levels of Toxic Industrial Chemicals (TICs) and Toxic Industrial Materials (TIMs) are within required limits (T=O)
- Can fit, and be secured, in the intended light tactical vehicle (MRZR Diesel, Ultra Light Tactical Vehicle (ULTV), Joint Light Tactical Vehicle (JLTV)) (T=O)
- Provide Mineralization for taste (T=O)
- Provide External potable water storage and purification (T=O)
- Adhere to applicable MIL-STD 810 standards: Environmental, Shock and Vibration, Transportability (T=O)
- Adhere to applicable MIL-STD-1472 standards: Weight, Lifting, Displays, Alarms (T=O)
- Adhere to applicable TB MED-577 standards: Sanitary Control and Surveillance of Field Water Supplies (T=O)
- Achieve complete system integration and integration with vehicle (T=O)
- Achieve regulatory approval of water output
- Operate from current or planned small unit conventional and alternative 28VDC power, and single-phase 120VAC, sources (T=O)
- Require little to no maintenance and is intuitive to operate/appropriate for an incidental operator (does not require intensive training or certification) (T=O)
- Reduce supported operational unit or supporting logistics unit's demand for conventional petroleum fuel and fuel-burning generator operation in the purification of potable water and the distribution/transportation of potable water (TB MED-577) supplies via ground or air delivery. (T=O)

PHASE I: Develop concepts for AWG-OTM systems that meet the requirements described above. Demonstrate the feasibility of the concepts in meeting Marine Corps requirements. Establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones, and that addresses technical risk reduction.

PHASE II: Develop 3-5 prototype AWG-OTM systems for evaluation to determine their capability in meeting the performance goals defined in the Description. Demonstrate technology performance through prototype evaluation and modeling over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps requirements; and for evaluation to determine its effectiveness in an operationally relevant environment approved by the Government. Prepare a Phase III development plan to transition the technology to Marine Corps use. The technology should reach TRL 6/7 at the conclusion of this phase.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Support the Marine Corps for test and validation to certify and qualify the system for Marine Corps use. The prototypes shall be TRL 8 at the conclusion of testing.
Commercial applications may include, but not be limited to: humanitarian aid, disaster relief, homeland security, emergency services, recreation, and automotive applications.

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KEYWORDS: Water; potable; atmospheric; energy; extraction; efficiency

N241-005 TITLE: Electrically Small Antennas at High Frequency

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

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

OBJECTIVE: Design, develop, simulate and demonstrate an electrically small antenna using metamaterials that can operate at frequencies from 2–30 MHz. The antenna will be used to transmit/receive Skywave radio-wave signals to provide Beyond Line of Sight (BLOS) communications on Navy aircraft.

DESCRIPTION: In the absence of satellite communication channels, current and future missions require aircraft to communicate at High Frequencies (HF) for BLOS communications. The principle constraint on modern air platforms are size and weight which drives the need for smaller, lighter, efficient radio and antenna technologies. The innovative use of metamaterials has shown to be a promising technology to reduce size and weight while achieving effective power characteristics when compared to conventional antenna designs at other portions of the RF spectrum. Therefore, it is hypothesized that the use of metamaterials in antenna design could dramatically reduce the size of the antenna and may improve other antenna parameters such as enhancing bandwidth and increasing gain at HF. The challenge is to determine if metamaterials can significantly reduce the size and weight of an HF antenna, be affordable, and be suitable for installation on Navy platforms. Innovative solutions are being sought to develop an HF antenna that can meet the design goals shown below. In addition, there is the need for a conformal antenna to minimize drag on the aircraft and reduce risk of damage.

Antenna Design Goals:
(a) Weight—reduced in half as compared to conventional
(b) Volume—1/5 as compared to conventional
(c) VSWR—No worse than conventional, over full frequency range, 2-30 MHz
(d) Gain—3 dB improvement over conventional

Conventional HF Antenna Examples:
(a) Chelton 435 Towel Bar Antenna, appx 8 in. (20.3 cm) stand off from aircraft skin (moldline) by 10 ft long (3 m)
(b) Shunt-fed embedded HF antenna found in airplane vertical stabilizer

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Investigate suitable metamaterials for an antenna at HF, create a digital model, and demonstrate the feasibility of the design to meet the antenna goals defined above. Document—with detailed analysis—the predicted performance with modeling and simulation. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Using the results from Phase I, develop a prototype antenna; demonstrate in the lab, and/or chamber that the prototype can transmit and receive at HF; and measure the performance of the prototype across the frequency band. Work with NAVAIR to perform initial qualification testing on sample sections of the antenna to gain insight into suitability of the design to operate under representative conditions. Deliverables of Phase II will be the prototype array and a final report, which documents the performance of the prototype.

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

PHASE III DUAL USE APPLICATIONS: Further develop the prototype produced in Phase II and work with the Navy to install on a rotorcraft. Demonstrate that the antenna can transmit and receive at HF for a military application.

This technology would be extremely useful for other airborne systems such as law enforcement, safety, and corporate transport. The technology would be helpful for situations where SATCOM is too expensive, not viable (e.g., Polar Regions or deep valleys), and if the SATCOM hardware is too large.

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KEYWORDS: antenna; high frequency wavelength; electrically small antenna; ESA; metamaterials; military helicopters; Beyond Line of Sight; BLOS; Skywave HF Transmissions

N241-006 TITLE: Two-color Mid-Wave Infrared (MWIR) LED Array Infrared Scene Projector (IRSP)

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

OBJECTIVE: Design a two-color Mid-Wave Infrared (MWIR) light emitting diode (LED) array with a Read-in Integrated Circuit (RIIC) to provide the capability for system design and integration of a high-fidelity Infrared Scene Projector (IRSP) to support testing and evaluation (T & E) of sensor and seeker. Develop a side-by-side structured two-color LED array with narrow spectral bandwidths with two different spectral bands between 3–5 µm.

DESCRIPTION: Chemical sensing, IRSP, and spectroscopy applications require improved MWIR [3–5 µm]) LED arrays. A 1024 X 1024 dual-band MWIR LED array that incorporates narrow-band emission LEDs to provide electromagnetic radiation in two spectral bands is highly beneficial. The narrow-band emission of LEDs will enable more precise spectral emissions for analysis of chemical composition, provide the core technology for smaller, lighter IRSPs, and provide the capability for better wavelength selection of two-color absorption spectroscopy. Narrow-band LED arrays with enhanced efficiencies that increase the brightness of individual LED pixels to replicate temperatures above 1500 K will improve signal levels for both chemical sensing and spectroscopy. The two-color LED arrays of an IRSP will improve the fidelity of projection systems for more effective Hardware-in-the-loop (HITL) and live-virtual-constructive (LVC) testing of missile warning systems (MWS). It will be extremely difficult to meet all these needs using current technologies.

The simulation of range-dependent high-fidelity threat signatures in complex environments for rendering images of HITL engagements is necessary for two-color MWS HITL ground testing and performance evaluation. Enhanced high-brightness LED arrays must provide a high-dynamic range and sufficient bit-depth to render variable thermal environments. Current IR scene projectors based on resistive emitter arrays have performance shortcomings such as low-radiance, slow-frame rates, and small-frame sizes. MWIR narrow-band emission LEDs will be optimized to produce higher in-band radiance at higher frame rates and larger frame sizes than existing technologies. Existing MWIR LED arrays produce photons over a broadband spectrum and have low photon-generation efficiency that affects spectral banded light levels and induces cross-band detection of narrow-band detectors. These issues make broadband LEDs unattractive for narrow-band detection. By contrast, a dual-band IRSP or spectroscopes incorporating two-color narrow-band LED arrays, which exhibit higher efficiency and brightness, will better match detection requirements. A collocated side-by-side two-color pixel design of a two-color LED array will allow independent electrical control of each color pixel and 16-bit continuous wave operation in a 1024 X 1024 format.

This SBIR topic will investigate two-color narrow-band LED arrays with emissions wavelengths centered for chemical sensing, sensor, or spectroscopy detection. The LED array will have a cross-talk value of less than 1% at an effective temperature of 450 K, designed to enhance the MWIR LED efficiency and brightness. Proposed approaches include designing, fabricating, and characterizing two-color MWIR LED arrays using narrow-band emission LEDs that match the in-band MWIR wavelength ranges. An electronically multiplexed LED array suitable for high-fidelity hardware-in-the-loop will have a Phase I LED array approach designed and a Phase II demonstration.

These attributes improve spatial and spectral resolution for chemical detection, IRSP, and spectroscopy applications. Improved chemical sensing and spectroscopy have applications for warfighter battlefield safety. The LED spectral bands will be determined for the warfighter's desired application. The two-color array design will include a RIIC approach with 16-bit capability. The LED will be designed for high-frame rates, low-cross talk, and variable set temperatures to improve the ability to design high-fidelity systems. These design features will improve electrical efficiency, which will improve reliability to lower lifecycle costs. This will allow the test programs to tailor flight test scenarios based on HITL test results, reduce their flight hour requirements, and improve overall test efficiency. For chemical sensing and spectroscopy, this capability will support the needs of the warfighter for the analysis and detection of biological or chemical agents. The Navy is in need of enhanced MWIR scene projectors that are smaller and lighter weight for placement on MWS HITL and flight line T & E.

PHASE I: Write a final report of the design and feasibility of a high-brightness two-color mid-wave-infrared LED array structure including the RIIC concept. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Develop a 1024 X 1024 two-color LED array structure with independently controlled pixels by a RIIC. Demonstrate a two color MWIR (3–5 µm) narrow spectral band (< 100 nm) LED array with a 300–1500 K dynamic range and 16-bit resolution and per specifications based on the research and development of results developed during Phase I for DoD applications.

PHASE III DUAL USE APPLICATIONS: The two-color IR LED array is developed for integration into two-color IR scene projector. Transition the IRSP to the Navy.
A two-color IR LED has potential application for industrial chemical sensing and safety protection. An IRSP has application for both firefighter and medical scenario training.

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KEYWORDS: Mid-Wave Infrared (MWIR); light emitting diode (LED); Infrared Scene Projector (IRSP); EO/IR; sensor; projector

N241-007 TITLE: Multi-Information Distribution System for Software Defined Radios

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software; Integrated Network Systems-of-Systems; Sustainment

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

OBJECTIVE: Research, design, develop, and test (Pilot) a Development, Security, and Operations (DSO) Pipeline for a Software Defined Radio (SDR) Capability.

DESCRIPTION: This SBIR topic will focus on process and cultural innovation for PMA/PMW-101 adopting DSO in accordance with (IAW) DoD CIO Software Factory Guidance. PMA/PMW-101 is moving towards a SDR leveraging Government and Industry Partner Third-Party Applications. The intent is to create a PMA/PMW-101 Sandbox for third-party vendors to innovate, modify, improve, and expand upon the PMA/PMW-101 Software Baseline. The project will improve and provide rigor to PMA/PMW-101's engineering support structure, governance, and technical authority to include software performance, Cyber Security, regression testing, verification, and validation.

Innovation: Implement Continuous Authority to Operate (cATO) and Zero Trust (ZT) policies into PMA/PMW-101's DSO Pipeline. Define, standardize, and implement Application Program Interface (API) IAW DoD Guidance and follow Software Acquisition Pathways. Once the software reaches the end of the DSO Pipeline, the software will be Cyber Security compliant and have minimal risk to the Fleet. Speed to the Fleet: A key aspect to DSO is pushing a low-risk, cyber secure, deployable software product to customers (i.e., aircraft, ships, etc.) for integration into their System of Systems.

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Research and develop approaches on the adoption of DSO cATO & ZT policies, Application Programming Interface (API) DoD Guidance and Software Acquisition Pathways via the following:
1. Identify PMA/PMW-101 software capabilities to transition into DSO Environment .
2. Identify DSO Environment(s) into which to transition.

3. Identify DSO Environment Tools needed with a training path.
4. Identify the process to execute DSO to include a "Sandbox".
5. Develop a transition strategy to go from "On-Premise" to the "DSO Environment".
6. Determine the feasibility of the conceptualized approaches.
The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype that is capable of the following:
1. Pilot – The identified Software Suite to transition selected capabilities into the desired DSO Environment(s) and connect/interface with other selected DSO Environments.
2. Provide PMA/PMW-101 training with regard to DSO Architecture, Engineering, Operations, Security, and Agile Project Management (i.e., Scrum, Scrum at Scale, Large Scale Scrum, etc.).

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

PHASE III DUAL USE APPLICATIONS: Connect and interface PMA/PMW-101's DSO with other DoD DSO Pipelines/Software Factories in compliance with Department of Defense (DoD) Chief Information Office (CIO) Software Factory Guidance. PMA/PMW-101 will provide Program Office funding and support to solidify cATO, and ZT Policies in their DSO Pipeline. Leverage the DSO Pipeline to include the Sandbox for rapid, secure, third-party application prototype and fielding. For example, a third-party vendor would check their software into the Sandbox, verify that the software was compatible with the baseline executable, API, Interface Control Document (ICD), and Security Checks within DoD Policy facilitating risk reduction and maturation of third-party vendor software into our Product Line. This effort saves money, time, and the amount of human resources required to adopt and field innovative products leveraging the U.S. industrial base.

Commercial DSO Environments such as Amazon Web Services and others can leverage the architecture, business rules, and interfaces developed in this effort.

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KEYWORDS: Development, Security and Operations; DevSecOps; DSO; Innovation; Continuous Authority to Operate; cATO; Zero Trust; ZT; Process Improvement; Agile; Overmatch Software Armory; Open System Architecture (OSA)

N241-008 TITLE: Oxygen Sensor for Fuel Tank Environment

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

OBJECTIVE: Develop an accurate oxygen sensor that can continuously operate in a fuel tank ullage environment with minimal maintenance required.

DESCRIPTION: On-Board Inert Gas Generator System (OBIGGS) is used to inert areas of the aircraft to reduce the risk of fire or explosions. Fuel tanks may utilize OBIGGS for both survivability and lightning protection, which require below 9% and 12% oxygen by volume, respectively. Feedback of the fuel tank ullage oxygen percentage would allow aircrew to select the proper oxygen concentration set-point for the situation, and receive feedback that the threshold has been reached. Due to requiring clean working environments, currently available oxygen sensors are not suitable for a fuel tank application. The desired oxygen sensor would be able survive in a fuel tank environment, accurately and continuously measure the oxygen concentration, maintain a small form factor, and require infrequent maintenance or repairs. The designed sensor would need to withstand the vibration loads and environmental requirements of a typical fighter aircraft flight profile, and meet the appropriate electrical criteria of a fuel tank environment. The oxygen sensor should be usable on any aircraft that is inerting fuel cells.

PHASE I: Identify the mechanism for the oxygen sensor that can withstand jet fuel and vapor. Develop an experimental bench top design to show the basic functionality and compatibility with the environment. Verify that the oxygen concentration readings are accurate in a lab setting. Develop a plan to address any technical hurdles with the design. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Produce an on-aircraft prototype of the oxygen sensor. Verify that size, power, and interface requirements are met. Perform appropriate environmental testing. Validate and demonstrate the sensor in a testing environment representative of a fuel tank.

PHASE III DUAL USE APPLICATIONS: Produce a final design that is ready for flight test. Provide documentation regarding sensor accuracy, operational limits, and failure analysis. Provide appropriate qualification documentation, including (a) environmental testing, (b) electrical testing/analysis, and (c) explosive atmosphere qualification.
Commercial aircraft fuel tanks could use oxygen sensor technology to ensure the tanks are inert. Additional applications may exist for storing commercial flammable liquids.

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KEYWORDS: Oxygen sensor; On-Board Inert Gas Generator System; OBIGGS; fuel tank; inert; oxygen; sensor

N241-009 TITLE: Adjustable Shock Absorber for Oversized Application

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

OBJECTIVE: Develop a large, adjustable shock absorber that can be tuned prior to compression in order to absorb energy and shock that varies in magnitude from one event to the next.

DESCRIPTION: The Navy requires a shock absorber that is larger in size than typical shock absorbers and that can be adjusted/ programmed to a specific setting prior to an event in order to optimize the resistance (i.e., rate of energy absorption for a given velocity and stroke position) given the expected initial conditions. This shock absorber will be required to dampen initial shock impulses and resist forces applied to it by converting kinetic energy to another form (such as heat or electricity) that can be safely dumped to the ambient environment. State-of-the-art shock absorbers are comparatively much smaller in size than required for this application. Prior research in this area of study has primarily focused on the fields of electromagnetism, and materials and fluid sciences, including rheology and tribology. However, innovative solutions leveraging other advances or developing new technologies are also welcome and encouraged. Although non-mechanical adjustment is preferred, the Navy is open to all ideas and will not limit innovation or disqualify a particular class of concepts. Many Navy and commercial applications utilizing relatively smaller shock absorbers and/or hydraulic cylinders would benefit from this technology if successful. The requirements of this shock absorber are as follows:

1. A shock absorber that is larger in size than typical shock absorbers, and that can be adjusted/programmed to a specific setting prior to an event in order to optimize the resistance (i.e., rate of energy absorption) given the expected initial conditions.
2. The shock absorber shall be required to damp initial shock impulses and resist forces applied to it, converting kinetic energy to another form of removable energy.
3. Heat must be released; electricity must be dumped/recovered.
4. The shock absorber design may include typical components, such as a cylinder, piston rod, accumulator, and check valve; or utilize a completely novel design.
5. Non-mechanical settings adjustment is preferred, but not mandatory.
6. Scalability of this technology is a desired objective.
7. The shock absorber shall satisfy all requirements in the military standards for vibration (MIL-STD-167-1A [Type 1]), shock (MIL-DTL-901E [Grade A]), electromagnetic interference (MIL-STD-461G), and environmental factors (MIL-STD-810H).
8. The shock absorber shall be operable in an industrial and marine environment.
9. Shock absorber shall fit within a space of 23 in. by 23 in. by 109 in. (58.42 cm by 58.42 cm by 276.86 cm) compressed.
10. Shock absorber stroke shall be no greater than 9 ft (2.74 m).
11. The shock absorber weight, including supports, shall not exceed 10,500 lb. (4,762.72 kg).
12. The shock absorber connects to a wire rope via multiple sheaves. Due to the nature of the application, the piston rod (or equivalent) will experience a different amount of input force and speed each time it is cycled. The velocity and force of the cable shock absorber shall be predictable in nature for set input loads.
13. The shock absorber shall be adjustable by adjusting the rate of stroke/energy absorption for low, medium, and high energy events (or with greater granularity).
14. The shock absorber shall compress during an event, and then extend to its original position after an event; this application does not call for a shock absorber that oscillates in the positive and negative directions during operation.
15. The shock absorber shall be adjustable to satisfy all specifications of the existing shock absorber operations.

16. The shock absorber shall be controllable/programmable to provide a force from nominally 0 lbf to 250,000 lbf, throughout its stroke and speed range, with a max stroke of 9 ft (2.74 m) and a speed range of 0 ft/s to 40 ft/s (0 m/s to 12.2 m/s), all while maintaining positive tension on the wire rope.
17. The shock absorber shall be controllable/programmable in its return to starting position by providing nominally 0 lb. to 35,000 lb. (0 kg to 15,875.73 kg) of force and 0 ft/s to 5 ft/s (0 m/s to 1.52 m/s).
18. The shock absorber shall provide a resistive force of up to 35,000 lb. (15,875.73 kg) indefinitely while in its starting position.
19. The tunable shock absorber shall have a minimum of 3 settings.
20. It is desirable that the shock absorber is capable of adjusting its setting within 5 seconds; however, if longer times are necessary to adjust the shock absorber setting, the setting shall be constantly maintained throughout repetitive cycles without deliberate adjustment.
21. The shock absorber shall operate within a temperature range of -13°F and 149°F (-25°C and 65°C) and withstand a storage temperature range of -27 °F and 160 °F (-33 °C and 71 °C).
22. The shock absorber shall provide functionality repeatedly for multiple cycles, at a minimum cycle time of 45 seconds, for 28 consecutive cycles in 21 minutes.
23. The shock absorber will experience cyclic loading so consideration in later phases shall be given to how repeated use will affect performance from a thermal and stress/fatigue standpoint.
24. The shock absorber shall be capable of supporting a cyclic operation sustained rate of 4,200 (Threshold)/5,600 (Objective) total cycles sustained over 30 operating days (12 hrs.).
25. The shock absorber shall be capable of supporting a surge cyclic operation sustained rate of 270 (Threshold)/310 (Objective) total cycles sustained over four (4) (Threshold)/6 (Objective) operating days (24 hrs.).
26. The shock absorber shall be capable of supporting a cyclic operation of at least 500,000 cycles within a 25-yr life without failure in fatigue.
27. The shock absorber shall be capable of monitoring and providing real-time information on the stroke position as well as the conditions of the system (e.g., hydraulic pressure and temperature).

The ability to provide dynamic control throughout the shock absorber stroke is not required.

Innovative solutions leveraging other advances or developing new technologies are also welcome and encouraged.

PHASE I: Design and develop a concept for an adjustable shock absorber that utilizes technologies that will allow it to function at the scale required for this application. Demonstrate feasibility using modeling and simulation, including 3D computer-aided design (CAD), fluid mechanics, stress analysis, control theory, and other appropriate design methodologies. Clearly explain the means by which the shock absorber response is adjusted. Full-scale designs are preferred, even at this preliminary stage, as size is considered one of the primary challenges. Subscale designs are allowable assuming the concept is scalable. A subscale design has value in that it can be used to inform creation of a physical prototype, which will be required in Phase II. If only a subscale design is provided during Phase I, supporting documentation will be required to assess whether the subscale system can be scaled-up effectively to meet requirements. Prepare a Phase II plan that includes prototype development plans.

PHASE II: Design and build a shock absorber prototype based on Phase I work. Prototype design may also include design of a system capable of subjecting the shock absorber to forces that vary in magnitude. Demonstrate the technology by performing preliminary tests that impart characteristic forces on the shock absorber. Utilize sensors and data acquisition to illustrate how the shock absorber absorbs energy/shock, and how the absorption changes when tuned to different settings. Employ iterative design, incorporating changes based on lessons learned during repeated testing. Complete the design, perform final testing, and validate that the concept meets operational needs and will work at scale. Prepare a Phase III commercialization/transition plan that includes construction of a full-scale prototype and verification against requirements.

PHASE III DUAL USE APPLICATIONS: Design, develop, and fabricate a full-scale working adjustable shock absorber based on work completed during earlier phases. Perform final testing at full-scale velocities and forces to validate and verify performance. Demonstrate adjustability by absorbing low, medium, and high energies as described.

Shock absorbers are used in countless mechanical applications in both the private sector and the DoD to attenuate unexpected shocks and in hydraulic and pneumatic mechanical control systems. The most commonly known applications for shock absorbers are in automobiles to prevent excessive bouncing when a vehicle wheel encounters a road hazard or a pothole. With an adjustable shock absorber, a mechanical control system can increase its functional range without being physically replaced, dramatically increasing the functional range of hydraulic and pneumatic control systems.

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KEYWORDS: Shock Absorbers; Hydraulics; Dampeners; Control Systems; Rheology; Tribology; Electromagnetics

N241-010 TITLE: Generalized Fragment Mass Estimation Library from 3D Stereoscopic Data

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

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

OBJECTIVE: Develop a general purpose fragment mass estimation library that complements high-speed 3D stereoscopic data for use in high-fidelity multiphysics hydrocodes.

DESCRIPTION: High Speed Video (HSV) systems (hardware and software) have evolved significantly over the past 10 years. One relatively new area of study and application involves Three Dimensional (3D) stereoscopic systems based on HSV hardware, which are then utilized to identify fragments in-flight emanating from a warhead. These 3D stereoscopic systems have been evaluated by the DoD for use in fragment characterization tests, usually referred to as “arena tests” with varying degrees of success depending on the metric of interest. Fragment position, speed, and vector information offers the greatest confidence; however, fragment mass remains an elusive parameter in such assessments. This parameter is a key measure in the U.S. Navy’s and DoD’s vision of leveraging advanced diagnostics, and the data generated from these, in the calibration of High Fidelity Multiphysics hydrocodes currently in use. Given these challenges, there is a need for innovative engineering solutions that allows the U.S. Navy and the DoD to bridge the last data gap related to 3D stereoscopic HSV systems by creating a general purpose fragment mass estimation library for use in high-fidelity codes.

Solutions (e.g., General Purpose Mass Estimation Library) must be able to leverage the 3D stereoscopic raw data independent of intrinsic hardware used. Additionally, the solution must generate verifiable and validated fragment mass data from said 3D stereoscopic raw data. The solution must work for all possible types, namely natural (e.g., random shapes), pre-scored and preformed fragments, as well as multiple materials such as—but not limited to—steel, aluminum, titanium, or tungsten compositions. The solution must be able to create accurate mass assessment for fragments in the range of 10 to 2500 grains, traveling at speeds ranging from 500–9000 ft/s (152.4–2743.2 m/s). Mass estimate generated from the solution must be calibrated to have uncertainties less than +/- 4% for fragments at 2500 grains, and less than +/- 20% for fragments at 10 grain levels (e.g., Mass Estimate threshold) from verifiable and validated data source(s). Based on this, the mass tolerance threshold would follow a linear relationship (e.g., Mass Tolerance Threshold [fragment mass, in grains] = 0.0394 * fragment mass + 1.604, Mass Tolerance Threshold has units of grains as well).

Verifiable and validated data sources for calibrating the proposed solution may be, but are not limited to, experimental or other empirical datasets, including any other representative Modeling and Simulation (M&S) techniques. Calibration must be performed at laboratory scale to include full mass scale. The solution may leverage precomputed data/regressions and/or any Machine Learning (ML) techniques. If ML techniques are utilized, open source tools/methods must be leveraged to the greatest extent possible. As part of the solution, a verification and validation package on the general purpose mass estimation library must be created along with any other required SBIR reporting, allowing full transparency to Subject Matter Experts (SME) in the U.S. Navy and DoD.

The solution must be able to generate mass estimates within seconds on a per fragment basis and within minutes for an entire populated 3D stereoscopic raw data set potentially consisting of thousands of fragments. The solution must have an appropriate and well-documented interface or Application Programming Interface (API) if relevant, so that other software tools may be able to leverage it effectively. The solution must be compatible with use inside modern Operating Systems (OS) such as Microsoft Windows and Linux. The solution must provide clear text data output consisting of estimated mass, as well as any ancillary graphical depiction of the post-processing results including statistical uncertainties in output values.

PHASE I: Identify and evaluate potential technologies/methodologies applicable for the solution. The feasibility study may include limited/initial lab scale test or M&S efforts that help provide grounding to a proposal/study. A preliminary design of the general purpose library and methodology will be performed that includes identification of current/future resources in the form of existing software packages and/or empirical or M&S datasets. Create (1) a preliminary engineering development plan that includes an evaluation of potential numerical/ML methodologies, calibration plans, and testing program needed and (2) a preliminary post-processing and analysis plan for the general purpose library that includes the proposed analysis/computational logic flow needed in order to meet the mass estimate uncertainties across the range of parameters indicated. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a working prototype. Demonstrate the prototype, including applicable testing of any post-processing features, and with laboratory scenarios/data including full scale scenarios, with comparison of the output data and associated uncertainties. Proposed solution must demonstrate capability for expansion in light of new test or M&S data enhancing the verification and validation package. Integrate the solution into a larger software package as directed by the Government or provide technical support in the event that the Government integrates it. Deliver source code, binaries, libraries, trained ML, verification and validation package, design specifications, configuration and user's manual for Government evaluation. Provide technical support for Government use of prototype libraries within a larger Community of Interest of Subject Matter Experts (SMEs).

PHASE III DUAL USE APPLICATIONS: Transition the updated solution to the U.S. Navy. Receive feedback from users and perform/release updates addressing feature requests and bug fixes. Enhance the text and visual capabilities per user feedback along with the verification and validation package expanding into further fragment ranges. Provide continuing technical support for Government use of libraries within a larger Community of Interest of SMEs. Update the technical report and user's manuals as required.

Commercial applications involve DoD contractors supporting the Tri-Service community, the Department of Homeland Security, the U.S. Coast Guard, the FBI, and other Government Agencies interested in fragment/debris flyout. Additional interest in this technology includes, but is not limited to, the motion picture industry, chemical manufacturing, the oil and gas industry or any other organization that utilizes high-pressure vessels, and is concerned about accurate characterization of flying debris or fragments from industrial accidents.

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KEYWORDS: munitions; warhead characterization; fragments; mass estimation, hydrocodes; Machine Learning

N241-011 TITLE: Generative Artificial Intelligence for Scenario Generation and Communications Analysis

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

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

OBJECTIVE: Develop the capability to rapidly generate high threat density scenarios with tactically representative red (adversary) threats that adapt in real time. Additionally, this effort will develop the capability to conduct automatic analysis of blue (friendly) communications to understand speed and accuracy of information exchange.

DESCRIPTION: As the carrier airwing of the future prepares for the high-end fight, the training paradigm will shift to almost exclusively Live, Virtual, Constructive (LVC) environments due to expanded range capabilities of the peer threat competitors and Operations Security (OPSEC) considerations. As a result, warfighters are able to train as they fight with higher fidelity scenarios that more accurately represent red kill chains. This high-fidelity, data rich environment provides unique opportunities for instructional strategies to better support end-to-end training and improve readiness. Specifically, LVC environments increase the amount of—and access to—data that can support improved scenario generation, performance assessment, and debrief when utilized appropriately. However, LVC training is not without its challenges. These challenges include resource requirements to develop these high-fidelity scenarios as they can be cumbersome and labor intensive. Moreover, scenarios that do not contain significant variations may lose utility very quickly as operators can begin to anticipate scenario outcomes after a few exposures. Consequently, a need exists for rapid generation of real-time, adaptive, high-fidelity scenarios. Additional challenges lie in the assessment of performance. The carrier airwing of the future will rely on integrated tactics that require a level of coordination and information exchange across platforms that have not been required in past tactics. The complexity of coordination associated with integrated tactics necessitates a significant amount of voice communications across the different platforms to provide Situational Awareness (SA) and elicit decision-making. While communication is critical to cross platform coordination and overall tactical execution, it remains one of the most challenging training objectives to meet during Air Defense events.

As such, this effort seeks to alleviate identified challenges with scenario generation and performance assessment through the investigation of generative artificial intelligence (AI) (e.g., DALL-E, ChatGPT) or other forms of AI to support scenario generation and communications assessment. This SBIR effort shall focus on utilizing AI to learn from pilot-in-the-loop red threat behavior to rapidly generate constructive threat presentations that adapt to trainee behavior in a tactically feasible manner. Additionally, AI shall be applied to further the state-of-the-science in communications analysis [Ref 6]. Specifically, AI shall support analysis of blue recorded communications and provide an initial assessment in terms of accuracy of the words said (relative to ground truth) and speed at which they are said. This analysis will include digesting communication recordings, assessing quality of communications-based accuracy and speed, and then providing these results via automated debrief.

These capabilities will improve the quality of training and readiness via end-to-end training enhancements. First, high-fidelity Air Defense scenarios that can be rapidly generated and are adaptive will yield greater training utility and provide cost avoidance associated with scenario development manpower and human-in-loop threat support manpower. Next, development of a communications analysis and debrief capability will improve SA, and decision making will benefit the Fleet by decreasing instructor workload, reducing human error and manpower time requirements, and automatically provide instructors with information on communication protocol adherence and timeliness to improve SA and increase debriefing capabilities.

This effort will specifically look at Air Defense training scenarios within LVC environments to increase speed at which high-fidelity, adaptive scenarios can be generated and assessed to enhance operator performance. This capability will be developed with the intention of a transition path to the Next Generation Threat System (NGTS).

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Research and develop an integration plan for development of a proof of concept, standalone, capability to rapidly generate high-threat density scenarios with tactically representative red threats that adapt in real time. This will include investigating unclassified sample data to determine appropriate AI models for future development. Additionally, Phase I will focus on identifying the most appropriate AI model or models to support automatic analysis of blue communications based on accuracy and speed results. An unclassified sample dataset will be provided to help support this investigation and to understand speed and accuracy of information exchange. Both objectives will use generative or other forms of AI. Performance assessment should focus on communications but may also include tactical assessments. Noise filtering shall be investigated to support communication analysis as the noise content in the operational environment for Air Defense is significant.

Demonstrate the feasibility of application into the larger, integrated training system. The plan shall detail integration into NGTS to allow for transition into an operational LVC environment. Additionally, the plan shall include a Subject Matter Expert (SME) evaluation of capabilities and methods for conducting an Analysis of Alternatives to identify best practice method moving forward for training delivery.
Provide prototype plans to be developed under Phase II.

PHASE II: Research, develop, design, and deliver a proof-of-scenario generation and communication assessment capabilities for Air Defense training scenarios through execution of the integration plan developed in Phase I. During Phase II, the sample data provided will be more tactically and operationally relevant and classified at the SECRET level. Developers can expect the scenarios to be more tactically complex, have larger amount of communication, and communications will include significant background noise. Noise will include, but is not limited to, background noise (engines, alerts, etc.), static, and the like. Integration with NGTS will enhance the capability with scenarios and performance data already resident in NGTS. Design and develop the tool to include visualizations, usability documentation, and technology evaluation. Demonstration of the tool, along with documentation of usability of the training software is critical. Risk Management Framework guidelines should be considered and adhered to during the development to support information assurance compliance.

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

PHASE III DUAL USE APPLICATIONS: Introduce additional data from NGTS as well as other Live-and-Virtual entities within the scenario. Scenario generation shall be enhanced to include external (live and/or virtual) entities. The AI implementation should account for any differences or effects external entities may have on the AI model. The voice communication assessment capabilities shall be flexible as to be deployed in varying training configurations. Training locations may differ in their setup of radios and networked communications, which will require easy and configurable settings and controls. Integration testing and demonstration of capabilities will be conducted in a distributed simulation via Distributed Interactive Simulation (DIS) protocol at the SECRET level. Software shall be integrated with NGTS to facilitate transition into operational LVC environment. Documentation and any supporting materials shall be delivered to NGTS team for maintenance and future enhancements.

The AI voice assessment model can be leveraged in the private sector as a speech-to-text model in environments with high noise or when non-standard English speech is in use, such as the brevity communications made during a tactical aviation scenario. Most AI speech models are trained with common English phrases. The data and voice communications from the tactical aviation domain will provide more robust speech-to-text analysis for the private sector in areas such as air traffic control or brevity communications training.

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KEYWORDS: Artificial Intelligence (AI); Scenario Generation; Communications Assessment; Voice Analysis; Live, Virtual, Constructive; Automated Debrief

N241-012 TITLE: Real-Time Thrust Control of Solid Propellants

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

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

OBJECTIVE: Develop technology to throttle a solid propellant rocket motor where a rocket motor can be fabricated, and the performance (thrust/time) can be selected at ignition or modified during motor operation, allowing for smart/networked weapon systems that can also fill multiple warfighter needs and respond to evolving threats.

DESCRIPTION: Currently, solid rocket motors are designed to achieve a specified thrust profile based on a detailed analysis of assumed mission needs. Over the course of many years and significant investment, the solid rocket motor is designed, tested, and qualified to achieve this predetermined thrust profile. Thus, when a new missile enters the field, there is a precisely known thrust profile and capability; however, this limits the system to specific and planned threat engagements. Changes to the specified thrust profile result in costly grain redesign and requalification. As new gaps are identified, new missiles are developed to fill those gaps. This increases the number of boutique missiles the military must now manage with the associated logistical footprint.

This SBIR topic seeks to develop a solid propulsion system technology that allows for modulation of thrust at time of launch or during flight to optimize missile performance relative to real-time mission objectives. Real-time thrust control of solid propulsion is a game-changing technology that has the ability to enable collaborative munitions where in-flight missiles can be redirected and throttled to engage evolving threats. Throttleable solid propulsion will also allow for mission flexibility or multi-payload, single-motor capability. When a single system is able to support multiple roles, the need for new boutique systems is reduced, as are the associated development costs.

Thrust control of solid propellants has been demonstrated to varying degrees with technologies—including pintle nozzle—to control the nozzle throat area [Ref 1], high-pressure self-extinguishing propellants [Ref 2], pulsed motors [Ref 3], and electrically-activated propellant [Ref 4]. Some of these technologies are currently utilized in fielded rocket motors because of their ability to control thrust, but their use is very system specific and their thrust control is limited. This topic seeks new or evolved approaches to thrust control of solid propulsion systems. The technology may be complimentary to other thrust control solutions to build a more dynamic overall system.

The objective of this topic is to develop a technology that can create effects on an energetic system to allow for the variation of thrust/time within a rocket motor. The developed technology should maximize compatibility/usage of existing rocket motor materials (propellant oxidizers and binders, insulation, liners, motor cases) and existing industry fabrication methods, as well as leverage industrial best-practices and minimize transition hurdles. The technology needs to minimize the size and weight impact on the rocket motor as gains in flexible energy management can be lost to parasitic weight. Additionally, the technology needs to have a path to be usable in the challenging thermal (-65 °F–150 °F) (-53.9 °C–65.5

°C) and mechanical environments (shock/vibe) required to enter military usage. Hardware and software required to integrate with the technology also needs to be considered as the technology matures.

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Identify and design a concept for real-time thrust control of a solid propellant rocket motor. Outline how the concept works (how and where effects are placed on the rocket motor to modulate thrust) and identify the individual components needed for insertion into a rocket motor. Maturity of the individual components will be assessed relative to the development needed for use in a solid propellant rocket motor. A notional system will be developed to demonstrate the bounds for thrust control. Lab scale testing and/or analysis will be performed to demonstrate the feasibility of the concept's ability to control rocket motor thrust. Testing may or may not include energetic material. Prepare a report outlining the findings of Phase I plus a technology maturation plan for Phase II. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a Phase II series of prototype rocket motors for evaluation. The prototypes will be used to evaluate the ability to achieve a wide variation of thrust/time profiles from identical motors. The prototype rocket motors will all be identical in design and materials (propellant, nozzle dimensions, igniter, etc.), so that testing can be done on any motor to achieve the desired thrust. The motor size will be based on the capability of the small business, but the propellant grain will not be smaller than 2 in. diameter X 4 in. length (5.08 cm diameter X 10.16 cm length). Pretest ballistics will be performed for each test to determine the thrust/time profile. The thrust/time profile will be preprogramed before each test. Post-test comparisons will be conducted to update models and ensure the prototypes are performing in a reasonably predictive manner. The intent is to demonstrate four different thrust/time profiles from identical prototype rocket motors. During Phase II, the sub-components will be identified and tracked for maturity. A final report will be provided that outlines the prototype design, fabrication, and testing. The report will also outline the less mature aspects of the technology and provide a plan to further mature the technology in Phase III.

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

PHASE III DUAL USE APPLICATIONS: Mature the thrust control technology, based on the results of Phase II, for higher fidelity static fire demonstrations. The developed rocket motors will be flight representative with subcomponents fitting into the cylindrical rocket motor (motor case and nozzle can be heavyweight if required). It is still allowable to have an external control unit to modulate the thrust. Demonstrate two static firings of identical rocket motors with different thrust/time profiles. Provide a final report that documents the design and testing results, includes a Technology Readiness Level (TRL) assessment, outlines the volume and mass requirements for a thrust-control system in a tactical missile, and outlines a path to further mature the technology.

The development of solid propellant thrust control would have applications to space-based systems including launching of satellites and satellite maneuvering.

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KEYWORDS: Solid Propulsion; Thrust Control; Throttling Propulsion; Energetic Material; Rocket Motor; Smart Munitions

N241-013 TITLE: Multi-target Bayesian Tracking for Air Anti-Submarine Warfare (ASW) Systems

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

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

OBJECTIVE: Develop a Bayesian tracker for Air Anti-Submarine Warfare (ASW) systems to improve tracking metrics when multiple targets (or target-like objects) are present in wide-area search missions.

DESCRIPTION: Future Air ASW missions will cover larger areas than currently fielded systems and must operate in scenarios with multiple targets and surface ships, including: finding a single submarine in regions of high surface ship traffic (fishing fleets and shipping lanes), detecting multiple adversary submarines that are closely spaced and following similar paths (wolf packs), or coordinating search activities with U.S. Navy surface ships and submarines. Improvements to track initiation and measurement association are necessary to maintain reliable system performance in these challenging scenarios.

Currently fielded track-before-detect approaches assume that a single undetected object such as a submarine, surface ship, or persistent clutter object, may be in the field at any given time, and as a result, performance is degraded when multiple objects ought to be promoted to contact followers at once. In addition, single hypothesis tracking can lead to confusion for low Signal-to-Noise-Ratio (SNR) targets with a significant number of clutter detections inside typical association gates. In the difficult association situations described previously, where tracks may cross or converge, the need for innovative approaches to the association problem are even more necessary. Advances in Bayesian tracking techniques have been developed to address these problems, even in the presence of substantial stationary clutter.
Successful approaches to the multi-target tracking problem will initiate contact followers when multiple targets (or target-like objects such as surface ships) are present in the field, and maintain track integrity when multiple tracks are temporally and spatially close (within the area of uncertainty of a single measurement).

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating

Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Design and develop an approach which reduces track initiation time by 30% when multiple objects are detected near the beginning of a mission which currently takes up to 10 pings. Show the proposed approach reduces false associations by 25% versus nearest-neighbor association when multiple targets are within the area of uncertainty of a single measurement. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop prototype multi-target tracking software. Demonstrate that the software prototype reduces track initiation time by 50% and reduces false associations by 33% in at-sea data.

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

PHASE III DUAL USE APPLICATIONS: Integrate the algorithm into the fleet-approved system for the Aircraft. The technology could be used in any field where Geo tracking is necessary. These technologies include Maritime tracking, Aircraft tracking, or Surface traffic tracking.

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KEYWORDS: Bayesian; Anti-submarine Warfare; ASW; Tracker; Multiple Targets; Clutter; Probability

N241-014 TITLE: Non-Destructive Evaluation for Corrosions/Defects of Naval Air Vehicles

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

OBJECTIVE: Develop an imaging system suitable for in-situ detection of hidden corrosions/defects in naval air vehicles.

DESCRIPTION: The deleterious consequences of fatigue and fracture in metallic structures arising from local microstructure, mechanical loading, thermal effects, and the corrosiveness of the maritime environment, usually lead to corrosions/defects of aircraft landing gears or other naval aerial platform surfaces. At the burgeoning of the corrosion/crack/fracture/damage, the damage areas are underneath some kind of protective coating or paints and therefore render conventional visible early inspection and evaluation ineffective. Early detection of the corrosion and related defects is critical, as it would reduce the remediation cost, improve the operational safety, and minimize mission downtime of fielded assets. Traditional methods for detecting corrosion defects are inefficient, and involve costly removal and replacement of the coatings and paints for visual inspection of the underlying surface. Removal and replacement of these polymer or painted sections involve costly operations in terms of labor and materials costs.

This SBIR topic seeks a solution of non-destructive evaluation (NDE) of hidden corrosion underneath paints or polymers. Corrosion of aluminum alloys generally develops as pitting or thinning, and in general changes a nominally smooth surface to an uneven and irregular surface, which can then result in cracking. The detection of this type of corrosion is not within line of sight. The detection of corrosion on aluminum formers that are under composite skins without disassembly would be very beneficial. Inspection through top coats would be ideal. The proposed solution should be able to detect defects with sizes greater than 0.005 in. (0.0127 cm) on a curved surface with a radius of curvature 2 in. (5.08 cm) radius or less. The proposed solution should be able to detect fastener corrosion. The proposed method should also detect corrosion on fastener threads without the need for disassembly.

This SBIR topic focuses on development of technologies that will image corrosion and defects through coatings and paints rapidly enough to support a sampled or completed NDE of an aircraft. The system should be portable that weighs no more than 12 lbs. (5.44 kg), be capable of expected constant system mobility without need for recalibration more than once annually, and sufficiently robust for operations under harsh maritime environmental conditions. The system needs to be in compliance with all FCC regulations. The preferred system prototype solution should yield detection results as close to real time as possible, and be equipped with a graphical user interface that is easy to use and understood by an operator with relevant training. It is also expected that any proposed system should have built-in wireless capability that can send imaging data to a remote user system for further detection analysis and evaluation.

PHASE I: Develop an imaging system with the capability to meet the operational, frequency, SNR, minimum corrosion/defect size, minimum paints/coatings thickness, and graphical user interface and wireless transceiver as stated in the Description. Detection of a defect is defined as the ability to accurately distinguish the defect from surrounding regions that do not contain the defect, and display the location and size of the defect in a graphic user interface. Demonstrate the feasibility of the concept to detect the aforementioned hidden defects via modeling and simulation. Concept feasibility will be supported by appropriate analyses and laboratory experiments. Provide a Phase II development plan that includes performance goals and key technical milestones. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype suitable for evaluation. Evaluate the performance of the prototype with regard to the goals defined in Phase I on a Navy provided test panel that is equivalent to testing on an in-service Navy asset under similar field conditions. Based on the initial results of the evaluation, refine the prototype and demonstrate that the final prototype meets the performance specifications stated in the Description. Deliver the final prototype at the end of the Phase II that is ready for field testing by the Navy.

PHASE III DUAL USE APPLICATIONS: Transition the technology into a system that can be acquired by the Navy. The Phase III plan should include testing, validation, certification, and qualification for Navy use.

With the ability to inspect aluminum material/structure under polymer and paint, this will provide the private sector with new instrumentation for detecting degradation of aluminum material. This instrumentation will certainly improve the maintenance of commercial aviation assets.

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KEYWORDS: Nondestructive Inspection; NDI; Corrosion detection; aluminum formers; fastener corrosion; imaging corrosion; Al corrosion

N241-015 TITLE: Enhanced Emissivity in High-Speed Window Materials

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

OBJECTIVE: Identify and develop methods to enhance the emissivity of sensor window materials capable of surviving high-speed flight environments.

DESCRIPTION: Weapons technology advancement has been driving missile systems to strive for greater speeds, ranges, and accelerations; all of which put much greater thermal and mechanical stresses on the system. Often the weak link in these designs is the sensing aperture, whether it be an Electro-Optic/Infrared (EO/IR) window or a Radio Frequency (RF) radome. In addition to being a structural material, these must also be transparent within the relevant wavebands, and maintain this transmission throughout the flight. This limits material choice significantly, and forces performance trade-offs to survive the high enthalpies.

Over the duration of a flight profile, transient heating of a window typically involves an energy balance of convective heat transfer, radiative heat transfer and conduction between the window, the external environment the weapon is flying through, the internal environment of the weapon, the weapon structure the window is attached to and the radiative exchange between the window and both the external and internal environments. The majority of the flight profile results in a strong convective aeroheating input into the window with some periods of aerocooling where the window is hotter than the surrounding recovery temperatures. As the window rises in temperature, radiative heat loss to both the external and internal environments also occurs. As the window temperature gets hotter, the magnitude of that radiative heat loss increases by a factor of temperature to the fourth power and at higher temperatures can result in equilibrium temperatures hundreds of degrees cooler than without the presence of radiative heat loss. Heat removal due to convection is limited in effectiveness due to the flight speeds involved and the negative effects of relying on internal convection to sink heat to the interior of the weapon. Enhancing the conduction of windows is limited in effectiveness without unintentionally altering the electromagnetic properties; plus the structural attachment location of the window is at similar temperatures, preventing the needed thermal gradient to conduct heat away into those surrounding structures. Radiation, however, is different; while the distribution of energy "available" to be radiated is simply a function of temperature (known as the blackbody curve), each material has its own emission spectrum, which describes at what wavelengths energy can be emitted. There is often, and in the case of IR windows necessarily, a gap in which the material cannot emit radiation. If part of the blackbody curve lies within this gap, that energy cannot be radiated, and as such can't contribute to cooling the window.

This is particularly a problem for IR windows, which rely on this gap in order to function. The typical mid-wave IR (MWIR) band is from 3–5 µm, meaning there can be little to no emission within these wavelengths, and typically not much below this as well. Even at the relatively low temperature of 500 °C, nearly 50% of the available energy lies between 1 and 5 µm, where essentially no emissions are expected to occur. This only gets more significant as temperatures climb and the blackbody curve shifts to shorter wavelengths.

If even narrow emission peaks could be engineered at shorter wavelengths, without interfering with the desired transmission window, it could increase energy dissipated through radiation drastically. At 1000 °C, a half micron band centered around 2.25 µm contains 15% of the energy available in the entire spectrum, roughly the same as all emission above 6 µm (which is about where state-of-the-art MWIR windows begin emitting). If this unused energy can be taken advantage of, the range of environments a window could operate in could be greatly expanded, and with it the mission space and possibly the performance of the system as a whole. A similar approach was used on the space shuttle, with the black tiles on the bottom used to maximize emissivity; it just didn't have the complication of needing to be a functioning aperture.

A successful project would produce a set of test articles demonstrating a significant increase in emissivity while maintaining transmission characteristics at high temperatures (> 1000 °C for IR materials, > 1250 °C for RF materials) within the chosen waveband (MWIR, X-Band, Ka-Band, etc.). The test articles must also demonstrate resiliency to stresses which would be encountered in high-speed flight. Testing for this may vary depending on the proposed solution, but may include: high high-temperature mechanical tests, thermal shock tests, electrical tests, arcjet/plasma torch testing, and microstructural examinations.

PHASE I: Develop a process/material that demonstrates significantly increased emissivity of the chosen window material without degradation of transmission in the relevant waveband. Show that the concept can feasibly meet the requirements of high-speed flight through analysis, modeling, and/or characterization of materials of interest. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and deliver notional full-scale prototypes (minimum of two) that demonstrate functionality under the required service conditions, including thermal and mechanical stresses. Produce sufficient test samples for material characterization efforts to show viability for high-speed flight as described in the Description section.

PHASE III DUAL USE APPLICATIONS: Work with a program office to produce a system-applicable window. Participate in qualification testing equivalent to the system, including environmental and hypersonic wind tunnel testing.

There have been some recent efforts looking into controlling emissivity to provide efficiency increases in thermophotovoltaic power generation, which this could possibly feed into. Space applications are also possible, as the only way to dump heat in a vacuum is through radiation. There could be some niche private sector applications, which utilize high-temperature windows as well, but unless commercial high-speed travel grows, this market is limited.

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KEYWORDS: Window; Aperture; Hypersonic; Emissivity; Infrared; Radome

N241-016 TITLE: Frost Icephobic Coating for Subfreezing Environmental Control Systems (ECS) Components

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

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

OBJECTIVE: Develop an icephobic coating that mitigates frost formation on downstream heat exchangers inside an Environmental Control System (ECS) environment for extended periods of time with minimal maintenance required.

DESCRIPTION: Unconstrained thermal operations for an aircraft is driving integrated thermal management designs. Condenser icing is a limitation for an aircraft air conditioning system using a high-pressure water separator to remove moisture from cooling air.

Inside the aircraft's ECS, frost can occur downstream of the Air Cycle Machine's (ACM) turbine outlet where the turbine expands the air and drops the temperature. Most ECSs are open loop in design, allowing moist air into the system, and that moisture can reach the turbine outlet cold area. To mitigate that moisture impact, high pressure water separators are utilized to remove the majority of the humidity. In addition, hotter air (trim air) is routed at the turbine's outlet to the condenser heat exchanger to prevent the temperature from going below freezing (example 35 °F–40 °F [1.67 °C–4.44 °C] as the controlled temp) [Ref 2]. This trim air wastes overall bleed air and limits the overall cooling capacity of the ECS due to the temperature regulation above freezing. The reheating and cooling of the bleed air in the water extraction process is carried out in a cross-flow plate-fin or tube heat exchanger called the condenser. The condenser causes water droplets to form on the hot side fin surfaces from the process of heat transfer from a cold side air/fluid stream. Frost can form on the cold side due to less than 100% water separation. On the hot side, frost can form due to bleed air cooling below its dew point during certain flight conditions [Ref 2]. Ultimately, frost buildup leads to ice accretion shedding, increasing pressure drops affecting the ACM performance, and greater thermal resistance [Ref 2]. Newer ECS designs (subfreezing condensers) aim to eliminate more moisture and mitigate icing from forming quickly on components downstream of the turbine's outlet. However, even lower temperatures lead to quicker frost formations on the condenser exchanger and duct interfaces.

The simplest approach to mitigate these frosting issues is to design fin surfaces that prevent frost formation in the first place. Such an approach can be accomplished by encapsulating target surfaces with an icephobic (ice resistant) coating. The difficulty in mitigating ice and frost in subfreezing temperatures using icephobic coatings/surface treatments is that fast impinging moisture freezes very quickly, penetrating the coating microstructure and locking/anchoring the ice in place. In addition, icephobic coatings are typically used to facilitate ice shedding, but this SBIR topic seeks surface treatments that can prevent condensed droplets from freezing into ice in the first place. New or alternate icephobic coatings/surface treatments for heat exchanger geometries that could potentially eliminate frost growth by preventing freezing of condensed water or direct deposition of water vapor to ice crystals on the surface is the primary goal of this topic. Metrics for performance will include water condensation rate, decreased frost onset time, and reduced frost thickness.

PHASE I: Demonstrate the feasibility of the proposed formulation for the icephobic coating/surface treatment to minimize ice formation in heat exchanger/condenser components that are inside the ECS. Identify the anticipated merits of the preferred solution related to thermal performance, manufacturing, installation, durability, and cost. Develop a plan to address any technical hurdles with the coating/surface treatment. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Fully develop and analyze the selected Phase I solution for a range of condenser environments and frost icing conditions. Develop subscale and/or full-scale hardware to demonstrate the selected approach for a representative heat exchanger geometry and establish the technology and manufacturing readiness level.

PHASE III DUAL USE APPLICATIONS: Produce a final icephobic coating/surface treatment that is ready for primary applications in advanced military fighter aircraft and possibly future commercial applications. Provide documentation for icing and ECS operational limits. Provide appropriate qualification documentation for environmental testing.

The icephobic coating technology could be used on commercial aircraft ECS. Additional applications may exist for naval refrigeration applications.

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KEYWORDS: Icephobic; coating; heat exchanger; icing; frost; condenser

N241-017 TITLE: Speedy UAV Swarms Detection, Identification, and Tracking using Deep Learning-Based Fusion Methodology for Radar and Infrared Imagers

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

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

OBJECTIVE: Develop and demonstrate an innovative deep learning-based fusion methodology for speedy radar and infrared cameras that can effectively detect, identify, and track unmanned aerial vehicle (UAV) swarm with high probability of detection and low probability of false alarms in the best overall track accuracy within the processing and time constraints availabl.

DESCRIPTION: The use of UAVs of various sizes and shapes is growing very rapidly for a wide variety of defense, commercial, and other applications. Along with their advantages in ease of operation and low cost, the widespread availability of UAVs has posed significant security threats in both defense and civilian arenas. As part of the effective UAV threat mitigations for the DoD, it is first necessary to be able to detect and identify UAVs in the airspace in a timely manner before UAV interdiction strategies can be executed arenas [Refs 1-3]. Straightforward adoption of currently fielded airspace surveillance technologies will not suffice as UAVs are much smaller in physical size and fly at lower altitudes. Furthermore, recent advances in UAV technology have enabled the capability of large swarms of UAVs flying together in either uncoordinated or coordinated groups. These UAV swarms with continuously growing swarm sizes pose an even more serious and emerging threats to the Navy forces, assets, and installations. These UAV swarms pose additional challenges to counter them over that posed by dealing with UAVs one or two at a time. In fact, there are reports that suggest that the Chinese military is strategizing attacking the U.S. aircraft carrier battle groups with swarms of multi-mission UAVs during a conventional naval conflict [Ref 4]. Many target detection and tracking systems rely on passive medium wavelength infrared/long wavelength infrared (MWIR/LWIR) thermal infrared cameras. LWIR camera in particular offers unique advantages and their performances are not adversely degraded from scattering by water-based aerosols, snow, rain, fog, and clouds in the atmosphere. However, it is still challenging to detect and identify small UAVs using IR imagers alone due to the low contrast in the thermal imagery, especially in environments cluttered with background noise. The various growing configurations of current and emergent UAVs and growing threats of UAV swarms, make a single optimized sensor solution in a timely fashion impractical and ineffective. The breadth of this UAV swarm threat is both wide in scope and deep in complexity. It therefore warrants a more capable solution tailored for different circumstances. To maintain a more robust situation awareness and to provide much improved protection for naval assets and forces against current and future UAV swarm threats, it is therefore logical to consider a speedy counter UAV swarms system comprising of a suite of multiple sensors with different modalities [Ref 4].

It is the objective of this SBIR topic to develop sensor fusion methodology from phased array radar system [Ref 5] and MWIR/LWIR infrared cameras to combine data from different and orthogonal modalities to generate inferences that would not be possible from a single sensor alone. To deal with a large swarm of targets, a phased array radar system can steer a narrow beam quickly to identify and target multiple targets in multiple directions simultaneously without having to physically move the system, as opposed to a spinning antenna from a legacy radar system. The target scope of data fusion from multiple sensors is to achieve much more accurate and faster results in UAVs detection, identification, and tracking than those derived from single sensors, while compensating for their individual weaknesses. Fusion of multiple sensors in a UAV swarms target acquisition and cueing system requires managing, interpreting, and analyzing a large set of heterogeneous input data. It is also expected that the sensors fusion and the detection/tracking algorithm would enable the detection, identification, and tracking of the UAV swarm in a matter of a few seconds instead of minutes. The low system latency of detection/identification/tracking of swarms of increasing UAV numbers is particularly critical in combat scenario to allow sufficient time to counter the threats. Recent advances in deep learning presents the ability to manage diverse and complex data. In particular, deep learning technique enables learning relationships between dissimilar input signals, such as the behavior pattern and relationship of the UAVs within a swarm. Multi-sensor learning is capable of understanding in detail real-world problems, as well as filling the missing or corrupted sensor data. Deep learning-based algorithm combined with multiple sensors for counter UAV swarm application has never been developed before for low-latency target detection and tracking. In order to exploit the advances in LWIR/MWIR imaging, radar systems, and deep learning, the Navy is seeking an innovative, game-changing approach in this application of deep learning on multi-sensor data fusion and exploitation system for accelerated UAV swarm detection, identification, and tracking.

Fusing tactical data from radar and infrared cameras poses significant challenges due to the diversity and complexity of the data, for example track count, accuracy, update rates, and uncertainty. The data sources often have different formats, resolutions, and phenomenologies, making it difficult to correlate the data accurately. Additionally, the tactical data can be affected by external factors such as weather, environmental conditions, and UAV swarm movements, which can lead to misinterpretation or misclassification of the data. Fusion algorithms must be able to handle these challenges and effectively fuse the tactical data to provide a reliable, real-time view of the UAVs swarm with the following performance:
First, the system must be able to ingest data from radar and infrared cameras in real time or near-real time, while maintaining data quality and consistency.
Second, the system must be able to normalize the data to ensure consistent data models, allowing for accurate correlation and temporal and spatial fusion of the radar and infrared camera sources.
Third, the system must be designed to handle the challenges associated with radar and infrared camera data, including different formats, resolutions, and phenomenologies. Due to differing collection footprints and inconsistent collection overlap of radar and infrared cameras processing their individual data and focusing on information level fusion (e.g., knowledge graph fusion) is acceptable.
Fourth, the system must be able to provide decision makers with a clear, accurate, and actionable view of the UAV swarm, improving classification confidence, and enabling effective decision-making with: (a) a probability of UAV swarm detection-to-track more than 90%; (b) a classification accuracy of more than 90% across the set of UAV swarms when only trained on simulated data; (c) a probability of false alarms less than 10% at the UAV swarm detection range up to 10 km; (d) common atmospheric obscurants reducing the visible transmission coefficient at UAV swarm detection distance down to less than 10% relative to that in vacuum; (e) the UAV swarm appearing a couple of pixels wide in a dim setting; (f) techniques to automatically analyze the data associated with UAV swarm tracks, hypothesize, and make ID classification over processed spatial resolutions of 2–70 cm/pixel; and (g) a deep-learning model and the algorithm having a provision that allows a growing library of current and future-generation UAVs.

PHASE I: Design, document, and demonstrate feasibility of a robust deep learning-based algorithm for a fusion system of radar and MWIR and LWIR cameras of the developer’s choice that meet or exceed the requirements specified in the Description. Identify the technical risk elements in the detection, identification, and tracking algorithm design for a UAV swarm of over 10 UAVs and provide viable risk

mitigation strategies. Demonstrate the feasibility of the approach utilizing commercial off-the-shelf (COTS) computer for the algorithm to perform at a 5 Hz or higher solution rate.
The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop, optimize, demonstrate, and deliver the fusion algorithms developed in Phase I for the selected system of radar, MWIR, and LWIR sensors for this project. The designs will then be modified as necessary to produce a final prototype. Work with the government team to test the algorithms against data collected from candidate sensors relevant to the Navy. Pertinent information will be provided to the awardee if necessary. Collect relevant training and testing data using contractor-provided UAV swarms of interest with at least 10 UAVs to validate their performance claims. Illustrate how the technology can be successfully expanded for detection, identification, and tracking of a UAV swarm of 20 to 50 UAVs against the aforementioned atmospheric and range conditions. Besides the algorithms, deliver all developed tools and data to the government.

Implement algorithm prototypes in a realistic environment that enables thorough testing of algorithms. Incorporate applications to support testing, for example, operator displays and decision support systems. Demonstrate and validate algorithm's effectiveness. Deliver an algorithm description document, engineering code, and test cases. Explore and document other potential methodologies identified in Phase I.

PHASE III DUAL USE APPLICATIONS: Include upgrades to the analysis, M&S, and T&E results. Provide mature prototypes of radar and infrared fusion system to perform broad area search for UAV swarm in a single image.

Phase III goals are:
(a) super-resolution processing to produce a higher resolution (HR) image from a lower resolution (LR) one with increased image content and without inducing artifacts;
(b) training models focused upon consistent UAV swarm features such as spatial characteristics while giving low weight to variable characteristics like color and background;
(c) create and adapt training data to build generalized broad area search target detection, classification, and tracking UAV swarm models that perform well using radar and infrared camera imagery and video;
(d) collection of relevant radar and infrared camera data for training and testing machine learning models;
(e) interfacing with C-UAV offensive device;
(f) adapting processing capabilities for onboard edge device demonstration;
(g) adding additional algorithms that optimize usage of the radar, infrared camera fusion system to operate without user input; and pursue civilian applications and additional commercialization opportunities, for example, enhanced surveillance for homeland/boarder security, identification of camouflaged/hidden targets, and nighttime facial recognition.

Regarding commercialization, a potential commercial venue/application could be the commercial maritime market, where improved neighborhood awareness can increase operational safety in the oceans. In addition, this work could be applied to track anomaly detection in other domains, including air traffic management and Space Domain Awareness. The Space Domain Awareness is becoming more and more relevant, as proliferated constellations of satellites continue to grow, and it becomes more important to track debris and space objects. Commercial companies like Exo-analytics and Kratos provide space objects tracking as a service and could provide an avenue for commercialization
An additional commercialization opportunity is tracking software with increased performance for valuable application in the automotive industry, as many manufacturers are pursuing more automation and aim to fuse the information from a variety of data sources, including onboard cameras and radars.

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KEYWORDS: Multi-Sensor Fusion; radar; camera; algorithm; deep learning; track accuracy

N241-018 TITLE: Acoustic Watermarking for Air ASW Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software; Integrated Network Systems-of-Systems; Sustainment

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

OBJECTIVE: Develop an active sonar watermarking capability for Air Anti-Submarine Warfare (ASW) sonobuoy systems that improves wide area search timelines, sonar track localization, and enables communication with other platforms such as Unmanned Underwater Vehicles (UUVs). Additionally, provide some method that indicates that the active transmission is from an authentic source.

DESCRIPTION: Sonar waveform watermarking embeds a digital message into an active sonar transmission so that the receiver can recover information from the transmitter, as well as conduct the usual echo detection and ranging. In future Air ASW systems, many active sonar sources will be operating in close proximity—both time and space—to each other. While this improves detection performance, a means of unambiguously providing detection association to a specific source will improve the system's track accuracy for a target. This SBIR topic seeks to develop a digital watermarking technology embedding information in each source ping that can be successfully interpreted at low signal-to-noise ratios (SNRs) and can assist in assigning sources to ambiguous echo detections (i.e., detection association).

This technology will reduce sonar search times by at least 25% against fast targets. Watermarking source transmissions will allow more sources to operate simultaneously and unambiguously, while maintaining a high degree of correct echo-to-source association. Watermarking technology will improve the target Area of Uncertainty (AOU) by at least 15% by increasing the number of near simultaneous detections used during target tracking.

The watermarking technology should degrade detection probabilities by less than 1 dB when operating in a wide range of ocean channel conditions, at SNR 2 dB higher than the theoretical Minimum Detectable Level (MDL). The watermarking should degrade Doppler estimation accuracy by less than 5% and range accuracy by less than 10% in realistic ocean channels that include Doppler and time spreading.
The watermarking must be applicable to narrowband waveforms such as Continuous Wave (CW) pulses, and should also be applicable to wideband waveforms such as Frequency Modulated (FM) waveforms. The same watermarking technology can be used to embed short acoustic communication messages in active sonar transmissions that are received by other platforms in close proximity such as surface ships, and unmanned underwater vehicles even when the receiving platform is operating with high self-noise. These short acoustic communication messages can be a means to provide authentication and transmission assurance.

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a digital watermarking technology applicable to wide area search systems to enable successful detection association with a set of at least four sources, maximizing source de-confliction, and being able to clearly identify the source that generated the detection. Demonstrate, using simulations, the watermarking technology does not reduce signal detection by more than 1dB at MDL+2dB. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype underwater acoustic source that includes embedded watermarks on typical Air ASW waveforms. Develop acoustic software that can be used for at-sea testing. Demonstrate the watermarking technology can successfully identify a specific source from at least 32 different sources. Demonstrate the watermarking technology can successfully transmit and interpret messages at low SNRs.

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

PHASE III DUAL USE APPLICATIONS: Make recommendations for this technology to be included into the Production Sonobuoy Specification. Demonstrate during an at-sea data-gathering event the watermarking technology functions as designed. Provide an interface documentation description for the integration of this capability into an active ASW sonobuoy system. This technology will primarily benefit military applications. Surface ship multistatics would benefit from this capability. A commercial application would be to include watermarking into audio files to provide a means of authentication and protection.

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KEYWORDS: Watermarking; embedding information; assurance; tracking; detection association; source de-confliction

N241-019 TITLE: Wideband 16x12 Non-Blocking Radio Frequency Switch

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

OBJECTIVE: Develop a dynamically reconfigurable, minimal latency 6U Virtual Path Cross-Connect (VPX) wideband non-blocking radio frequency (RF) switch that can simultaneously handle thousands of diverse signals from multiple apertures to multiple channels on a single processing card to increase autonomy while addressing emerging and dynamic threats.

DESCRIPTION: Signal intelligence (SIGINT) is the intelligence obtained by the interception of communications and electronic signals. An Electronic Support Measure (ESM) provides the passive capability to search, intercept, collect, classify, geo-locate, monitor, copy, exploit, and disseminate these signals over a specific RF range. A key subsystem to an ESM is the RF distribution, a unit which routes the incoming RF signals to the appropriate channel for processing and analysis. Current 6U RF switches are limited in the exploitation of the frequency spectrum due to size, weight, power, and cooling (SWaPC) constraints associated with the frequency response of the components in the signal conditioning path.

This SBIR topic's goal is to develop a 16x12 non-blocking switch that operates from 1.5 MHz to 18 GHz. The proposed non-blocking RF switch should maintain present 6U SWaPC constraints. The non-blocking RF switch must be a single processing card while maintaining the following open interface standards: ANSI / VITA 46.0 VPX Baseline Standard.

The non-blocking RF switch must be able to route any of the 16 input apertures to any of the 12 output tuner channels while remaining dynamically reconfigurable via a sensor open systems architecture (SOSA). The Application Programmer Interface (API) and Interface Control Documents (ICD) will be supplied during Phase I.

An RF Cascade analysis of the design should address the non-blocking RF switch's performance in signals' Gain, Isolation (input-coupled and output-coupled), Noise Figure (NF), Input third order Intercept Point (IIP3), 1 dB Compression Point (P1dB), and switching time at a minimum. Hardware must be delivered with software and firmware APIs and development kits for rapid integration into U.S. Government Labs.

Design tasking in Phase I and Phase II will not be classified. Analysis tasking associated with hardware in Phase II may become classified.

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004.

PHASE I: Design and develop an initial non-blocking RF switch solution for airborne platforms in maritime environments including an assessment of the ability of the technology solution to meet SWaPC form factor as detailed in the Description above. Additional ICDs and APIs will be supplied in Phase I to develop a conceptual architecture of the RF switch. An initial design of the RF Switch is required as a product of the Phase I effort, along with initial SWaPC analysis. The Phase I Option should lay out initial design requirements for the operating bandwidth of the RF switch; the RF switch's NF, Isolation, IIP3, and P1dB; verification of operational performance requirements through modelling and simulation (M&S); and prototype plans to be further developed under Phase II (e.g., associated documentation; i.e., initial block diagram, schematic, capabilities description).

PHASE II: Develop and demonstrate a prototype hardware and firmware solution, or engineering demonstration model (EDM), which builds upon the proposed solution and architecture developed in Phase I with a brass-board, proof-of-concept design. A design review should be conducted early in the development phase. The effort shall include a lab demonstration, that is, the prototype hardware should be delivered at the end of Phase II, ready to be tested by the U.S. Government. The final report should include a lab demonstration plan and results, and a transition plan for Phase III focusing on an integration of the RF switch, including further technical maturation and manufacturability of the resulting prototype for an airborne military environment.

Analysis tasking associated with hardware in Phase II may become classified. Please see note in the Description paragraph.

PHASE III DUAL USE APPLICATIONS: Refine the design, lab (or ground) test, and integrate the RF transceiver solution within a government systems integration lab (SIL). If not completed during Phase II, the Phase III design should focus on the manufacturability, production, and sustainment for compliance with the military operating environment (military standards and handbooks such as MIL-STD-810, MIL-STD-704F, MIL-STD-461, MIL-STD-464C should be used as reference until exact specifications are supplied). Phase III deliverables will include documentation not addressed during Phase II such as, but not limited to, Critical Design Review (CDR), associated Qualification Testing and analysis to support Flight Testing, performance requirements, associated ICDs, and manuals.

Dual use in the commercial sector is presently limited; however, some commercial companies are addressing this with the FAA. FedEx is reviewing to install self-defense systems similar to military aircraft and helicopters, and its proposal for anti-missile infrared laser countermeasures to the FAA states "in recent years, in several incidents abroad, civilian aircraft were fired upon by man-portable air defense systems". As missile protection for commercial aircraft (RF systems) continues to be explored, a modified EMS system may be used as an early warning system.

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KEYWORDS: Signal Intelligence; SIGINT; radio frequency; RF switch; ESM; Electronic Support Measures; ANSI/VITA; Digital Signal Processing; DSP; High bandwidth Processing; Signal Detection; Spectral Awareness

N241-020 TITLE: High-Speed Wavelength Division Multiplexing (WDM) Optical Backplane for Avionics Applications

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

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

OBJECTIVE: Develop and package a high-speed (100–400 Gbps) optical backplane based on Wavelength division multiplexing (WDM) for onboard avionics applications.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic, communications, and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in Size, Weight, and Power (SWaP). The effectiveness of these systems hinges on (1) optical communication, computation, and networking components that realize high connectivity and throughput, (2) reconfigurability, (3) modularity (plug and play), (4) low-latency, (5) large link budget, and (6) compatibility with the harsh avionic environment. The traditional use of copper traces to support board-to-board communications in sensor and mission computing applications requires hundreds upon hundreds of electrical pins and a spider web of connecting copper traces. For example, the latest embedded system backplane standard, VITA 65 – OpenVPX, has connectors with 728 pins on a 6U size card and 280 pins on a 3U card, and still does not provide enough bandwidth for current or future generation systems. This situation complicates the integration of processing cards within mission computers, sensors, and imaging systems. The saturation of high-speed traces throughout the backplane can generate electrical impedance problems, creating bandwidth limitation problems [Ref 16].

In the commercial data center sector, the bandwidth capacity needs to increase along with reduced power consumption, which has increased the demand for efficient interconnects. These functions are not available with traditional interconnects, which are copper-based, thus further enhancing the utility, and in turn the need, for an optical interconnect technology refresh. Moreover, companies are innovating new solutions with multiple variants of 100 to 400 Gbps+ optical transceiver modules. Although these solutions are designed to enable network operators to address increasing bandwidth demand through simplified network architecture, these solutions are not directly compatible with the complexity of modern digital avionics networks [Ref 1]. Traditional optical implementations based on single-wavelength fiber optic transceivers operating at up to 28 Gbps per lane, 100 Gig Ethernet switches, along with the OpenVPX and Sensor Open Systems Architecture (SOSA™) standards, is testing the boundaries of optical connectors and backplanes in avionics [Ref 2–5].

Future avionics signal transmission rates are expected to increase to 100 Gbps per lane and higher over 50 µ OM4/OM5 fiber. The use of high-speed digital fiber optics and wavelength division multiplexing in avionics backplanes can enable a significant increase in aggregate bandwidths beyond traditional electrical and optical networking implementation limitations. A 100 Gbps (scalable) and WDM-based optical backplane with OpenVPX capability and SOSA™ compatibility will be required for future data transmission and networking in avionics [Ref 6]. As such, a high-speed WDM optical backplane for onboard avionic networking that extends beyond the current state-of-the-art technologies is desired [Ref 7–14].

The proposed WDM optical backplane should minimally meet the SOSA™ roadmap expectations. The proposed high-speed WDM optical backplane must operate across a -40º-+95ºC temperature range and maintain performance upon exposure to typical naval air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments [Ref 15]. The proposed approach should incorporate a quick routing capability to overcome latency and connectivity limitations and enable future avionics network architectures.

PHASE I: Develop a WDM optical backplane hardware engineering design with OpenVPX capability and SOSA™ compatibility. Demonstrate the feasibility of the optical backplane design and packaging. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Optimize the backplane design for future avionics networking and sensors. Build and test the optical backplane in a simulated avionics environment that is compatible with OpenVPX and SOSA™. Deliver one optical backplane—including active and passive components—for future WDM avionics application.

PHASE III DUAL USE APPLICATIONS: Support transition of the technology being developed to military aircraft platforms, commercial data center and defense avionics industries.
Commercial sector telecommunication systems, fiber-optic networks, and data centers will benefit from the development of the WDM-based optical backplane such as mitigating the bandwidth limitations. These applications will be able to drive more data input at a higher speed.

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KEYWORDS: OpenVPX; SOSA; Wavelength Division Multiplexing; optical backplane; multimode fiber optic; higher bandwidth

N241-021 TITLE: High-Temperature, High-Efficiency Electrical Starter/Generator

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

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

OBJECTIVE: Develop a high-temperature, high-efficiency ES/G and a system generator control unit (GCU), with the goal of optimizing heat load, output power, size, and/or weight of future power systems.

DESCRIPTION: The Navy is interested in pursuing new Electrical Power Generating System (EPGS) technologies for increasing efficiency, specific power, power density, and power capacity for 270 Vdc More-Electric Aircraft (MEA) systems. The EPGS is the main power source for MEA and the solution should provide motoring for main engine start capabilities. Improvements to the existing EPSG, or a new novel power generation system architecture/design, will be considered.

A 200-kW EPGS that converts rotational shaft power to 270 V is of interest. The generator should be able to produce this voltage and power across at 1.00-to-1.75 speed range—with the higher region of the speed range around 24,000 rpm. The generator should be capable of proving a stable power source for continuous and intermittent power across the operating speed range. It should be able to source stable electrical power into high step-load Constant-Power Loads (CPL) commensurate with MIL-PRF-22140B. The EPGS should also be able to maintain typical MIL-STD-704F power quality metrics while considering relevant line impedances for generating into the dynamic CPLs.

The offeror should show feasibility of the benefits and performance capability during Phase I using modeling, simulation, and analysis of the electromagnetic, thermal, rotor dynamics, reliability, fault conditions, etc. Careful consideration should be made that this is a mission-critical component for most MEA systems. The analysis should be provided for both steady-state and transient conditions.

The Navy requires new technologies to increase the efficiency and power capacity of today’s EPGS. The electrical starter/generator (ES/G) (ES/G) is the main power source for a MEA systems, providing motoring and main engine start capabilities for the aircraft. Improvements to the existing EPGS, or a new novel power-generation system architecture/design, will be considered. This effort should focus on providing an ES/G system to provide a minimum generator power output of: 200 kW (continuous), 250 kW (2-minute overload), 300-500 kW (5-second overload), and > 500 kW (0.5-second overload). The power generation operating range should be able to generate 270 Vdc and power across a 1.00 to 1.75 speed range (with peak speeds at roughly 24,000 rpm).

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 NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Define generator design approach and develop an implementation plan. Validate approach analytically or provide test data or bench top hardware that would validate approach. Ensure maximum use of computer modeling and simulation techniques in this phase. Demonstrate a thorough working knowledge of applicable military standards. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate generator technology that can provide 200 kW of continuous power that can be fitted into the aircraft. Ensure that the generator package includes a GCU that is capable of controlling generator functionality. The package will be subjected to proof-of-concept testing at full qualification levels.

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

PHASE III DUAL USE APPLICATIONS: Package and integrate new generator for use in the aircraft. Provide unit(s) to be subjected to full qualification testing and flight test profiles. The notable benefits include the increased efficiency and power capacity of the ES/G, reduction of system volume and weight, and interconnected complexity. It will improve thermal performance over the current system while also providing better engine and air vehicle performance. It will significantly reduce engine heat loads throughout the mission while focusing on heat rejection impacting the ES/G.

Specific industries, such as the automotive, marine, industrial machinery, agricultural machinery, and construction machinery, could benefit from this innovative ES/G technology. All of the above would provide significant benefits to both military and commercial aircraft applications.

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KEYWORDS: Generator; Generator Control Unit; Voltage Regulator; Electrical Power; Alternating Current; Direct Current

N241-022 TITLE: Precision Sensing for AS(X) Submarine Tenders

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

OBJECTIVE: Develop a precision sensing system capable of providing real time relative positioning and orientation between a submarine and its tender in open water during resupply operations.

DESCRIPTION: Submarines are typically resupplied in port, or under benign sea state 2 conditions typically found in sheltered waters that may be far from the submarine's operational area.
In higher sea states, the differing movement of the tender ship and the smaller submarine becomes a major obstacle to high-precision transfer of supplies. The tender, submarines, and the resupply materiel will move in their own frame of reference. Precise sensing of relative pose is critical when applying automation of motion mitigation to support the tender's operations during transfers. The sensing system must operate in real-time, and accurately provide the distance to the transfer destination on the submarine, as well as the relative velocities between the two vessels in six degrees of freedom (DOF) in Sea State 3 (Objective) and 4 (Threshold). No satisfactory commercial sensing system exists currently.
The system must be operable and accurate in a marine environment, day and night, including in conditions of fog, salt spray, icing, etc. The sensors and computers performing analysis of the sensor data will be based on the tender, without excluding possibilities of establishing other temporary vantage points for transfer operations. The system must be operable at a distance to the submarine of up to 50 feet over the side of the tender, and 30 feet vertical from the location of transfer equipment on the tender. The position sensing system should also be usable for vertical lift transfers. No permanent targets or sensors may be installed on the submarine.

The system must provide an indication of when sea conditions permit safe operations for the capabilities of a given transfer method. The actual transfer method is outside the scope of this SBIR topic. A design for the sensing system is expected to enable this technology to operate on other platforms as needed.

PHASE I: Develop a design to address precision sensing for AS(X) submarine tenders during underway replenishment of submarines. Identify sensor choices, locations and methodology for sensor data analysis, yielding real-time 6-DOF motion identification outputs. Validate the feasibility of the approach in a marine environment by providing computer simulations or other evidence. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype system in Phase II.

PHASE II: Develop a prototype system for evaluation based on the results of Phase I. Develop a test methodology to show how the technology will be evaluated to determine if the system has the potential to meet Navy performance goals described in the Phase II SOW. The goals will be defined by the Navy in Phase II. Testing in a two-body wave tank or an equivalent marine environment is expected. Develop plans for full-scale testing in an open water environment in Phase III.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Perform full-scale testing in an open water environment and further refine the technology for Navy use. The same technology needed to transfer supplies from tenders to submarines can also be used for other Navy ship-to-ship transfers, as well as offshore oil and wind industry applications.

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1. Ziezulewicz, Geoff. "Navy planning to bring back at-sea missile reload capability." Navy Times, 1 August 2017. https://www.navytimes.com/news/your-navy/2017/08/01/navy-planning-to-bring-back-at-sea-missile-reload-capability/

2. "U.S. Navy Tries Reloading VLS Missile Cells With a Commercial OSV." The Maritime Executive, 7 October 2022. https://maritime-executive.com/article/u-s-navy-tries-reloading-vls-missile-cells-with-a-commercial-osv

KEYWORDS: Relative Position Measurement; Underway; Inertial Measurement Unit; Precision Real Time Sensing; Sensing in Marine Environment; Cargo Transfer at Sea

N241-023 TITLE: High Reliability Flame Detector

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

OBJECTIVE: Develop a flame detector capable of identifying flaming fires in the quickest amount of time while also discriminating against false and nuisance alarm sources.

DESCRIPTION: Optical Flame Detectors (OFDs) are generally designed for large spaces with the expectation that there will be little to no interference from structural members (e.g., frames, bulkheads, etc.) and personnel. Previous installations on the Navy ships have experienced nuisance and false alarms due to lighting conditions and movement of equipment and personnel in the monitored space.
Each inadvertent Peripheral Vertical Launching System (PVLS) sprinkling event caused by a nuisance or false alarm generated from the flame detector costs ~$270k, resulting from PVLS equipment damage. High false and nuisance alarm rates without an underlining system understanding causes watchstanders to lose confidence in system credibility. This instills watchstander indifference towards alarms/faults potentially resulting in the ship's force not responding to an actual fire event. The innovative nature of the required work is to transition commercially used technology into a non-ideal environment, represented by the high-traffic open spaces and crowded, compact spaces experienced on Navy vessels.

The Navy is seeking a shipboard qualified flame detector solution that reliably functions in compact, crowded spaces and can be integrated with the Fire Detection and Actuation System (FDAS) Navy Program of Record. Flame detector solutions should indicate power and alarm status at the sensor location and perform an automatic functional self-test. The sensor must integrate into the DDG 1000 FDAS, be adequately sized for shipboard application and meet vibration, EMI, and shock requirements.
Flame detectors should not register a false alarm when directly aimed from 3 feet dead ahead in constant or intermittent sunlight, 100 watt incandescent light, 40 watt fluorescent light, 2-D cell flashlight, and Shielded Metal Arc welding at maximum amperage of two carbon steel plates, or lit cigarette at 1 foot dead ahead.

The flame detector shall be selected based on the radiant emissions expected from the burning fuel or material to be detected and have a discrimination capability to prevent false alarms when exposed to non-fire related radiant emissions. It shall also be capable of detecting a 1 foot by 1 foot n-heptane pane fire in less than 30 seconds at a distance of no less than 60 feet, a 100 kW wood crib fire within 2 minutes at a distance of 60 feet, and a 10 kW propane fire within 5 minutes at a distance of 20 feet as well as other Class A and B fires.

The flame detectors shall be listed or approved in accordance with either FM 3260 or EN 54-10, shall be tested in accordance with MIL-PRF-32226, and shall be able to meet vibration, Electromagnetic Interference (EMI), and shock requirements within MIL-STD-167-1, MIL-STD-461E, and MIL-DTL-901E, respectively.

PHASE I: Develop the concept of a system to detect and evaluate flames with automatic functional self-test which will reduce or eliminate false alarms. Demonstrate the feasibility of the concept in meeting Navy needs. Demonstrate that the flame detector solution can be readily and cost-effectively manufactured through standard industry practices by material testing and analytical modeling. The Phase I Option, if exercised, should include the initial layout and capabilities to demonstrate the application in Phase II.

PHASE II: Develop and deliver a prototype sensor for integration into the DDG 1000 FDAS that is adequately sized for shipboard application and meets vibration, EMI, and shock requirements. Also develop a modular test bed in which prototype evaluation can occur to demonstrate capability to detect flames while eliminating false alarms. Perform testing at a facility determined to be appropriate by the government to prove detection capability as well as false alarm rejection. Final product will be integrated with FDAS Navy Program of Record.

PHASE III DUAL USE APPLICATIONS: Assist with Navy integration of the flame detector solution into fleet FDAS systems.

Commercial OFDs are used in warehouses and open spaces as fire detection. The developed flame detector can be used in any such application where environmental interference can be expected and alternative methods of fire detection such as smoke and heat detectors are not feasible due to ventilation or tall overheads.

REFERENCES:
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2. Gottuk, Daniel T. "Flame and Smoke Video Image Detection (VID)." SFPE Issue 21: Flame and Smoke Video Image Detection (VID). https://sfpe.connectedcommunity.org/publications/fpemagazine/fpeextra/etarchives/fpeetissue21

KEYWORDS: Fire Detection; Fire Detection and Actuation System; FDAS; Flame Detection; Survivability; Ordnance Safety; Personnel Safety

N241-024 TITLE: Vertical Launch System High Speed Interface

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

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

OBJECTIVE: Develop a high-speed interface within the MK41 Vertical Launch System (VLS) architecture.

DESCRIPTION: One of the biggest challenges VLS has with integration of new missiles and new capabilities relates to its low-speed interfaces and legacy technology of current platform hardware. The evolution of existing missiles and the advent of new missiles to meet an ever-changing threat have made upgrades to both system performance as well as reduced life cycle costs a necessary objective. Lifecycle cost reductions are needed in the redesign of the architecture where current legacy serial data exchange limits upgrades at both the launcher as well as the missile, and requires additional manhour expenditures for both maintenance as well as missile availability. Existing network interfaces are limited in speed and bandwidth, resulting in fenced performance limits affecting system availability and maintainability. Additionally, these interfaces, in their current configuration, establish a limit for optimization efforts between missile and weapon control system design and upgrade. A technology to redesign the interface between the Weapon Control System and the Missile to take advantage of High-Speed Ethernet capabilities will result in augmented magazine capacity, increased weapon availability, and reduced lifecycle costs.

Increased data rates would increase availability time for VLS in the fleet; for example, current Tomahawk upgrades can take hours per missile, which inhibits any launcher maintenance or action during that period. A key element to address these performance limitations is a redesign of the interface between the Aegis Combat System and the VLS Launch Control Unit, and the missile. The transition to a Gigabyte Ethernet architecture and definition of the Interface Control Document and Interface Design Specification requirements is sought to remedy these performance restrictions. Currently there are no commercial solutions to this issue.

A solution is needed to significantly enhance the performance of this interface while maintaining backward compatibility of existing data flows and timing. The solution must provide on-the-fly software upgrades and reduce downtime of VLS launch capabilities. Novel constructs that build upon current state-of-the-art network design will have the following specifications:

- Utilization of 802.3 1000BASELX (Gigabit) Ethernet Interface standard
- Interface of greater than 66 fiber ports (and extensible beyond this limit)
- Achieve benchmarks of 40MB in less than one minute and 400 MB in under 10 minutes, simultaneously, over 25% of the fiber ports

In-depth characterization and testing are critical for elucidating the mechanisms to achieve advanced data rates and digital assurance. Some critical considerations for any High-Speed Interface Processor (HSIP) would include design tradeoffs, Time Sensitive Networking protocol, development of a standard interface and compliance with Cybersecurity requirements. It is expected that the hardware developed can meet surface ship environmental requirements (e.g., MIL-DTL-901 Grade A shock, MIL-STD-167 Shipboard Vibration, 0-50C Ambient Temperature and MIL-STD-461 EMC). The awardee must propose adequate test protocols to demonstrate the suitability of the proposed technology to satisfy Navy requirements.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a common High-Speed Interface Processor (HSIP) to provide missile digital data that meets the parameters in the Description. Demonstrate that the concept can feasibly meet the requirements through analysis, modeling, and experimentation of materials of interest. 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 notional full-scale prototype(s) that demonstrate functionality under the required service conditions including thermal stresses. Demonstrate the prototype performance through the required range of parameters given in the Description and as identified through Technical Interchange Meetings with the government.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use in the MK41 VLS program. Support the manufacturing of the components employing the technology developed under this topic and assist in extensive qualification testing defined by the Navy program. Potential commercial uses for high-speed interface processing performance improvements exist in the commercial industrial process, spacecraft, and aircraft industries.

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2. Hopf, Daniel. “High-Speed Interfaces for High-Performance Computing” Continental_Corporation Holistic Engineering and Technologies, September 15, 2020. https://standards.ieee.org/wp-content/uploads/import/documents/other/eipatd-presentations/2020/D1-02-Hopf-HighSpeed-Interfaces-for-HighPerformance-Computing.pdf

KEYWORDS: Vertical Launch System; Gigabyte Ethernet; Time Sensitive Networking; VLS Launch Control Unit; Advanced Data Rates; Cybersecurity.

N241-025 TITLE: Advanced Artificial Intelligence/Machine Learning Techniques for Automated Target Recognition (ATR) Using Small/Reduced Data Sets

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

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

OBJECTIVE: Develop an innovative automatic target recognition (ATR) capability that leverages state-of-the-art Artificial Intelligence/Machine Learning (AI/ML) technology to support naval mine countermeasure (MCM) operations using reduced data sets.

DESCRIPTION: ATR is the ability for a system or algorithm to recognize and identify targets, objects of interest or threats based on data obtained from sensors. In Navy mine countermeasure (MCM) operations, sensors collect data to identify and localize targets of interest in marine environments.
The Navy is interested in developing state-of-the art AI/ML ATR processing algorithms, or techniques to facilitate target detection and identification using smaller data sets to train the algorithms and perform ATR. The Navy's existing Minehunting systems collect data using forward-looking sonar, a pair of side-scan sonars, and a volume search sonar. Identification and localization of underwater objects is challenged by both a reliance on large, curated data from the onboard sensors that are needed to train and perform ATR and the amount of time required to conduct ATR operations. Current MCM ATR algorithms require large amounts of data (over 200 hours of acoustic video and 1,000-2,000 target images) to train the algorithms. This training data is quite costly to obtain because it must be collected in a variety of representative operational environments.

The proposed solution should demonstrate reduction in the amount of data required to train algorithms by an order-of-magnitude smaller without degradation to identification performance (Pid) and no increase in the Probability of false alarms (Pfa). If possible, the solution should incorporate advanced ML techniques such as One Shot, Multi Shot, Few Shot etc. as well as others that yield the benefits sought.
The ATR will be initially integrated into the Navy's Generalized ATR (GATR) framework to improve detection and classification performance. The capability could eventually be integrated into a towed body to support in-stride ATR.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of

Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept to facilitate target identification using smaller data sets that meets the requirements described above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established by testing and analytical modeling.

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 for evaluation as appropriate. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for the algorithms. Demonstrate performance across a broad set of Government -Furnished Information (GFI) data. Performance will be validated against Government-provided target truth. Prepare a Phase III development plan to transition the technology to Navy use.

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: Produce and support a final prototype that will be integrated into developmental and operational frameworks used by the AN/AQS-20 Mine Hunting Sonar Post Mission Analysis (PMA)/ Generalized ATR (GATR) system. Additionally, AI/ML algorithms developed may be inserted onboard the AN/AQS-20 Mine Hunting Sonar towed body. Due to the nature of the effort coupled with the anticipated implementation of DEVSECOPS, technology insertions may also be accelerated and/or incrementally introduced into various other MCM sensors (e.g., Mk18 FOS, AQS-24, Barracuda, etc.).

Technology developed under this effort is applicable to any domain that requires subsea platform autonomy such as subsea oil and gas pipeline inspection.

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1. Koch, G.R. (2015). Siamese Neural Networks for One-Shot Image Recognition. Department of Computer Science, University of Toronto. Toronto, Ontario, Canada, 2015. http://www.cs.toronto.edu/~gkoch/files/msc-thesis.pdf
2. Tiu, E., Talius, E., Patel, P. et al. Expert-level detection of pathologies from unannotated chest X-ray images via self-supervised learning. Nat. Biomed. Eng 6, 1399–1406 (2022). https://doi.org/10.1038/s41551-022-00936-9
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KEYWORDS: Artificial intelligence; machine learning; mine countermeasures; acoustic sensor; automatic target recognition; few-shot learning

N241-026 TITLE: Automatic Boresight Alignment of Optical Sensors

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

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

OBJECTIVE: Develop a capability for automated in-situ boresight alignment of multi-spectral imaging sensors and lasers.

DESCRIPTION: The Navy is fielding a suite of imaging sensors (cameras) with unprecedented capability. These sensors will provide both wide field of view (WFOV) and narrow field of view (NFOV) video imaging across a full 360° in both visible and infrared (IR) bands. Imagery from these cameras has a variety of uses from navigation to target detection, identification, and tracking. WFOV cameras will cue potential targets of interest to NFOV cameras which will then center on the target location for higher resolution inspection of the target. Therefore, knowing the axis along which each camera is looking, relative to a common reference (the position of the camera on the vessel) is critical in sensor coordination and cueing.

The optical axis of an imaging sensor normal to the center point of its focal plane, or a NFOV reticle at or near the center, is its boresight. The optical axis of laser devices, such as a NFOV rangefinder, must also be boresight aligned with the imaging sensor reticle in order to receive reflected energy from the intended target. The mechanical mount and positioning structure of the sensor serves to point the optical axis in the desired location. However, mechanical tolerances naturally cause a difference between the mechanical axis of the sensor's mount and the true optical axis. For deployed sensors, ship vibration and harsh environmental conditions can cause alignment to degrade over time. Calibration to correct or compensate for misalignment of the optical and mechanical axes is known as boresight alignment. Therefore, boresight alignment applies across multiple elements to include the imaging sensors, laser(s), and line-of-sight (LOS) pointing by the director mount. Boresight alignment is an important step in preparing the sensor for deployment and it is particularly critical for NFOV, high magnification cameras.

Mechanical and optical alignment of the Navy's optical sensor modules, known as line replaceable units (LRUs), is typically done in the factory or some centralized Government facility, both when the sensor is newly manufactured and after depot overhaul of the system. When the system is installed on a ship as an assembly, or following organizational level maintenance of the LRUs of a LOS director, the combination of factory alignment and mechanical tolerances is insufficient to ensure alignment across imaging sensor, laser, and LOS director elements. This results in manual, labor intensive processes that require skilled technicians to execute differing procedures across multiple systems. The current process also requires the ship to be in port with distant objects within view and is not practicable while the ship is underway. Therefore, if alignment could be performed in-place utilizing automated processes and a minimum of additional equipment, the current difficulties of calibration could be eliminated, thereby resulting in a reduced mean time to repair and significant cost savings. In addition, performance of the imaging system could be maintained while underway as environmentally induced misalignment could be periodically corrected or compensated for.

The Navy needs a technique (realized in software and hardware) for in-situ boresight alignment of optical imaging sensors (cameras) and rangefinders. There is no current capability commercially available. Techniques that generate an offset table for registration of the imagery to the baseline frame of reference are acceptable. The technique must also be useful for cameras operating in the IR spectra as well as the visible spectrum. The solution must be applicable to imaging sensors where multiple focal plane arrays use the same aperture as well as systems that have co-located but separate apertures. Most Navy systems of interest incorporate lasers that operate in the short-wave infrared (SWIR) for range finding so the solution should include the facility to calibrate in conjunction with the laser (which also may be subject to misalignment). The visible, near infrared (NIR), SWIR, and mid-wave infrared (MWIR) bands are of most interest however, a technique that could be extended to the long-wave infrared (LWIR) is attractive. The technique should provide boresight alignment to an accuracy of 100 micro-radians or better. Solutions that require a minimum amount of added hardware (hardware added either permanently to the sensor baseline or installed temporarily for the calibration process) are desired. Likewise, the solution should be largely automatic, requiring no more skill or human intervention for calibration than typically required of the operator during normal system operation. A technology that requires no added hardware and is fully automated, if feasible and sufficiently precise, represents a full solution to the problem. Solutions that require the cooperation of other vessels or aircraft, solutions that are only feasible in certain locations of the ocean (e.g., along known coastlines), and solutions that can only be deployed to specific ship classes or require extensive modification of the vessel are not of interest. Solutions that make use of two or more imaging sensors (either co-located or not) working together are potentially acceptable, although it should be noted that the feasibility decreases rapidly as the number of cooperating sensors required for calibration goes up. For this effort, NFOV cameras are of primary interest. However, the fundamentals of the technique should be extensible to any format and magnification imaging system. Note that the Navy does not intend to furnish tactical or otherwise representative imaging system hardware for this effort. The proposed solution should therefore include the means for test and demonstration on surrogate hardware, provided as part of the solution. A prototype (hardware and software) of the technology will be delivered to NSWC Crane Division at the conclusion of Phase II.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an automated boresight alignment technique that meets the objectives stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy's need by any combination of analysis, modelling, and simulation. Analyze the accuracy of the proposed technique in compensating for axial misalignments in NFOV multi-spectral imaging systems. 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 boresight alignment technique for imaging sensors based on the concept, analysis, preliminary design, and specifications resulting from Phase I. Demonstration of the automated boresight alignment technique shall be accomplished through test of a prototype in a laboratory or controlled outdoor environment utilizing surrogate cameras, lasers, and mounts. At the conclusion of Phase II, prototype hardware and software shall be delivered to NSWC Crane along with complete test data, installation and operation instructions, and any auxiliary software and special hardware necessary to operate the prototype.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Develop specific hardware, software, and operating instructions for specific Navy optical sensor systems. Establish hardware and software configuration baselines, produce support documentation, production processes, and assist the Government in the integration of the boresight alignment technology into existing and future imaging sensor systems.

The technology resulting from this effort is anticipated to have broad military application. In addition, there are scientific, security and commercial navigation applications. This would include commercial aircraft maintenance and assembly, power generation plants, machining, and automotive maintenance.

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KEYWORDS: Rangefinder; Imaging Sensor; Boresight Alignment; Video Imaging; Narrow Field of View; Optical Axis.

N241-027 TITLE: Precision Stabilization of Large, Wide Field of View Imaging Sensors.

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

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

OBJECTIVE: Develop a capability to accurately stabilize high performance, large, wide field of view (WFOV) imaging sensors during operations in adverse maritime environments.

DESCRIPTION: Imaging sensors (cameras) are used for a wide variety of purposes by naval vessels while underway. This includes general observation of the surroundings for purposes of navigation, specific search for objects both airborne and in the water, identification of other vessels, and target acquisition and tracking for weapons systems. WFOV cameras are typically used for navigation and general situational awareness while narrow-field of view (NFOV) cameras are used for target tracking and identification as well as scanning specific sectors of ocean and sky, searching for particular (and usually very small or very distant) targets. Both types of cameras require stabilization to compensate for ship motion and the buffeting effect of wind and wave during heavy sea states. NFOV cameras are almost always deployed on stabilized gimbal mounts that respond quickly to ship motion in the three axes of roll, pitch, and yaw. These cameras are used to move to a specific target cue or coordinate. Once a target is within view, these systems can employ feedback for stabilization or use inputs from inertial sensors to maintain target tracking.

WFOV cameras are very often used in “staring” mode. In this mode of operation, the camera does not scan or move to a target cue. The camera stares in a pre-defined direction (with respect to the platform), whether a target is present or not. In panoramic applications, multiple WFOV cameras can be assigned individual sectors of coverage and the composite image stitched together. In this way, even full 360° coverage can be achieved. However, this presents particular problems not experienced by NFOV systems. In general, WFOV imaging systems are typically larger than NFOV sensors, especially for multi-spectral systems, and their greater mass requires larger mounts and greater power input if active stabilization is to be used. In systems with 360° coverage and stitched panoramic output, the mount may be somewhat simplified since effects of ship yaw can be compensated for electronically. However, ship pitch and roll are extremely detrimental to the image quality as they inhibit proper stitching of the image and lead to images with a constantly moving horizon.

The Navy is fielding a suite of imaging sensors with unprecedented capability. These sensors will provide both WFOV and NFOV video imaging across a full 360° in both visible and infrared (IR) bands. Adequate stabilization technology exists for the NFOV sensors. However, the WFOV sensors present a particular challenge, as described above. The Navy needs a stabilization technology for large WFOV sensors that achieve 360° panoramic imaging through sector coverage. Currently there is no commercial capability that can meet the requirements. The desire is to provide imagery that can be efficiently processed (for example, through stitching) and achieves a stable horizon for easy viewing. Electronic stabilization cannot provide a solution in high sea states, so a mechanical solution is required. This is further complicated by the design of the sensor, which packages multiple cameras and apertures into a single unit.

For purposes of initial design and demonstration, the full sensor package to be stabilized can be viewed as a rectilinear "box", approximately 65 inches across the face, 42 inches deep, and 29 inches high. The box has a weight not to exceed 560 lbs and a center of mass at the true center of the box. The sensor package covers a 135° sector of the vessel. The sensor package defined by this box's dimensions must be stabilized for ship motion in ±20° roll and pitch displacement, 7.5°/sec roll and pitch velocity and 5.0°/sec2 roll and pitch acceleration (with ±40° roll and pitch displacement, 20°/sec roll and pitch velocity and 10°/sec2 roll and pitch acceleration as an objective). Stabilization to a minimum accuracy of 25 mirco-radians (15 micro-radians as an objective) in elevation is required. As an objective, the sensor package should also meet stabilization requirements while experiencing the vibration levels in MIL-STD-810H table 528.1-I. A solution that presents the minimum size, weight, and power (SWaP) necessary to achieve the required stabilization accuracy is desired. While the dimensions, weight, and center of mass listed above define the Navy's current need, a solution that is extensible to both larger and smaller packages with variation in the center of mass represents a solution with broad utility that is highly desirable.

Note that the Navy does not intend to furnish tactical or otherwise representative imaging system hardware for this effort. The proposed solution should therefore include the means for test and demonstration on surrogate hardware, provided as part of the solution. A prototype (hardware and software) of the technology will be delivered to NSWC Crane Division at the conclusion of Phase II.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a WFOV imaging sensor stabilization system that meets the objectives as stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy's need by any combination of analysis, modelling, and simulation. Analyze the accuracy of the proposed technology in compensating for ship motion. The Phase I Option, if exercised, will include the initial design specifications and capabilities description necessary to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype sensor stabilization system based on the concept, analysis, preliminary design, and specifications resulting from Phase I. Demonstrate the technology using a surrogate payload in place of the Navy's imaging sensor package in either actual or simulated sea states sufficient to achieve the roll and pitch described above.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Develop specific hardware, software, and operating instructions for specific Navy imaging sensors. Establish hardware and software configuration baselines, produce support documentation, production processes, and assist the Government in the integration of the stabilization technology into existing and future imaging sensor systems.

The technology resulting from this effort is anticipated to have broad military application. In addition, there are scientific and commercial applications, for example, the stabilization of telescopes and motion picture cameras.

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KEYWORDS: Stabilization; Imaging Sensor; panoramic imaging; Wide Field of View; WFOV; video imaging; Narrow Field of View; NFOV

N241-028 TITLE: High Volume Low Pressure (HVLP) Style Spray for Rapid Cure Ultra-High Solid (UHS) Coating Systems

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

OBJECTIVE: Develop paint spray equipment for ultra-high solid (UHS) coatings that allow application at low thickness for specific, targeted areas such as propulsors or geometrically complex superstructure.

DESCRIPTION: The application of Type VII UHS epoxy coatings for naval applications relies entirely on commercially available airless coating spray equipment. The equipment used to spray the UHS coatings consist of a single or plural component mix pneumatic pumping/proportioning unit, in-line heaters for viscosity control, high pressure hoses and static mixers followed by a spray whip connected to a spray gun. Because of the viscosity of the UHS coatings system, it is typical for heat to be applied by the inline heaters to reduce the viscosity to achieve a properly atomized spray pattern at the tip of the spray gun. Various spray tips are used as well to properly atomize the spray fan or cone shape of the coating being delivered to the surface being painted. The current systems deliver the coating at high pressure and high volume, which causes difficulty in controlling film build and spread during application. For most of the work performed where UHS systems are employed, the result of coating application does not require a finished surface akin to an evenly spread, uniformly thick coating without surface flaws.
In an ever-growing need, the maintenance community relies on MIL-PRF-23236 Type VII UHS coatings for corrosion control in areas where legacy thin film coatings were historically applied in multiple thin layers to achieve the desired surface finishes and thickness. Transitioning to UHS coating applications increased the difficulty of achieving the surface finish and increased dry film thickness (DFT) that affect ship component fit of covers, plates, and other equipment assemblies in new ship designs. Controlling the volume of flow and spray pattern of UHS coatings in many applications will dramatically improve production efficiency when preserving naval assets.

Developing a spray gun that can achieve adequate volume and tailored spray capabilities is not trivial. To achieve the atomized spray desired, the developmental spray gun will have to control incoming pressures up to 7250 psi (50MPa), meter coating volume to a level to achieve control of spray atomization, pattern, and thickness control while allowing sufficient flow and productions levels as not to allow the rapid cure nature of the UHS coating to solidify within the application equipment past the static mix blocks or in the lines due to too slow coating deposition. The gun should be light enough for use by the applicator for long periods, handle the heat generated by fluid temperatures used to modify coating viscosities, and be able to spray coating film metered between 2 – 10 min/max mils wet film thickness, (WFT) per pass with an average targeted range of 2 – 5 mils per pass by an applicator.

Existing UHS spray technology is not well suited for applications where highly detailed work is required. Technologically advanced structures continue to be developed for marine service using light weight corrosion prone materials in seawater. When the structure being coated is geometrically complex, it becomes difficult to apply coatings properly and with any level of detail. Developing the capability to tailor spray parameters will provide significant advantages for controlling the application of UHS coatings, providing the asset with the necessary corrosion protection and functionality to operate as intended in a highly corrosive seawater marine environment.

The Naval Research Enterprise (NRE) produced an in-house prototype spray gun using existing commercially available gun bodies and was successful at achieving and demonstrating basic spray capabilities. However, the prototype was highly dangerous as the components were not designed for such high fluid pressures. Additionally, the ability to fully realize the desired performance of the gun itself was never met. Development was necessary with respect to flow, volume control, and atomization behavior of the coating. The science behind the operation and thus the ability to tailor to a wide range of spray conditions were not addressed since a production problem with a new Navy asset necessitated a hastily designed and constructed spray gun prototype for just that application. NRE engineers surveyed commercial industry manufacturers that supply coating equipment and were not able to identify such a spray gun with the desired capabilities. Discussions with equipment manufacturers indicated they had no desire to invest in such a design since their customer base was satisfied with the existing technology. However, as with the development of UHS coatings, the Navy's need drove UHS development, and the commercial sector followed suit as the demand began to increase. It is likely the same process will play out for this effort. When applicators who routinely use UHS systems have an alternative spray gun that allows them to control their application parameters to a higher degree, the equipment manufacturers will likely follow suit. The Navy currently has several designs for autonomous vehicles in operation and under development which require controlled coating applications. Over the past few years, the need has grown significantly.

To properly spray high solids/rapid cure coatings, a balance of pump pressure, temperature, flow rates, distance from pump, and a host of other factors need to be met. Existing commercial products are designed to meet a wide range of capabilities. However, the need to restrict many of these parameters will cause significant issues and are counter to how both the equipment and coatings were designed for use. R&D and innovation is needed to address how to change the parameters to achieve desired properties; (tightly controllable surface thickness and finish) over a wide variety of applications where a high-volume coating is being applied in a low volume situation without affecting coating cure properties or performance. Additionally, a new spray gun must be developed to ensure applicators can safely apply the coatings which are under high pressure metered down to some working pressure while having the ability to adjust the spray to geometrically complex structures in the field. The Navy needs a method to apply existing high-performance coatings in a way to achieve asset operation that supports asset design.
On average, the cost of such equipment is dictated by the complexity of the design, required machining, and availability of incorporated parts. Sales of spray guns assumed to be within the same complexity of design range from $3K to $7K each. The design should weigh no more than a comparable style commercial gun because weight and balance affect the applicator's ability to spray for long durations. Physical weight should not exceed 3 lbs. and fall within a box 8" W X 8" L X 2.5" D dimensionally. In addition, the design should account for ease of use when spraying in tight geometries, for example, in a rectangle that is 12" W X 14" D X 72" L. Supply lines for fluid and potentially compressed air should be attached in a way that they allow flexibility at the applicator's wrist. The gun should be able to sustain continuous spray for several hours at a time, and not suffer from any internal erosion of moving parts or fluid pathways.

To date no Commercial Item Description, (CID) exists for such a spray gun. CID A-A-50310 is a spray gun CID however it is not applicable to this design and should not be used as a reference. However, the pumping system to which the gun will attached falls under the CID A-A-59780 accessible through Assist Online at Defense Logistics Agency https://quicksearch.dla.mil/quicksearch.aspx. During the demonstration phase, the prototype gun will be attached to a plural spray pump that meets this CID. Coatings that will be sprayed through this prototype are qualified to MIL-PRF-23236, Type VII, Class 5, 5/18, 7, 7/18, &13 Grade C. All the specifications listed are available as Distribution A to the public and can be found at the DLA quick search website mentioned above.

The product shall be a packaged spray gun with all the necessary components for operation and connectivity to plural component spray equipment, like that of existing commercial spray gun sales. If adapters or any component deemed proprietary is needed for use, it shall be included in the end products inventory. The company identified for commercialization shall have the ability to provide repair and maintenance components and services as necessary to support end user needs. Beyond the immediate need for GFE components, the military industrial complex has immediate needs for coating specific equipment and designs for UHS coatings that require detailed spray capabilities. Those organizations both government and commercial will require this equipment. In addition, some of those commercial entities rely heavily on outside commercial coating applicator companies to perform the applications. Many of these companies also perform routine maintenance on military assets e.g., surface ships, submarines, barges, etc., and will likely adopt the use of this product to other activities as it will improve their ability to provide a level of control over the process they struggle to manage. In many instances coating appearances plays a larger role in acceptance of the final coating product, than intended coating performance. Coatings companies strive to perfect the applications so the job can be accepted by the owners of the assets they were hired to coat.

PHASE I: Define and develop a concept for an UHS delivery system that meets the specifications identified in the Description. Modeling and simulation should be used to articulate the feasibility of the design features and functionality, and to provide a computerized working model and detailed diagrams. The concept for a working prototype shall be at a level so that prototype construction and operation methodology are well defined. The Phase I Option, if exercised, will require the small business to provide a written report detailing the design concept, proposed functionality, construction methodology and materials, and marketing strategy to develop the desired product. The report shall include the initial design drawings and specifications with sufficient detail to complete construction of the working prototype in Phase II.

PHASE II: Develop and deliver a working spray gun prototype that meets the requirements detailed in the Description. The prototype will be required to function as designed and be demonstrate using a plural component proportioning pump like that used in industry. Recommendations will be made to identify such equipment if necessary. Demonstrate performance in house prior to demonstrating to the government. Upon completion of the government demonstration, the prototype shall be delivered to the government for additional testing if the prototype has met the performance criteria. A total of four prototypes units will be required to be constructed for field testing at industrial sites specified by the Topic Author.

PHASE III DUAL USE APPLICATIONS: Assist the Navy to transition from prototype to full production. In the early stages the Phase III product will initially role out to specific Navy organizations that currently require coatings applications which are driving the spray gun development. The spray gun will be introduced into the system that supports GFE. It will be through this effort that the Navy will validate performance during complete preservation of GFE components and certify it for Navy use. Commercial interest will be driven by the need for controlled coating application where high volume deposition fails. The polyurea/insulation community has high volume and low volume spray guns (e.g., GX-7 vs GX-8 respectively) where controlling the volume of coating being deposited is driven by application requirements and type. Industrial coating application such as refineries and chemical plants where complex structure is involved would benefit from tighter application controls to reduce overspray and film build. It would also reduce the cost of materials through wastage.

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KEYWORDS: UHS thin film deposition; Airless spray guns; UHS coatings application; Marine coating anticorrosive coatings; Tunable spray atomization and thickness control; Low volume rapid cure spray gun

N241-029 TITLE: Advanced Acoustic Hailing

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

OBJECTIVE: Identify and develop advanced acoustic hailing systems to provide a highly effective alternative for embarked security teams that encounter non-responsive boats and craft.

DESCRIPTION: Acoustic Hailing systems are prevalent in the security industry, especially with law enforcement and Commercial Cargo Ships. However, marinized capabilities scaled for U.S. Navy boats and combatant craft do not currently satisfy size/weight requirements; small craft have limited weight, space, and power which require systems to fit within the load bearing capabilities of 34 to 40 foot craft. The Navy seeks to develop an Acoustic Hailing system that has utility in operation of 34 ft, 40 ft and similar U.S. Navy boats and combatant craft. Proposed deterrent systems will be required to keep a steady low angle beam on target from a distance up to 1000 meters and be effective within all environments, conditions, and regions that Expeditionary boats and craft operate. A successful deterrent system would allow embarked security teams to have a concept of operations that does not require that they enter an approaching craft's threat zone, reducing the risk to personnel on both sides by providing an annoying and clearly audible deterrent sound out to 1,000 meters in open water. A marinized Acoustic Hailing system will complement the operational profile of small boats/craft, which can include extreme environmental conditions in which the U.S. Navy operates.

Intelligibility criteria for the Acoustic Hailing voice communication should be minimally at the normal acceptable intelligibility, i.e., about 98% of sentences are correctly heard with single digits understood. The modified rhyme test, phonetically balanced word test and articulation index/speech transmission index are incorporated in the intelligibility criteria.

PHASE I: Develop a concept for a marinized advanced acoustic hailing system for a relevant vessel similar to a U.S. Navy 34 to 40 foot Patrol Boat that meets the requirements in the Description. Demonstrate the feasibility of the operational concept via physics-based modeling and simulation. Define the proposed components of the system hull, mechanical and electrical interfaces, to include power sources as well as any additional functioning design concepts of the system. Provide a preliminary concept design and an associated component validation plan. 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 Acoustic Hailing system capable of being integrated with a U.S. Navy 34 to 40 foot Patrol Boat. Evaluate the prototype to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for the 34 to 40 foot Patrol Boats. Demonstrate system performance through prototype evaluation and testing, modeling, and analysis. Evaluate results and accordingly refine the deterrent system concept. Ensure that the prototyped hardware clearly shows a path to development of a marinized system. The prototype model is to be made available for Government demonstration or testing, as required. Prepare a Phase III development plan to transition the technology to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the fully hardened Acoustic Hailing system for Navy use to include demonstration/sea trials on a relevant vessel. Support for participation in fleet demonstration is aimed at transition with the intent to purchase and integrate the system into the U.S. Navy Patrol Boat Fleet.
A deterrent system of this type should benefit any number of working craft in the fishing, oil, or research industries operating in open water or contested environments.

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KEYWORDS: Intelligibility; Acoustic Hailing; U.S. Navy 34 to 40 foot Patrol Boat; Force Protection; Distributed Maritime Operations; Contested Environment

N241-030 TITLE: Acoustic Training Data Prioritization

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

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

OBJECTIVE: Develop a tool for assessing training data with artificial intelligence or machine learning (AI/ML) algorithms that provides desired data prioritization results from current or new data for effective, complete, and precise training.

DESCRIPTION: Systems that detect and track submarines are migrating to AI/ML to improve the probability of detecting submarines and to limit the probability of false alerts. The current paradigm for training AI/ML is to use large sets of data. However, the cost associated with training AI/ML on large amounts of data is high and may not result in optimal training results.

There is not currently a commercial tool to assess how comprehensive a training set truly is, how much of the training data is effectively redundant, or whether some data over-represents unusual conditions. Additionally, there is not currently a tool that would enable researchers to determine a priori whether a newly collected data set would add useful diversity to the existing training data. This lack of tools for assessing training data for AI/ML algorithms results in a current state where all data is collected for training, resulting in possible excessive training costs as well as possible over-training to specific data which may not be representative of the full range of conditions in which the system will function during hostile tactical operations.

The Navy seeks a tool for analysis of acoustic data collected by undersea warfare systems to enable selection of data that is diverse, representative, and as small as practical for training of AI/ML algorithms. Acoustic data used for detection of submarines is collected on arrays of transducers, whether towed line receive arrays such as the Multi-Function Towed Array, or hull-mounted source/receiver arrays such as the 576-element AN/SQS-53C hull-mounted sonar array. The signals from the transducers are formed into beams representing the acoustic environment as a function of bearing at any given point in time. Key characteristics of data sets will include both meta-data (e.g., season, latitude and longitude, time of day) and attributes of the data (e.g., volume reverberation levels, numbers of “clusters” associated with reflectors such as bathymetric features, marine entities, surface ships, submarines, and wakes).
The tool developed will need to demonstrate the training data prioritization technology which reduces the amount of training data used to allow the AI/ML algorithm(s) to maintain or improve performance. Performance of the system is determined by the Receiver Operating Characteristic (ROC) curve, where recorded data is run through the system to determine the number of true positives are achieved as a function of false positives.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an AI/ML training data prioritization tool that meets the requirements in the Description and demonstrate the feasibility of that concept using unclassified data obtained or created by the company. If the unclassified data is not acoustic data, then it must be clearly extensible to the acoustic data use case. Feasibility will be demonstrated through analysis and modeling. Demonstrate the ROC curve associated with training on all data and how the ROC curve is maintained or even improved when AI/ML is trained using the prioritized subset of all data.

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: Design, develop, and deliver a prototype AI/ML training data prioritization tool for testing and evaluation based on the results of Phase I. Demonstrate the prototype meets the requirements in the Description. The government will provide data sets used to train current AI/ML algorithms that are used in the AN/SQQ-89A(V)15 sonar system, and a MatLab implementation of at least one such algorithm.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The Navy will establish a contract vehicle to apply the training data prioritization technology to AN/SQQ-89A(V)15 in support of additional AI/ML algorithm development opportunities, not limited to Undersea Warfare systems.

Given the emerging importance of AI/ML in numerous major industry sectors this technology can be used in many training areas. Science and engineering professions would do well their training centers to incorporate the technology because of ever changing information data.

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2. "The Essential Guide to Quality Training Data for Machine Learning: What You Need to Know About Data Quality and Training the Machine." Cloudfactory. https://www.cloudfactory.com/training-data-guide
3. Rim of the Pacific (RIMPAC) international maritime exercise website, available 6 Apr 2023 at https://www.cpf.navy.mil/RIMPAC/

KEYWORDS: Artificial intelligence or machine learning (AI/ML); training data for AI/ML algorithms; acoustic data; undersea warfare systems; data that is diverse and representative; Multi-Function Towed Array; AN/SQS-53C hull-mounted sonar

N241-031 TITLE: Silver-Oxide/Zinc Battery Test Measurement and Diagnostic Equipment (TMDE) Tool

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

OBJECTIVE: Develop a man-portable Battery Test Measurement and Diagnostic Equipment (TMDE) tool for assessing health status and remaining useful battery life of Silver-Oxide/Zinc (AgO/Zn) batteries to provide a cost savings while increasing safety and readiness.

DESCRIPTION: AgO/Zn battery cells are safe for use onboard submarines and are a field-proven power source for underwater vehicles with a wet-life of about 24 months. One of the main challenges associated with deployment of AgO/Zn battery cells is the lack of a reliable and accurate way to measure the battery's state of charge, state of health and remaining useful life at any stage of application/in-situ. Currently, the AgO/Zn battery (up to 120 cells in series) set assembled with 365 ampere hour (Ahr) capacity is de-commissioned based on the pre-determined wet-life duration instead of cell state-of-health due to a lack of commercial ability to assess state-of-health without extensive analysis or destructive testing. This results in potentially healthy batteries being removed from service before the end of useful life. The Navy is seeking a man-portable (preferably hand-held or laptop installed) Test Measurement and Diagnostic Equipment (TMDE) tool that can detect early signs of battery degradation and predict the remaining useful life of AgO/Zn batteries, other, application and scalability to additional battery chemistries are also desired.

A TMDE tool would result in cost reduction, risk reductions, and better sustainment of fleet underwater vehicles by removing batteries from fleet once a 'true' End of Service Life was met based on battery condition versus timed maintenance. It would achieve these benefits by allowing maintenance activities to provide requisite Objective Quality Evidence (OQE) to determine life extensions, informing maintainers of the real-time battery conditions that indicate a thermal event, allowing operators and maintainers to make more informed and safer decisions, and enable targeted replacement of weak cells in a battery set instead of replacing the entire battery set. The latter would increase the life of a battery set, thereby reducing the amount of battery sets needed to be purchased and increasing operational availability. The former would reduce schedule risks when planning and conducting operations.

The tool developed must be non-destructive and user-friendly with a graphical user interface (GUI) to display metrics to accurately describe battery condition. It should utilize advanced sensor technologies to assess the state-of-health and remaining useful life of AgO/Zn battery sets prior to deployment, transport, maintenance, or storage. If the device is handheld, it should be battery powered by 20VDC or less, and rechargeable using standard 110VAC.

PHASE I: Develop a concept for a portable Battery Test Measurement and Diagnostic Equipment tool that meets the requirements in the Description. Establish feasibility by developing system diagrams as well as Computer-Aided Design (CAD) models that show the tool's design concept, and provide estimated weight and dimensions of the concept. Feasibility will also be established by computer-based simulations that show the system's capabilities are suitable for the Navy's needs. 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 fabricate a prototype for demonstration and characterization of key parameters of the TDME tool as detailed in the Description. Conduct a prototype demonstration capable of full-scale operation according to the design. Complete relevant testing to prove the full-scale metrics. Based on lessons learned through the prototype demonstration, develop a substantially complete design to allow for

Navy integration. Ensure that this design includes all ancillary equipment required to operate components such as the TMDE tool and control software when applicable to the proposed concept.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Although a fully operational TMDE tool is initially targeted for use in maintenance and sustainment of underwater vehicles, it should have the ability to support additional battery chemistries and be suitable for shipboard use.

The TMDE tool could be useful in commercial applications where safe, high energy density batteries are used. Examples would be oceanography, offshore oil rig inspection, UAVS, and robotics.

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KEYWORDS: Silver-Oxide/Zinc Battery; Battery/Cell State-of-Health; Electrical Test Measurement and Diagnostic Equipment Tool; Non-destructive battery testing; Battery State of Health Estimation Experimental Methods, Battery State of Health Model-Based Estimation Me

N241-032 TITLE: Air Cushioned Vehicle Erosion Resistant Coatings

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

OBJECTIVE: Develop coatings suitable for metal and marine composites to improve durability, decrease maintenance time and costs, and improve craft operational availability.

DESCRIPTION: Landing Craft, Air Cushion (LCAC) and Ship-to-Shore Connector (SSC) are Air Cushion Vehicles (ACVs), or “hovercraft”, providing amphibious transportation of equipment and personnel from ship-to-shore and shore-to-shore. Erosion has been an antagonist for the ACV industry for many years. In operation, ACVs produce high airflow rates at speeds up to 300 mph across mostly composite components and surfaces. This massive amount of air flow can be saturated with saltwater and sand particulates. ACV components are also exposed to constant vibrations, high winds, impacts, and other foreign object debris. ACVs require erosion protection to cover large internal composite surfaces while minimizing both cost of acquisition and manpower for installation and maintenance. After a comprehensive survey of the industry, multiple commercial products have been attempted with no viable solution found. The internal flow surfaces on the craft that must be preserved from erosion include the bow thruster nozzle, upper lift fan volute, lower lift fan volute, propulsor shroud, propulsor stators, and rudders. As each component is custom and designed specific to its location, it must maintain its shape and composition. Figures and dimensions of these components can be found in Reference 4 linked below. The Navy has researched and evaluated multiple erosion coatings and tapes with marginal success in the harsh environment. Current solutions are difficult to apply and repair in the field. The Navy is seeking an optimized erosion protection solution to decrease maintenance and inspection intervals on all ACV composite surfaces, increasing mission efficiency and readiness. This product solution should be manageable for the onsite maintainers to reapply and repair when needed, including inside an amphibious ship’s well deck or on an isolated beach in a deployed environment. A successful coating technology must bond to all contact surfaces and not present the possibility of separating or delaminating, causing further damage to other components. A solution that meets all ACV erosion requirements would result in lowered overall maintenance effort and cost.

PHASE I: Develop a concept for erosion prevention for ACVs that meets the requirements as described above. Demonstrate the feasibility of the concept in meeting Navy needs. Demonstrate that the durable erosion prevention application can be readily and cost-effectively manufactured through standard industry practices by material testing and analytical modeling. The Phase I Option, if exercised, should include the initial layout and capabilities to demonstrate the application in Phase II.

PHASE II: Based on the results of the Phase I effort and the Phase II Statement of Work (SOW), develop and deliver an erosion prevention application that meets the requirements in the Description. A production representative application will be installed on an actual ACV component or appropriate test platform for durability and wear testing. The technology will be evaluated and compared to other erosion prevention methods to determine its ability to meet specified requirements. These evaluation results will be used to refine the erosion prevention application into a design that will meet ACV Craft Specifications. Prepare a Phase III development plan and cost analysis to transition the technology to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the erosion prevention application for use on the ACV program. The satisfactory ACV erosion prevention method will have private sector and commercial potential for hovercrafts of this scale operating in the near-shore or on-shore environment, which are all currently struggling with erosion prevention. Commercial applications include ferries, the oil and mineral industry, cold climate research and exploration. Other industrial and military machinery with high airflow could also benefit from technologies developed during this effort.

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KEYWORDS: Air Cushion Vehicle (ACV); Ship-to-Shore Connector (SSC); Landing Craft; Air Cushion (LCAC); Foreign Object Debris; High Velocity Airflow

N241-033 TITLE: Inert Gas Reclamation for Minimally-Enclosed Directed Energy Deposition (DED) Additive Manufacturing (AM) Equipment

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

OBJECTIVE: Develop a modular system designed to reclaim inert gas used during the metal Directed Energy Deposition (DED) Additive Manufacturing (AM) process.

DESCRIPTION: Currently, AM equipment suitable for afloat use is limited. The current capabilities were installed to support the development integration requirements for AM equipment, but is limited to polymer machines. Current metal AM technologies are designed for the lab or machinery spaces ashore, and have not been configured for the harsh shipboard environment. The inclusion of a metal AM capability shipboard would drastically improve ship self-sufficiency and increase readiness.
There are increased needs for AM afloat as it is explicitly identified in the COMNAVSEA Campaign Plan 3.0 as a technology focus area. The Navy directly supports efforts to integrate AM into the Fleet and support a more self-sufficient ship. The Navy seeks to maximize its use of AM to fabricate "hard to source" or obsolete parts, reduce cost, field more effective systems, and reduce reliance on vulnerable supply chains through production at the point of need.

Current metal AM technology can be classified under powder bed fusion (PBF), DED, material extrusion, sheet lamination, or hybrid processes. These processes all have their benefits and limitations from a part production standpoint. At this time, these metal AM system installations are typically expected to be on the shop floor in industrial or lab settings. There is an interest to integrate these metal AM systems in more expeditionary settings to increase warfighter readiness and increase the Navy's distributed manufacturing capabilities and self-sufficiency. The operational conditions within these expeditionary settings include ship motion, ship vibration, shock, ventilation, and electromagnetic interference (EMI). In order to successfully install metal AM equipment and enable adequate operation of the equipment, the machine must not experience severe degraded performance under these conditions. Testing of these conditions in the lab environment should occur to determine system performance under shipboard environmental conditions.

Specifically related to this SBIR topic, these metal AM machines use an inert shielding gas to manufacture components, a consumable that is a logistical challenge in an expeditionary environment. This inert gas is utilized to provide an inert environment for the deposition of the material to form but is off-gassed into the atmosphere. Capturing, cleaning, reusing, and overall reclaiming this gas would be beneficial to utilizing this process in a deployed environment because there would only need to be a small amount on hand for startup that could then be reclaimed throughout the life of the builds. The solution must not impede on the operations of the DED process, ensuring that there are no capability reductions as a result of the gas reclamation. Another aspect to this solution is that the manufacturing envelope will not be completely sealed to the outside atmosphere, which adds complexity to the reclamation strategy. As a result, the company shall take this into account when selecting alternatives to investigate. In addition, this solution would require shipboard hardening, a small footprint not exceeding the footprint of the machine in which it is installed, high efficiency, modularity, and innovative approach to meet the topic criteria. This SBIR topic will address the current shipboard mitigation requirements associated with shipboard integration and performance of metal AM. The product developed from this topic could result in the establishment of a Navy vendor for shipboard AM equipment. In addition, the current modifications, costs, and qualification to Commercial Off the Shelf (COTS) equipment would no longer be required if the system was designed around the shipboard environment. AM has the potential for major readiness impacts for the Fleet, improving self-sufficiency and reducing the reliance on the supply chain.

PHASE I: Develop a concept for a gas reclamation system(s) into a minimally closed DED machine. This means that the manufacturing envelope will not be completely sealed to the outside atmosphere, which adds complexity to the reclamation strategy. As a result, the company shall take this into account when selecting alternatives to investigate. Feasibility shall be demonstrated by conceptual models, drawings, integration schematics, and description of workflow and operation. The concept during this stage should also consider the operation of the machine, requirements for installation, and lifetime maintenance that is necessary. 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 which will be evaluated based on the overall integration into an existing machine. This prototype shall have no interruptions with the main functionality of the system and tie seamlessly into the existing workflow. It shall also be user friendly by providing an easy-to-use interface, warnings if something is out of normal operating parameters, and minimal maintenance. The prototype shall also be compact into as small of a form-factor as possible due to the limited space available in the expeditionary environment. The system should aim to be able to fit within the footprint of the identified DED machine or be no larger than the size of the machine.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the reclamation capability to Navy use. Use the feedback from Phase II and perform necessary changes to complete the prototype. The final product shall be a turn-key system that can be integrated into machines that are already deployed or planned to be deployed. This would include, but not be limited to, having Standard Operating Procedure (SOP) documentation, installation instructions, and troubleshooting tips and tricks, as necessary. The platform in which this machine would be targeted would be the installations of this type of equipment through the NAVSEA 05T1 AM Program Office's Afloat Program of Record on the following, but not limited to, large deck platforms and regional maintenance centers.

The dual use of this developed final product outside of the military will be able to reach a wide breadth of companies with similar DED machines. The ability to have a system like installed on other machines means a logistical burden of resupplying inert gas for the manufacturing process is lifted from all users.

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KEYWORDS: Directed Energy Deposition; Gas Reclamation; Additive Manufacturing; Inert Gas; Hybrid Metal Additive Manufacturing; Expeditionary Additive Manufacturing; Gas Recycling

N241-034 TITLE: Modular and Scalable Extended-Sonobuoy Deployment System

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

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

OBJECTIVE: Develop and deliver an innovative low Size, Weight, Power and Cost (SWaP-C) Modular and Scalable Extended-Sonobuoy-Form-Factor Deployment System for an A-sized or extended A-sized Sonobuoy Form Factor Unit that can be easily integrated on multiple platforms.

DESCRIPTION: As underwater systems become increasingly prevalent in maritime operations, the Navy requires a means of deploying A-sized and extended A-sized sonobuoy form factor units as single and multiple payloads from various platforms including craft and vessels of opportunity. The Deployment System should be capable of deploying an encased A-Sized Sonobuoy and an encased extended A-sized sonobuoy form factor payload roughly the size of a cylinder 5.5 inches in diameter and 48 inches of length with a weight of 40 pounds. When deployed, the case (e.g., sonobuoy launch container) shall be left behind in the deployment system. Currently, there is no commercial technology that meets this requirement.

The Deployment System must be designed to be modular/reconfigurable such that it is capable of deploying 1 to 16 A-sized or extended A-sized sonobuoy form factor payloads depending on the platform’s available payload space. It must also not interfere with operations of the vessel and must be capable of deploying explosive payloads. For the purposes of this SBIR topic, deploy can mean released, launched, propelled or dropped in the water. However, the payload deploying mechanism must result in a consistent, repeatable, and safe separation of the payload.

At its maximum configurable size (16 payloads) the deployment system shall deploy each payload at a minimum distance of 3 plus or minus 0.5 meters. At its minimum configurable size (1 payload), the deployment system shall deploy each payload at a minimum distance of 0.5 plus or minus 0.1 meters. At its maximum configurable size (16 payloads), the deployment system must be capable of integrating on the deck of a vessel with a maximum footprint of 238 inches by 70 inches, a deck load of 3,400 pounds and electrical power of 28 VDC at 25 A supplied by the vessel. Coordination with NAVSEA will be critical to understanding the most current available space(s) aboard other platforms, crafts and vessels of opportunity, as well as any weight/power restrictions on the Deployment System.

The Deployment System must be simple enough in design to allow for sustained operations and must be capable of at least 100 deployments before repair or refurbishment with high reliability and little maintenance down time for 24 hour/7 day surge periods. The Deployment System must also include a communications interface. While a communications package is not part of this topic, the deployment system should be capable of interfacing with a data communications system. The interface is intended to provide a mechanism for future unmanned or autonomous deployment. The system shall adhere to all applicable environmental standards of the latest version of MIL-STD-810, such as shock, vibration, electromagnetic interference/emission, etc.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an innovative Modular and Scalable Extended-Sonobuoy Deployment System that meets the requirements specified in the Description. Demonstrate the feasibility by modeling and simulation, analysis, and/or laboratory experimentation, as appropriate.
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 for evaluation. The prototype will be evaluated to determine its capability in meeting the Navy’s requirements. Perform detailed analysis, and live demonstration in a test environment as part of the evaluation. Provide detailed technical documentation of the design, including an interface control drawing and interface specification, to allow successful transition of the product.

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

PHASE III DUAL USE APPLICATIONS: Support the transitioning the technology to Navy use through system integration and qualification testing of the Modular and Scalable Extended-Sonobuoy Deployment System. If successful, the Modular and Scalable Extended-Sonobuoy Deployment System could be applied to other Navy platforms.

In addition to such DoD applications, the communication system could be used in commercial oil, gas, and oceanographic sensing applications.

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KEYWORDS: Deployment System; Low SWAP-C; Surface Vehicle, sonobuoy, A-sized sonobuoy; Easily Integrated; Reconfigurable; Sustained Operations

N241-035 TITLE: Coordinated Effectiveness Assessment

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE);Integrated Network Systems-of-Systems

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

OBJECTIVE: Provide an automated Tactical Effectiveness Service for Electromagnetic Effectors (TES-EE) within the decision support services of the Integrated Combat System which provides consistent and accurate real-time effectiveness assessment of electromagnet engagements for coordinated engagements among hardkill and softkill effectors across the force.

DESCRIPTION: Typical engagements conducted by Naval platforms employ either hardkill or softkill effectors. Kinetic effectors (hardkill) such as missiles, naval guns, or other types of projectiles defeat targets primarily using kinetic energy alone or with the assistance of energetics to physically damage or destroy the target, rendering it harmless as a threat. The effects of a kinetic engagement are generally straightforward to observe, and may include rapid changes of trajectory, observing a single target becoming many smaller targets, detection of explosions, inability to reacquire the target after impact, and many others. In short, the effects are typically easily observable using typical Naval sensor suites. A limitation of kinetic effectors is that they are limited in number, and once expended, are not easily replenished in the heart of a battle.

Conversely, electromagnetic (EM) engagements (softkill), such as those accomplished through lasers, high power microwaves, other radio frequency (RF) sources, or other electronic attack mechanisms, can be much more subtle in their effects and may not be directly observable by naval sensor suites. Where kinetic weapons like missiles typically take time to travel to the target, but once there, achieve a near-instantaneous effect, EM engagements may start immediately (think of applying laser energy to a target), but may take some amount of time to accomplish their purpose (that is, laser dwell time on a spot to burn a hole). Some EM effects may be observable, such as in the case of a laser burning a hole in the flight control surfaces of an unmanned aerial vehicle, causing it to plummet to the water below. Others, such as RF energy, may be achieving an effect to prevent the target from acquiring its target, but from outside observation, the target is still behaving nominally. EM effectors, unlike kinetic effectors, are not inherently limited to a finite number of shots, and therefore may represent a greater number of engagement opportunities than their kinetic analogs.

A challenge for naval forces is achieving efficient expenditure of effectors to balance adequate self-protection with mission completion. EM effectors offer the promise of defeating threats without the expenditure of limited kinetic effectors, which can then be preserved for the most stressing threats. The ability to defeat threats with a mix of kinetic and EM effectors opens the possibility of optimizing the use of engagement resources to defeat the greatest number of threats while prolonging the amount of time the force can stay in the fight. This is only possible if the predicted effectiveness of a weapon can be determined and the actual effect against a live target can be assessed in real-time. Herein lies the challenge inherent to EM weapons, and subsequently the challenge in effective kinetic/EM coordination. To effectively make use of EM weapons, the warfighter (or the combat system acting on the warfighter's behalf) must be able to determine if the EM weapon being employed is achieving the desired effect. The greater confidence the warfighter has that the weapon will achieve the intended effect against the target, the more likely he or she is to rely on it in real circumstances. Similarly, in live operations, the ability to confidently determine whether the EM weapon is being effective on an engagement-by-engagement basis is critical to efficient and effective employment of coordinated kinetic/EM engagements. Currently, there is no commercial means to make this assessment.

The Navy needs a means by which to assess in real time the softkill effectiveness expectation that EM weapons are having against a threat to make decisions about whether additional engagement resources may be needed. Moreover, confidence in the predicted effectiveness of EM weapons as well as the real-time performance may even lead to warfighter decisions to employ them first, ostensibly preserving kinetic effectors. This tradeoff is a challenge when conducting engagements from a single ship, and only grows more complex as we scale to the Integrated Combat System (ICS) vision of force-level engagement coordination of kinetic and EM effects. An automated TES-EE is needed to determine how real-time effectiveness of EM engagements can be consistently determined and provided to the warfighter across the spectrum of naval EM weapons (e.g., directed energy, electronic attack, high-power RF/microwave, etc.). An operator must be able to confidently rely on the effectiveness of data being provided in order to make decisions regarding employment of supplemental weapons for the engagement.

The solution will leverage all available sensor and data feeds available on a surface ship to assess effectiveness of EM Effectors and communicate that to the ICS as a success/no-success or percent chance of success assessment of the desired EM Effector intent. Effectiveness assessments should be presented to operators as a combination of an ‘alert’ and relevant data for each effector engagement pairing via current operator graphical user interfaces and may leverage updates to display architectures planned by ICS. Transition is expected to be via the ICS program, notionally as a hosted application, service, or container(s) as best supports the implementation.

The solution will provide a description of mechanisms for assessing the real-time performance of EM Effectors (such as SLQ-32(V)7, LEED, NULKA, etc.) against nominal threats in the context of a surface Navy combat system. Additionally, the Government desires a System Modeling Language (SysML) model and sufficient views to represent the TES-EE concept that captures necessary TES-EE inputs and system responses agnostic to a specific combat system and analyses to quantify expected impacts to self-defense performance and potential confidence bounds associated with EM versus kinetic weapon expenditures.

The TES-EE prototype will demonstrate software algorithms, present EM real-time effectiveness data to the warfighter supporting tactical decision making, provide data and associated analyses demonstrating kinetic weapon expenditure reduction through effective EM weapon employment, a software design model of the prototype TES-EE with traceability to the system model, and a white paper describing the prototype TES-EE’s extensibility to supporting force-level (multiple ships acting in concert) engagements.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a TES-EE 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 demonstrate a prototype TES-EE based on the results of Phase I. Demonstrate the prototype's functionality through software design modeling that provides the warfighter real-time data for tactical weapon employment decisions in a containerized microservices architecture.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final product will be the set of containerized applications that make up the TES-EE along with the necessary product-level objective quality evidence to support authorization for demonstrations via Mission Readiness Assessments (MRAs) and certification as part of the ICS. Developers for TES-EE are encouraged to leverage the Forge Ecosystem for development and testing to leverage the benefits of the Surface Navy's DevSecOps pipeline for combat systems. Support Level 3-5 combat system test events as necessary.

The TES-EE will provide a critical Decision Support Service as part of the ICS Combat Management System architecture, paving the way for integrated kinetic/EM coordination. The TES-EE will be able to be deployed to USN ships of all classes (DDG, FFG, CVN, L-Class) upgraded with a computing environment that enables independent applications/services to be employed. All ICS platforms will enable independent applications/services within the combat system enclave.
As a standalone application or as a plug in with other decision support applications, there are potential commercial applications in the communications sector assessing or obviating electromagnetic interference in over-the-air communications through frequency agility or bandwidth management methodologies and enhancing site security assessments associated with vehicle disablement options at facility entry points.

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KEYWORDS: Engagement Coordination; Hardkill or Softkill Effectors; Integrated Combat System; Decision Support Services; Softkill Effectiveness; Real-Time Effectiveness Assessment

N241-036 TITLE: Virtual Well Deck Operations Trainer: Line Handling

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

OBJECTIVE: Design and develop a virtual Well Deck Operations Trainer replicating an L-Class ship well deck environment able to support and train various surface craft and shipboard crews on duties and responsibilities associated with embarking, debarking, and emergency procedures of expected connectors (i.e., Landing Craft Air Cushion (LCAC), Ship to Shore Connector (SSC), Landing Craft Utility (LCU), small boats).

DESCRIPTION: There are currently limited training resources that develop individual and collective proficiency for handling craft inside an L-class ship well deck. In a review of data regarding the Well Deck Watch Stations training, it becomes clear that there is a need to standardize and enhance the existing training approach. The current process involves On-the-Job Training (OJT) along with a Personal Qualification Standard (PQS) and Job Qualification Requirements (JQR). However, additional training is sought to maximize effective OJT. The establishment of a training continuum. either virtual or on a scaled temporary on demand basis. that emphasizes performance in a controlled environment is required to support expeditionary readiness.

A Well Deck Line Handler Trainer would be part of a training continuum utilized prior to conducting training/operations aboard Naval shipping at sea, so that time and training value can be maximized. The Well Deck Operations Trainer, either virtual or on a scaled temporary on demand basis, shall provide live form and function capabilities associated with well deck operations to meet individual and collective training standards. The proposed solution should provide line handlers, supervisors, and small craft operators an opportunity to train under realistic conditions in a controlled environment before underway operations on an L-class ship. The well deck, as much as possible, shall replicate the material and working conditions of an L-Class ship to prepare individuals and crews for live shipboard operations. The LPD 17 Class well deck is 188 feet long and approximately 50 feet wide at mid well, increasing to 59 feet at the sill, or stern of the ship. Vertical clearance in the well is 31 feet. The trainer should be able to replicate ballasting requirements for various craft to include maximum 8-10 ft at the sill for LCU operations. To support training requirements, the Well Deck Operations Trainer should provide embark and debark procedures that replicate recovery and emergency procedures for craft expected to conduct wet well operations. The trainer should include a catwalk where line handlers are stationed, as well as replication of day and night operations. Training should be structured to replicate skill components required of the integrated working environment utilizing the building block approach.

The culmination of block training would be conducting line-handling duties aboard L-class shipping under normal operating conditions. The phased approach is a cost-effective solution that maximizes prime time skills development ensuring a high level of competency.

The design, development, and implementation of a Well Deck Trainer will provide a location for teams to train, rehearse, and refine Required Operational Capabilities and Projected Operational Environment (ROC/POE) and Mission Essential Tasks (METs) that directly relate to amphibious requirements.

PHASE I: Develop a conceptual design to meet the requirements in the Description. Through modeling and simulation, or other means, demonstrate the feasibility to develop a concept that meets the needs of the Navy. 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: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop and deliver a prototype. Demonstrate the capability of the prototype to recover and secure an LCU in a controlled environment incorporating line-handling practices. Construct one task trainer prototype for testing. Support the Navy for test and validation in accordance with Navy regulations and requirements. Navy technical leads will validate the prototype to ensure compliance with training certification requirements. Refine the design of the Well Deck Operations Trainer for the training and qualification of line handlers and small craft/boat crews to conduct wet well procedures.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Following testing and validation, implement the final prototype at multiple sites in Fleet concentration areas.
This technology will help the Navy meet the critical needs of increased warfighting capability for L-Class ships and expand the Amphibious Warfare Mission Area(s). Rescue boat crews from civilian fire and law enforcement rescue units will also benefit from this training.

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KEYWORDS: L-Class Ship; Well Deck; Embark; Debark; Wet Well Operations; Small Craft launch and recovery

N241-037 TITLE: Weapons Scheduling for Uncertain Weapon-Target Assignment

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

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

OBJECTIVE: Develop an automated capability for the Ship Self-Defense System (SSDS) that maximizes weapon scheduling effectiveness where explicit weapon-target assignment solutions are not possible.

DESCRIPTION: Current US Naval platforms use a variety of onboard sensors, communications networks, data processing systems, weapons, and other components organized into a combat system to detect, track, and classify inbound targets, determine how to best employ weapons and countermeasures to defeat those targets, and then use those weapons and countermeasures to maximum effect. This involves explicit selection, scheduling, and assignment of self-defense weapons to inbound targets to achieve an optimal defensive solution, often across multiple layers of weapons in range (i.e., “depth of fire”). This process uses a variety of factors to make explicit weapon-target assignments (WTA) and schedule engagements against incoming targets, including but not limited to: assessments of target attributes, the number of detected targets, the number of defensive weapons in inventory, doctrine describing how and when particular weapons are used, and other factors. Furthermore, engagement schedules are “dynamic, changing as new sensor data are provided, additional targets are disclosed, and initially scheduled engagements are executed” [Ref 1]. This is a challenging and complex process.
Due to the ever-shifting landscape posed by our adversaries, future Naval combat systems must be resilient to scenarios in which generating engagement schedules with explicit WTA approaches are not tenable and no current solution is available. The Navy therefore seeks an automated capability that generates engagement schedules enabling incoming target raid annihilation in the face of uncertainty regarding the number of inbound targets, the physical location and position of targets, knowledge of expected inbound target behavior during terminal homing phases, inferred target identity, and other characteristics occurring during off-axis, massed and/or swarm attacks [Refs 2, 3]. Proposals using machine learning approaches will also be considered, but candidate solutions must be capable of generating schedules against completely novel, never-before-seen threats and raid conditions, and in scenarios for which training data for use in ML-focused solutions cannot be provided. Solutions must reside inside and support integration into the SSDS combat management system (CMS) (that is, algorithms should not be targeted for integration into weapons or sensors), but must use data (e.g., radar track and state data, sensor data, and others) that are common to other CMSs. Furthermore, the solution should consider the potential complexities introduced by distinctions between CMS-provided WTA, and WTA approaches decided by defensive interceptors themselves as they near their targets [Ref 4]. Finally, the solution must be compatible with current combat system operational characteristics and constituent components (that is, solutions cannot depend on integrating new weapons and/or sensors into the combat system) [Ref 1]. The solution used to demonstrate proposed methods and/or algorithms for scheduling under WTA uncertainty should be demonstrated under low- to medium-fidelity modeling and simulation approaches. Simulation and analysis results should be presented in the form of scenario descriptions, Red and Blue force asset laydown(s), and engagement timelines using synthetic yet realistic engagement events, parameters, and data. The inner workings of proposed algorithmic approaches must be explainable.

Three SSDS Top Level Requirements (TLRs) would be supported by this investigation. These TLRs will be provided by the government to the awardee. These requirements are:

- The SSDS CS shall determine, recommend and apply weapons tactics to include firing policy, salvo size, and salvo spacing [SSDS_CS_TLR-1571];
- The SSDS CS shall reevaluate and rebuild HK and SK schedules periodically, as well as when certain events occur that can change target and resource status [SSDS_CS_TLR-1674]; and
- The SSDS CS shall consider the effects of multiple targets in the weapon's field of view on weapon performance when building the engagement schedule [SSDS_CS_TLR-1684].

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a capability to generate SSDS engagement schedules that enables incoming target raid annihilation without using explicit weapon-target assignment approaches. Demonstrate the feasibility of the concept to meet the conditions outlined in the Description section 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 an engagement scheduling system prototype capable of meeting realistic engagement and operational requirements based on the results of Phase I. Demonstrate at a Government- or company-provided facility that the prototype meets all parameters detailed in the Description. The technology will be assessed by Navy subject matter experts.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The technology will go through system integration and qualification testing for the prototype engagement scheduling approach developed in Phase II. This prototype will be delivered to support the Navy through a critical experiment conducted jointly by the awardee and combat system engineering agent (CSEA). This is expected to take place in a live environment with tactical SSDS CMS software. Integrate the prototype into the SSDS CMS.
Dual use applications to consider include commercial resource management, delivery, and scheduling challenges that are particularly vulnerable to uncertainty that is difficult to deterministically quantify and/or changes over time.

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KEYWORDS: Operational characteristics; WTA uncertainty; weapon-target assignment; schedule optimization; stochastic optimization; weapons and countermeasures

N241-038 TITLE: Runtime Software Verification for Non-Standard Compute Infrastructure

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

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

OBJECTIVE: Develop an automated software runtime verification capability that reveals errors or conditions for combat management systems running on US Navy ship computer hardware.

DESCRIPTION: Current US Naval platform combat management systems are a system-of-systems, operating as a complex collection of computers, controllers, sensors, communications networks, rack-mounted servers and hardware, and other systems required to accomplish the ship's objectives. These components communicate and interact over local area networks. Safeguards must be taken to identify unexpected errors before they result in potentially catastrophic system failure modes, improving the resilience and reliability of platforms and the safety of embarked personnel. Currently there are no commercial solutions known that apply to the Navy's need. The Navy seeks an automated software solution, using current development and engineering approaches, that updates both software and computing infrastructure (CI) hardware on faster timescales than current refreshes and overhauls. Improved methods to identify unexpected but potentially catastrophic failure modes while new software is running on new CI would significantly improve the resilience and reliability of the Navy's future combat management systems. Three Ship Self-Defense System (SSDS) Top Level Requirements (TLRs) would be supported by this investigation. The TLRs will be provided by the government to awardee. These requirements are:

- The SSDS Combat System (CS) shall have the ability to automatically discover, identify, and record security relevant information such as hardware and software attributes [SSDS_CS_TLR-1065];
- The SSDS CS shall periodically validate the integrity of persistent operating system and application software files against a known-good baseline, and log and notify the operator for further analysis [SSDS_CS_TLR-1071]; and
- The SSDS CS shall support modular, extensible, rapid, and transparent introduction and integration of new and updated cybersecurity capabilities to the CS elements [SSDS_CS_TLR- 2162].

The solution must monitor and detect early indicators and warnings (I&W) of combat system software component errors or failures through the application of runtime verification or dynamic software analysis techniques. Critically, this approach must be able to detect these conditions in combinations of software and CI that cannot be anticipated and tested prior to release (i.e., as both hardware and software are upgraded across the lifetime of the ship). An approach should be used that supports displaying detected findings relevant for embarked personnel. It should provide personnel an understanding of the nature of the identified I&W so actionable steps can be taken before catastrophic system failure occurs. Runtime error types relevant to combat management systems include memory leaks and memory management errors, system process concurrency errors, race conditions, livelocks, deadlocks, and unexpected system process executions. Furthermore, while relevant errors can address potential cybersecurity vulnerabilities, solutions are desired that address the above types of runtime errors. Note that potential solutions should be distinct from software verification techniques that can be used during the software engineering process (e.g., static code analysis, fuzzing, testing, and others). Potential solutions should be suitable for the SSDS but also support extensibility to other combat management systems [Ref 1]. Finally, solutions must be flexible enough to support prototype construction and integration into US Navy consoles and display system approaches, as well as perform these tasks agnostic of specific combinations of software and CI hardware.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for performing automated runtime verification of combat management system (CMS) software components. The concept must demonstrate feasibility to detect early indications and warnings (I&W) of potential error modes, as well as an approach to display those errors for relevant embarked personnel according to the parameters of the Description. Demonstrate feasibility through modeling, simulation, analysis, or other formal methods. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype automated runtime verification solution capable of meeting realistic operational requirements for the SSDS based on the results of Phase I. Demonstrate at a Government- or company-provided facility that the prototype meets all parameters detailed in the Description. The government will provide a reference combat management system architecture example and additional information for demonstration development. The technology will be assessed over the course of Phase II by Navy subject matter experts.

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: Support the Navy in transitioning the technology to Navy use. The final product will use system integration and qualification testing. This prototype will be delivered to support the Navy through a critical experiment conducted jointly by the company and the combat system engineering agent (CSEA). This is expected to take place in a live environment with tactical SSDS CMS software. Integrate the prototype into the SSDS CMS.
Dual use applications to consider include extension of these technologies and capabilities to any safety-critical system monitoring use cases, including but not limited to: industrial control systems; manufacturing systems; electrical grid or other resource distribution systems; transportation and logistics systems; and others.

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KEYWORDS: Runtime verification; software verification; dynamic software analysis; formal methods; system failure modes; combat management systems

N241-039 TITLE: Portable Boats & Small Craft Assembly Kits

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

OBJECTIVE: Develop a craft that is easily manufacturable in theatre to allow more assets to arrive at the Expeditionary Advanced Base (EAB) within the same shipping/logistic footprint for forward deployments.

DESCRIPTION: More craft available in theater would support reduction in refuel, rearm, and resupply times allowing on demand supply transport from a capital asset or a supply depot to forward bases. This will enable risk worthy asset support to contested logistics and distributed lethality during littoral operations in a contested environment through manned or unmanned operations. The kit shall be stored within a standard shipping container no larger than 40 foot that may contain other supporting equipment. A form factor similar to the portable rigid inflatable boat is desired. Craft must be recoverable by conventional ship boat handling mechanisms. Maximum craft weight cannot exceed 5,600 pounds fully outfitted. The portable boat & small craft assembly kits need to contain, within shipping containers, all components needed for construction. Forward deployed sailors would then construct the craft, assisted by manufacturing aids. The craft that is manufactured would then need to meet stability and speed requirements in a minimum of sea state 3.

Stage of completion and speed to deployment must be weighed against compactness of shipping. Flexibility to disassemble craft for storage or repurposing is desired. Craft operation should not require more than two boat operators. Expected maximum payload is no more than 925 pounds. Payload includes weapons/ammo (forward M60/M240 machine gun mount), other outfit and personnel.
Autonomous operation is not a requirement but inclusion of the capability to attach a tactical autonomous operation kit is desirable. Number of craft kits per container will be determined by scale of finished craft and volume needed for accessories and payload support systems. Payloads may include offensive or defensive systems and humanitarian support.

PHASE I: Develop a concept for portable boats & small craft assembly kits for an Expeditionary Combatant Craft or relevant vessel. Demonstrate the feasibility of the operational concept via physics-based modeling and simulation. Define the components of the system and hull, mechanical and electrical interfaces as well as additional functional design concepts of the system. Provide a preliminary concept design and an associated component validation plan. 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 portable boat & small craft assembly kit capable of being constructed by forward deployed sailors. Evaluate the prototype to determine its capability in meeting the performance goals defined in the Phase II SOW. Demonstrate system performance through prototype evaluation and testing, modeling, and analysis. Evaluate results and accordingly refine the system concept. Ensure that the prototyped hardware clearly shows a path to development of a sea worthy hardened system. The prototype model is to be made available for Government demonstration or testing upon Government request. Prepare a Phase III development plan to transition the technology for Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the system for Navy use. Support the Navy in transitioning a fully hardened system for sea trials to be demonstrated on a relevant vessel. Ensure that the system passes an underway test to be developed for the defined test platform. Support for participation in fleet demonstration is aimed at transition with the intent to purchase and integrate the system into the US Navy.

Commercial applications include disaster recovery efforts where an abundance of quickly assembled small craft will make significant impact in humanitarian relief efforts in moving people and provisions in ravaged environments brought on by natural disasters or war.

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2. Smith, Eric M, Lieutenant General, US Marine Corps, Deputy Commandant for Combat Development and Integration, 'Tentative Manual for Expeditionary Advanced Base Operations", February 2021, https://mca-marines.org/wp-content/uploads/TM-EABO-First-Edition-1.pdf

KEYWORDS: Portable Boats; Assembly Kits; Force Protection Operations; Distributed Maritime Operations; Littoral Operations; Contested Environment

N241-040 TITLE: Additive Manufacturing of Textured Piezoelectric Ceramics

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

OBJECTIVE: Develop a low-cost, flexible manufacturing technique to produce textured piezoelectric ceramics for undersea sensor applications.

DESCRIPTION: Ceramics with a high degree texturing or grain alignment can exhibit enhanced properties compared to traditionally manufactured ceramics with randomly oriented gains. One such property benefitting from gain alignment is improved piezoelectric performance of ceramics used for sonar sensor applications (early prototypes have shown upwards of 12dB improvement in performance, enabling sensors to detect potential threats much farther out). Current manufacturing techniques to produce highly textured ceramics involve using an expensive and complex tape casting technique to properly align the material seed crystals.

Additive manufacturing (AM) could provide a solution by improving the Manufacturing Readiness Level of these new textured ceramic materials and enabling technology insertion at a scalable, cost-effective rate. Current stereolithography (SLA) and digital light processing (DLP) 3D printers create parts by using a light source to polymerize a liquid photopolymer resin to create a high resolution 3D printed part with minimal need for additional post processing. SLA employs a laser to trace the shape of each layer. DLP, on the other hand, projects a mask of a whole cross-sectional layer at a time. Proposals will be evaluated on the modification to the existing photo-polymerized resin systems used in SLA/DLP 3D printers to be compatible with Navy piezoelectric ceramics. Additionally, there is a need to modify existing 3D printing hardware to incorporate the ability to properly align high aspect ratio seed particles within each print layer to produce grain alignment during sintering of the ceramic. Currently, there are very few commercial solutions that have the ability to align particles or fibers within each layer while printing.
The first objective will be to validate the feasibility to integrate a Navy provided piezoelectric ceramic with a photopolymer resin system. The system must demonstrate the ability to properly polymerize with darker colored ceramic materials. Evaluation criteria will include the ability to polymerize each layer, the layer height that is able to be polymerized, adhesion between layers, percent solids loading of the resin as well as density of final parts.

The secondary objective will be to demonstrate the ability of the 3D printing hardware to properly align high aspect ratio barium titanate platelets during the printing process. These platelets should be dispersed in the piezoelectric ceramic resin and aligned within each print layer. Prototype samples of approximately 1in outer diameter cylinders will need to be produced and undergo binder burn off and sintering. Prototype parts that will be electrically and acoustically tested will be sent to a 3rd party that will apply electrodes and pole the piezoelectric ceramic parts. Prototype parts will be evaluated by Naval Surface Warfare Center Crane Division for density, surface finish, particle/grain alignment, texture fraction as well as electrical and acoustic properties. Textured prototype parts will be electrically tested for resonance frequency, capacitance, dielectric constants, and loss factor and then compared to traditionally manufactured non-textured materials. The company will aim to create a material that exceeds a capacitance of 200pf while minimizing the loss tangent. The company will then revisit particle alignment and binder composition as needed in an attempt to improve acoustic and electrical performance.

PHASE I: Develop a concept that will demonstrate the ability to validate the compatibility of 3D printing resin systems with Navy piezoelectric ceramics and for 3D printing hardware that can align high aspect ratio ceramic platelets within the constraints listed 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 prototype hardware based on Phase I work and demonstrate the ability to construct a prototype ceramic that meets the constraints listed in the Description. The prototype hardware will be delivered at the end of Phase II ready to be tested by the government.

PHASE III DUAL USE APPLICATIONS: Focus on transferring the technology and knowledge to the Navy. Scale/volume/speed of production will also be optimized in this phase. Finalize the equipment and consumables needed to produce the parts and make the products available for Crane/Navy to utilize/purchase. This new technology will support the Navy programs/platforms by providing advanced piezoelectric transducers with better performance and capability.

This added technology/capability will also assist in other projects that require advanced, textured ceramics including hypersonic radomes as well as various sensors in the commercial sector and the military. This specific technology could be used in commercial and recreation sonar such as fish finders and navigation devices. It could be used to develop high resolution seafloor mapping devices. There are some possibilities of using this technology for communications/data transfer. This technology is also commonly used in the medical field for imaging devices.

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KEYWORDS: Additive manufacturing; digital light processing; DLP 3D printing; textured ceramics; piezoelectric; undersea sensors; sonar transducer

N241-041 TITLE: High Power Optical Splitter for Laser Weapon Systems

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

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

OBJECTIVE: Develop a capability to efficiently split the power of a high energy laser beam into two outputs.

DESCRIPTION: The Navy is fielding a family of high energy laser (HEL) weapons designed for surface ship self-defense. As the output power of these systems has been steadily evolving, the realities of shipboard implementation are coming to the forefront. This includes issues of cost, size, weight, and power consumption on the one hand, and issues of employment and tactical effectiveness on the other. HEL weapon systems can be divided into two main sub-systems: the sub-system that generates the laser power and forms a high quality output laser beam, and the laser beam director that places and holds the beam on target. Between these two units is an optical path that is essentially lossless.

The laser generation hardware is housed below deck in an environmentally controlled space. The beam director is mounted above deck, preferably as high on the ship’s structure as practical. The complete functional independence of the two units and the lossless path between the two make this possible. It also makes it possible, in theory, to supply multiple beam directors from the same laser power source. Theoretically, this would then provide a cost-effective means for providing full coverage around the perimeter of a vessel without the need for multiple laser power sources. Currently there is no commercial capability that can split a high power laser beam.

The Navy needs a technology for splitting a high power laser beam into two separate channels (optical paths). The splitter is intended to be placed in the optical path between the laser source and beam director(s). An optical splitter that can switch the entire beam between two channels is the minimum requirement. However, a technology that can split the bream fractionally between channels is most attractive. The ratio of power split between the paths can be continuous or fixed to discrete increments but, in addition to complete switching between channels, ratios of 50/50 to 20/80 are desired. True splitting of the continuous wave power provides the greatest flexibility in operation, however, solutions that achieve average power splitting by time division of the full continuous wave beam power are acceptable provided the switching between channels occurs at a rate of at least 500 Hz. As the quality of the transmitted beam is of great importance, acceptable solutions should not degrade the beam quality of the input beam (as measured by M2) by more than 5%.

The solution must be capable of handling a minimum of 300 kW of continuous wave input power at a wavelength of 1.0 micron. As a goal, the beam splitter should have a 98% transmission efficiency (95% is the minimum acceptable). As the technology is intended for eventual deployment aboard Navy vessels, the solution should be fundamentally rugged and require no manned intervention (e.g., periodic calibration, alignment, tuning, etc.) during operation. Note that the Navy does not intend to furnish tactical or otherwise representative laser hardware for this effort. The proposed solution should therefore include the means for test and demonstration on surrogate hardware, provided as part of the solution. To verify power handling, demonstrations using scaled hardware, analysis, and comparison to proven component technologies are acceptable. A prototype (hardware and software) of the technology will be delivered to NSWC Dahlgren Division at the conclusion of Phase II.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an HEL beam splitter that meets the objectives stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy's need by any combination of analysis, modelling, and simulation. Analyze and predict the splitter performance, including the ability of the splitter to handle the input power required. Include in the proposed concept a means to test the technology. 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 HEL beam splitter based on the concept, analysis, preliminary design, and specifications resulting from Phase I. Demonstration of the beam splitter technology shall be accomplished through test of a prototype in a laboratory or controlled outdoor environment utilizing surrogate lasers. At the conclusion of Phase II, prototype hardware and software shall be delivered to NSWC Dahlgren along with complete test data, installation and operation instructions, and any auxiliary software and special hardware necessary to operate the prototype.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Refine specific hardware, software, and operating instructions for specific Navy HEL weapons. Establish hardware and software configuration baselines, produce support documentation, production processes, and assist the Government in the integration of the beam splitter technology into existing and future HEL weapon systems.

The technology resulting from this effort is anticipated to have broad military application. In addition, there are scientific uses, specifically in high energy physics. Machining, food packaging, and solar energy are a few industries that may benefit from this technology.

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KEYWORDS: Laser System; High Energy Laser; Beam Director; Laser Weapon Systems; Optical Splitter; Beam Splitter

N241-042 TITLE: Compact Rapid Attack Weapon (CRAW) 100HP Electric Powerplant

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

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

OBJECTIVE: Develop a 100HP powerplant that fits into a 6.75” Compact Rapid Attack Weapon (CRAW) afterbody form factor while delivering performance similar to that of the existing CRAW propulsion system and integrating with existing interfaces.

DESCRIPTION: The CRAW is a very lightweight multi-mission torpedo with a 6.75” diameter that is launched out of the Virginia Class submarine external countermeasure launchers. CRAW development is ongoing, but leverages several existing technologies to reduce technical risks. As such, the propulsion system remains a cost and maintenance driver, but has shown to provide the performance that CRAW needs to meet its requirements.

A new 100HP electric powerplant that fits into the CRAW afterbody space to replace the existing propulsion system would be beneficial for various reasons, including reducing cost and maintenance complexity. Ideally, a small business industry partner would be capable of utilizing existing electric motor technology or developing new electric motors to fit the CRAW form factor. The CRAW program envisions a future state where electric propulsion could become the preferred method as electric motor performance meets existing propulsion performance requirements. One of the most difficult aspects of developing technologies for CRAW remains the tight 6.75” diameter form factor. The CRAW program anticipates that use of an electric motor could cut maintenance labor by 50%, which could reduce cost significantly. Ultimately, success of the new electric motor design will be measured by its ability to meet or exceed total energy of 2.5 kW/hrs and 100 hp at 7000 rpm.

The powerplant will consist of three components; 1) a primary or secondary battery capable of sourcing over 100 electric HP, 2) an electric motor capable of continuous 100HP for up to 10 minutes and 3) a small form factor motor controller able to control battery input to the electric motor at To Be Determined (TBD) current levels (type of motor selected and chemistry of the battery will determine current capability). The entire power plant system will be contained in a circular tube of the following dimensions; approximately 6” outside diameter (OD) by 38” in length overall. Details on shell components will become available as the proposed design matures.

Voltage requirements for a system of this compact nature should lean toward levels greater than 600Vdc to reduce conductor size for a lightweight and condensed packaging scheme.
In addition to the above, overall system weight is restricted to below 90 pounds counting the aluminum shells the devices are contained in; these are approximately 23 pounds. Details for the overall packaging scheme will be available.

Evaluation criteria for the electric powerplant system consists of battery load testing to determine overall available power, duration of the battery and any relevant US Navy testing for abuse and safety. The electric motor and controller performance will be verified via dynamometer testing to confirm the ability to make the expected 100HP.

PHASE I: Develop a concept for a design of a 100HP electric powerplant that meets the requirements in the Description. Provide all analyses supporting the design's compliance with Navy safety requirements. Establish feasibility through modeling/simulation to meet propulsion performance requirements. 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 100HP electric powerplant system for testing and evaluation based on the results of Phase I. The prototype electric powerplant will be evaluated on its ability to meet propulsion system requirements and its ability to meet or exceed existing propulsion system performance. Likewise, the ability of the 100HP electric powerplant to integrate with the existing CRAW architecture and its set of interfaces will be paramount to the success of the prototype.

PHASE III DUAL USE APPLICATIONS: Assist the Navy to transition to low rate initial production while coordinating with existing CRAW partners. Particularly, Penn State University's Applied Research Lab (PSU/ARL) will require integration support to integrate the 100HP electric powerplant into the electric CRAW variant for full system testing. It is anticipated that this size powerplant could be useful for other 6.75" devices launched out of external countermeasure launchers (e.g., acoustic countermeasures), as well as high powered Unmanned Aerial Vehicles and electric automobile applications.

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KEYWORDS: Very Lightweight Torpedo; Compact Rapid Attack Weapon; Electric Motor; Virginia Class Submarine; External Countermeasure Launchers; High Power Density Battery

N241-043 TITLE: Extended Reality (XR) for Use in Naval Shipyard Industrial Environments

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

OBJECTIVE: Develop extended reality (XR) solutions to combat safety mishaps and, decrease repair/maintenance times, additional travel expenses, re-work, congested areas, and unnecessary breakdowns and repairs in naval shipyards.

DESCRIPTION: The Navy is seeking the use of XR, which encompasses virtual reality (VR), augmented reality (AR), and mixed reality (MR), to cultivate a digital workforce for driving digital transformation of Navy Shipyards (NSYs). The Navy is seeking technology to introduce high velocity learning, first time quality, and better objective quality evidence (OQE) while removing safety hazards, travel expenses, unplanned work, and physical costs associated with waste generation, mock-ups, tear downs, assembly/disassembly. The Navy currently works and trains in harsh high-risk environments, lacks operational efficiencies, requires additional travel for troubleshooting, assistance, and inspections, lacks first time quality (human errors), congested areas with tours and workers, and requires unnecessary disassembly and repairs.

In its current state, shipyards carry out activities by qualified and trained personnel who perform procedures established by technical documentation in its physical form. When working in an industrial environment in which losing a single asset can mean million-dollar losses or those with complex procedures or time-sensitive product timelines, increasing efficiency and eliminating human error whenever possible becomes crucial for the enterprise. Failure of valuable equipment correlates to extra cost required to purchase material and/or extra man-days required to recover and repair. When equipment in one shop or area is down, it has potential to create a ripple effect that halts or diminishes work in other areas, leading to even further costs and delays. These issues are currently resolved by following complex procedures for diagnostics and maintenance, some of which are sparsely or poorly documented or so extensive that it requires additional training or understanding when conveying to maintainers. In some instances, troubleshooting or repair requires an expert to travel and perform the maintenance or repair leading to additional travel costs. Moreover, record keeping in physical formats is becoming obsolete so there exists a need to transfer physical documents such as standard operating procedures (SOPs), records, and reports into a secure digital format.

XR will cultivate the needed workforce by filling in technology gaps and will unlock new opportunities, drive new efficiencies, and inform analytical-based decision making. Public shipyards are currently working to move design, planning, and execution to computers in order to replace the physical formats that are currently used. XR will catalyze the workforce to efficiently move in the direction they are seeking allowing for 2D and 3D interactive digital forms that are easier to understand, work to, and maintain.

The Navy is seeking to develop XR solutions tailored for use in NSY environments to include considerations such as bandwidth availability (e.g., 5G networks), safety effects (e.g., motion sickness), XR interface (e.g., without peripherals such as mouse, keyboard, or touchscreen), 3D model generation, easy content creation, and IT/cyber security zero trust principles and policies for use in arenas such as mockups, training, surveys, hands free step-by-step instructions, reality capture (3D modeling), remote assistance, virtual tours, spacial computing, object recognition, dimensional digital twinning, behavioral digital twinning, remote collaboration, digital retention, and record keeping. XR solutions should allow for long term archival and would not require someone to be physically present for training or assisted applications and should introduce high velocity learning, first time quality, and better objective quality evidence (OQE) while removing safety hazards, travel expenses, unplanned work, and physical costs associated with waste, mock-ups, tear downs, assembly/disassembly. This includes cutting-edge and powerful technologies that provide an engaging environment, leading to useful data capture about the task(s) being performed. Advances in XR in the commercial sector could be adapted for shipyard use.

Augmented Reality (AR):
Problem: Unfamiliar situations or anomalies require expert/experienced personnel or engineering intervention over the phone with word or photo descriptions of the situation during maintenance, inspection, troubleshooting, or any procedural work. The technician or mechanic describes the situation and solution is implemented for remediation. This all happens without the expert seeing the “true” environment the person is trying to explain or support and can delay processes. Step-by-step instructions for complex maintenance or assembly involve steps that can be difficult to remember and are subject to interpretation. Maintainers and operators perform steps by reading from an operating procedure while holding the current step in memory before coming back to the paper copy for further instructions, which can be distracting.
Desired Resolution: The objective is to develop an AR solution to allow for remote assistance and communication in real-time using digital tools. These devices would be the eyes and ears of the expert and the on-site professional can act as the surrogate body to accomplish the work. AR methods would avoid transit and travel costs and time, disseminate knowledge quicker, and less experienced personnel can be accompanied by senior personnel or experts when needed. With AR, users would work on steps, without diverting their eyes or hands from the work being performed. As tasks are completed, there would be visual confirmation and the next step would be presented when the current step is completed safely and with good quality.

Virtual Reality (VR):
Problem: Training is primarily performed in classroom-based sessions, with physical mock-ups, part task trainings, just-in-time trainings, and work familiarization with examinations and evaluations. Mechanics and technicians need a human trainer and rely on rudimentary tools and paper documentation to complete their job functions. Shipyards incur costs associated with providing the right information, by the right people, at the right place, and with the right equipment. Current mock-ups are being physically produced, torn down, and lose historical knowledge overtime, which cost up to millions of dollars depending on the intricacy of the project. Construction requires experts from various organizations and locations to meet for collaboration and usually entails tours of areas where work will be performed, which congest and distract the area. Space at NSYs is at a premium and VR would save space on mock ups, tear downs, and/or storage of mock ups not being utilized, rather than bringing in large bulky machinery and components for training or mock-up or utilizing large spaces for this application, virtual reality allows access to features through a 3D virtual model that can be visualized in its intended space while a 1:1 scale is maintained.
Desired Resolution: The objective is to develop a VR solution to modernize operations and amplify physical mockup training by creating immersive training environments, streamlining the creation and sustainment of technical documents, and enhancing mechanic, technician, and engineering services. VR methods would reduce costs by decreasing the amount of text to be translated; streamlining training processes for operators of complex equipment; training in safe environments that would otherwise be harmful, expensive or dangerous; and providing the opportunity to train on exact configurations rather than “similar” configurations. VR would allow access to features through a 3D virtual model that can be visualized in its intended shop or space while a 1:1 scale is maintained, removing the need to view in a reduced format. Additional text, graphics, and videos should be superimposed along with any manuals, procedures, or documentation. VR solution should allow all parties to collaborate in their current location(s) removing the need for travel expenses. Furthermore, mock-ups and spaces would be viewed digitally and can bring in unlimited number of machinery or equipment of any size, enabling realistic demonstrations similar to physical spaces. This removes the need to physically interrupt locations or to build expensive parts for demonstrations. Mock-ups will have the capability of digitally being placed in

the intended location to capture any potential issues that may arise during installation or use before physical movement takes place.

Mixed Reality (MR):
Problem: Quality assurance and inspection tasks are subject to human error with a potential for negative outcomes such as equipment failure, injury, pollution, damage, and more. Inspectors perform inspections using checklists in order to confirm quality of work, equipment, or structures.
Desired Resolution: The objective is to develop MR to provide enhanced information to the inspector. The user can be taken through the inspection process where settings, states, locations, and parts can be presented to the inspector who can compare expected values and verify with automated visual confirmation and has the ability to alert the user when results are outside expected values. MR methods would reduce inspection errors due to human error, improve reliability of inspection tasks, assist with interactive checks, and automate storage or results for traceability and reproducibility. MR should also provide the value of monitoring student behaviors to ensure proper job execution and increased procedure accuracy. Instructors can adjust training based on student's ergonomics, positioning, and time spent in certain areas to help reduce safety risks and exposure while applying the best ergonomic practices.

PHASE I: Develop a concept to implement XR solutions into secured industrial workspaces by identifying the highest anticipated risks associated with the concept and proposing viable risk mitigation strategies to technological and reliability challenges. Feasibility must be demonstrated through modeling and analysis for a useful product to be used in NSYs including technical feasibility of integrating virtual or augmented visuals into current processes as well as meeting risk management framework guidelines associated with cybersecurity compliance.

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, task, test XR, and deliver a prototype for existing networks utilizing current work processes. Develop hardened system architecture and complete the risk management process for gaining cybersecurity accreditation for system deployment. Develop high fidelity prototype(s) that are acceptable for use within the current NSY infrastructure and demonstrate technological competence through evaluation and modeling over systems and processes that are already available and in place at NSYs. Demonstrate prototype performance in a simulated or realistic/piloted environment. Identify, evaluate, and mitigate risks, roadblocks, and challenges. Create milestones to incorporate this technology into the Phase III development plan.

PHASE III DUAL USE APPLICATIONS: Further refine the prototype(s) and support the Navy in transitioning, testing, validating, and certifying the technology for shipyard use. Introduce training and incorporate the product into NSY processes for sustainment.

Commercial applications may include, but are not limited to, any public industrial environment setting performing common trade work, maintenance, repair, or inspections.

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KEYWORDS: Extended Reality; Augmented Reality; Virtual Reality; Mixed Reality; Remote Assistance; Navy Shipyards

N241-044 TITLE: Rapid Scalable Time Synchronization

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

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

OBJECTIVE: Develop a rapid time synchronization capability for nodes that use single beam antennas in a Global Positioning System (GPS) denied environment.

DESCRIPTION: As modern networking technology has proliferated, the “Internet of Things” describes the increasing interconnectivity of devices at all layers of modern society. This has enabled sharing of information and coordination of operation in real time across a wide range of applications, in particular allowing for comprehensive control of devices by centralized or distributed command structures. Recent industry gains in this area have provided an opportunity to leverage modern networking technology to reduce communications operations overhead by integrating much more efficient networking methods. Time sync has been identified as a specific area where significant gains can be realized that will make larger fleet operations much more robust and flexible.

The Navy is tasked with connecting, improving, and expanding over-the-air tactical network functionality to support expanded mission areas and new and evolving future warfighting capabilities. Time synchronization is an essential requirement for Navy networked sensor systems to perform their primary mission, which relies on sensor data distributed across the network. The existing time sync methods are laborious and slow, necessitating specific input from operators and disruption to network operations. Incorporation of modern, Transportation Control Protocols / Internet Protocols (TCP/IP) time sync methodologies, specifically the methodologies utilized in wireless fidelity (Wi-Fi) switches and routers, into the larger communications system would reduce this operational overhead. This has great value as networks increase in node size consistent with integrated Naval operations currently being developed. The Navy network is a C-Band, maritime, half-duplex, line of sight network of mobile nodes including both ships and aircraft. This networking capability needs to be as agile as possible to enable utmost flexibility for the warfighter. A time sync capability with the desired performance will enable large networks to form more rapidly, as time sync is the first step in network formation. It will also enable new nodes to enter an existing network in much less time. This will enable the warfighter to respond more rapidly to changing battle space conditions.

The Navy needs a rapid time sync capability for nodes that use single beam antennas in a GPS denied environment for nodes in a large, directional, half duplex, C-band, microwave, maritime, mobile network that uses single beam antennas, but can be extended to multi-beam capability. There is currently no commercial capability known that can do this. The capability should optimize transmit power and minimize total power required given an available Effective Isotropic Radiated Power (EIRP) of approximately 50 decibel-Watt (dbW).

The solution must leverage protocols from technologies developed for, and used in, 5G and other modern communications networks, such as Precise Timing Protocol (PTP) and Network Time Protocol (NTP), while maintaining sub-microsecond (i.e., current state of the art with PTP for wired networks) accuracy within a mobile, wireless network. A key improvement sought is minimizing prime power required from the supporting platforms. This will enable application to a larger number of smaller platforms. The goal is to use no more power than required in the mobile maritime environment. The protocol should adaptively determine what is required. The maximum available EIRP is 52.2 dBW. The threshold requirement for time accuracy is sub-microsecond with an objective of 100 nanoseconds. The time sync protocol should meet its performance requirements without GPS but should be able to use it when available. It shall adapt to varying radiated power limits placed on the network, with the capability to provide accurate solutions even when operating at reduced power. It shall be scalable to many moving platforms with a threshold of dozens of nodes to an objective of 100 nodes, accomplishing time sync for this network within 2 minutes or less. It shall not require prior knowledge of node locations. It may use directional or Omni antennas or both. Finally, it must do all of this in a contested, congested, and constrained Naval electromagnetic and electronic warfare environment as described in the 2020 Department of Defense Electromagnetic Spectrum Superiority Strategy and MIL-STD-461G requirements.

Classified legacy time sync requirements in Navy network system specifications shall provide a baseline against which the prototype will be compared.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a rapid time sync capability for a network of mobile maritime nodes using a line of sight C-band microwave link. Demonstrate the concept can feasibly meet the Navy requirements as provided in the Description. Establish feasibility by a combination of analysis and modeling. The modeling should include maritime ducting conditions resulting in signal degradation [Ref 4]. 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 rapid time sync capability based on the results of Phase I. Demonstrate that the prototype meets the performance parameters outlined in the Description. Testing, evaluation, and demonstration are the responsibility of the awardee but government subject matter experts will validate the improvements achieved by the prototype.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Further refine the prototype for evaluation to determine its effectiveness and reliability in an operationally relevant environment. Support the Navy in the system integration and qualification testing for the technology through platform integration and test events to transition the technology into Navy applications for simultaneous communications links to improve and expand tactical network functionality. A substantial amount of this Phase's effort will be in integrating the new time sync protocol with the pre-existing networking code.

High-performance time sync protocols will have direct application to private sector industries that involve mobile microwave networks. These applications include transportation and communication industries.

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KEYWORDS: Time synchronization; over-the-air tactical network; precise timing protocol; Effective Isotropic Radiated Power; scalable to many moving platforms; Global Positioning System (GPS) denied.

N241-045 TITLE: Composite Launch Tube (LT) for the Compact Rapid Attack Weapon (CRAW)

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

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

OBJECTIVE: Develop a composite launch tube that will be used as part of 6.75-inch diameter Compact Rapid Attack Weapon (CRAW) Launcher Assemblies.

DESCRIPTION: The CRAW is a very lightweight multi-mission torpedo with a 6.75-inch diameter that will be launched out of the Virginia Class submarine External Countermeasure Launcher (ECL) system. The CRAW is contained within a Launcher Assembly (LA). The Launch Tube (LT) is a major component of the LA and is capped on one end with a muzzle cap/nose assembly and sealed to sea pressure on the breech end by the Mk 77 Gas Generator (impulse system). The CRAW and ancillary hardware such as a pressure plate, ram plate, drag fin assembly reside within the LT between the muzzle face of the Mk 77 Gas Generator and the muzzle cap/nose assembly. The LT is designed to meet Grade A shock requirements (i.e., heavyweight, high-impact, air-backed, wetted-surface environment), implosion, hydrostatic, hydrodynamic and Mk 77 impulse/launch loads. The current stainless steel LT represents nearly 50% of the total projected weight of the overall CRAW LA weight. Furthermore, there is little to no ability to achieve weight savings in any of the other LA hardware, including the CRAW itself. Additional service life/environmental factors include, but are not limited to, Hazards of Electromagnetic Radiation to Ordnance (HERO), Grade A shock qualification (i.e., heavyweight, high-impact, air-backed, wetted-surface environment), shipboard vibration, corrosion preventions/life, and contributions to CRAW and Mk 77 Gas Generator Insensitive Munitions qualification.

The Navy seeks a new composite LT that would replace the existing stainless steel in the CRAW LA, which would be beneficial for various reasons, including reducing cost, weight, and manufacturing complexity. Ideally, a small business industry partner would be capable of utilizing existing commercial composite material technology or developing new composite materials that can be shaped to house a 6.75-inch CRAW device form factor along with the Mk 77 Gas Generator and CRAW launcher ancillary hardware. The CRAW program envisions a future state where composite launch tubes could become the preferred manufacturing method as material properties could meet existing launch tube requirements. One of the most difficult aspects of developing launch tube technologies for CRAW remains the tight 6.75-inch diameter form factor, combined with the stringent requirements to meet the aforementioned operational and environmental loads, and the machinability of the launch tube internally and externally along its entire length. Ultimately, success of the composite launch tube will be measured by its ability to meet existing CRAW launch tube requirements.

Requirements and performance characteristics for a composite CRAW LT are (but are not limited to):

- Maintains existing shipboard interfaces per CRAW LT drawing (to be provided) – same form factor as existing LT tube design
- Maintains existing interface (internal to LT) with Mk 77 Mod 0/1 gas generator (drawing to be provided)

• Meets or exceeds existing LT service life (2 years deployed with minor maintenance (paint and anode replacements, 4 years to full maintenance cycle)
• Reusable: Threshold – unlaunched condition; Objective – launched condition
• Meets requirement for Grade A shock qualification under MIL-DTL-901E
• Maintains Hazards of Electromagnetic Radiation to Ordnance (HERO) safe designation of current system
• Adheres to MIL-STD-464 – latest rev
• Adheres to MIL-STD-461 – latest rev
• Adheres to MIL-STD-167 – latest rev
• Adheres to NAVSEA Temporary Alteration (TEMPALT) Manual - NAVSEA S9070-AA-MME-010/SSN/SSBN, 3rd Revision, ACN-5
• No impact on corrosion susceptibility and life of surrounding hardware/structure
• No hazardous material generation or addition to post-launch combustion by-products effluent from exposure to launch process and/or seawater
• Adheres to NAVSEA Implosion requirements for VIRGINIA and COLUMBIA Class
• Compatible with existing Weight Handling Equipment (WHE), Ordnance Handling Equipment (OHE), and Weapon Handling Equipment (WHE)
• Minimum weight reduction, compared to the current LT: Threshold – 150 lbm; Objective – 175 lbm

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Complete a robust conceptual design for the composite LT and provide all critical analyses supporting the design's compliance with Navy safety, performance, and operational requirements. Support the feasibility of meeting propulsion performance requirements through modeling/simulation. 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: Design, develop, and deliver a prototype composite LT for testing and evaluation based on the results of Phase I. The prototype composite LT will be evaluated on its ability to meet LT requirements, and its ability to meet or exceed existing LT system performance as identified in the Description section. Likewise, the ability of the composite LT to integrate as part of the existing CRAW Launcher Assembly along with its set of interfaces will be paramount to the success of the prototype.

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

PHASE III DUAL USE APPLICATIONS: Assist the Navy to transition to low rate initial production which will occur while coordinating with existing CRAW partners. Particularly, Penn State University's Applied Research Lab (PSU/ARL) and Navy Warfare Centers will require integration support to integrate the composite LT into the CRAW Launcher Assembly for full system testing. Testing at this point would include MIL-STD-2105 (Insensitive Munitions), Implosion, Hydrostatic, Explosive Shock qualification, and other shipboard integration and ordnance qualification tests, as required.
It is anticipated that this composite launch tube could be useful for other 6.25-inch and 6.75-inch devices launched out of external countermeasure launchers (e.g., acoustic countermeasures). Outside industries such as the commercial Unmanned Undersea Vehicle (UUV) designers, offshore energy industries, and other marine or industrial applications where a high-strength, lightweight pressure vessel or piping would be of interest.

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KEYWORDS: Very Lightweight Torpedo; Compact Rapid Attack Weapon; Virginia Class Submarine; External Countermeasure Launcher; Composite Materials for Tubes; Torpedo launch sequence

N241-046 TITLE: Micro Inertial Measurement Unit for Maritime Navigation

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

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

OBJECTIVE: Develop a highly accurate 6-axis Inertial Measurement Unit (IMU) that is low-cost and lightweight for future U.S. Navy surface and subsurface platforms.

DESCRIPTION: The success of U.S. Navy missions depends on personnel and platforms having access to accurate and reliable position, velocity, attitude, and time information. Maritime platforms specifically need this information continuously to support safety of ship, weapons deployment, and network communications. They rely on inertial navigation systems to provide continuous position and velocity information for accurate navigation. However, current inertial navigation systems are large and expensive to build and maintain. Small-scale factor IMUs, such as Micro-Electro-Mechanical (MEMS)-based sensors, micro-Hemispherical Resonating Gyro (HRG)-based sensors, and other micro-Machined Vibrating Gyroscope (MVG)-based IMUs, offer the advantage of lower production costs through batch processing and fabrication. Some MEMS and HRG devices have also proven superior survivability to environmental shock and vibrations, which makes them ideal for military applications, given their potential for low cost and small size.

In the commercial sector, long-term accuracy has been a challenge for MEMS gyros with gyro-bias stability and Angular Random Walk (ARW) performance metrics not yet meeting navigation-grade standards, though bias-stability in MEMS accelerometers has been demonstrated to near-strategic-grade standards. Achieving the long-term accuracy desired for Naval maritime applications (going from hours to days), requires further reductions in gyro bias drift. Some factors shown to impede gyro performance include temperature drift error, mechanical imperfections, imbalances, and misalignments in the fabrication process. These can be resolved by effective vacuum packaging for environmental-resistant MEMS and/or effective temperature compensation by control circuitry, quadrature compensation, laser trimming, and circuit compensation.

Low-cost production has been a challenge in commercial HRG technology because early designs of macro-HRGs have focused on the higher performance, and higher cost, space application market. As a result, there are a limited number of HRG manufacturers, which has driven up production costs. However, new fabrication techniques, such as glassblowing and glass molding, have been developed to fabricate 3D-MEMS, or micro-HRG, devices that show the same promise of lower fabrication costs with batch production.

These existing and emerging technologies are applicable in meeting the future needs of the Navy to develop a lower cost, lightweight, and highly accurate 6-axis IMU that can be integrated into future U.S. Navy platforms. While both technology areas present challenges, fabrication and manufacturing techniques have developed significantly in MEMS wafer-scale etch processing and micro-machine fabrication techniques used to produce micro-HRGs and other MVG-based sensors in recent years.

To meet mission requirements of future deployed surface and subsurface vessels, the Navy needs a low Size, Weight, Power, and Cost (SWaP-C) 6-axis (3-axis accelerometer and 3-axis gyroscope) IMU with performance equivalent to or better than the existing Ring Laser Gyro (RLG) navigator in use in the Fleet today. Government subject matter experts will guide development for these specifications.

Achieving the desired accuracy in position, velocity, and attitude will require gyro bias stability to be demonstrated at or better than 0.005 degrees/hour (1 sigma) and ARW < 0.0005 degree/root-hour (1 sigma). Accelerometer bias stability must be demonstrated at or better than 5ug. Contributions of other error sources (that is, scale factor, misalignment, etc.) should be balanced to meet the overall error budget of the IMU. SWaP-C must meet IMU performance requirements in the range shown below:

- Size: < 5 Liter
- Weight: < 10 Kg
- Power: < 25 W
- Cost: < $100,000

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept that characterizes inertial measurement sensors that meet the target metrics in the Description. Establish feasibility of an approach through analysis, modeling, and simulation to show the concept will meet the required parameters 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: Design and deliver a prototype of the system described in Phase I. The prototype will undergo an independent evaluation at a government provided facility based on its ability to satisfy the parameters in the Description and its functionality in a maritime environment.

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

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use. The final product will be a 6-axis inertial measurement unit and will be tested on a maritime platform to demonstrate performance. Ultimately, it will be validated, tested, qualified, and certified for Navy use. The technology will be highly valuable in any at-sea situations where GPS is not always available and high accuracy is a requirement.

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KEYWORDS: Inertial Navigation System; Micro-Electro-Mechanical; Hemispherical Resonating Gyroscopes; Inertial Measurement Unit; Micro-machined Vibrating Gyroscope; Navigation

N241-047 TITLE: [DON has removed topic N241-047 from the 24.1 SBIR BAA]

N241-048 TITLE: Virtualized Naval Tactical Data System Interfaces over Ethernet

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

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

OBJECTIVE: Develop a capability for Ethernet-based Naval Tactical Data System (NTDS) interfaces to allow hardware abstraction of Interface Processor Computer Programs (IPCPs) to virtual machines.

DESCRIPTION: Currently AN/SQQ-89 infrastructure uses legacy hardware interfaces to connect. The Navy is seeking innovative solutions to replacing legacy hardware used in tactical systems with software defined solutions supported in an Infrastructure as a Service (IaaS) architecture. The IaaS architecture uses the latest release of VMWare / ESXi hypervisors with virtual machines running Red Hat Enterprise Linux (RHEL) operating system (RHEL7 or later). Hardware abstraction in software will address the growing problem of hardware obsolescence and lowering installation, maintenance, training, and logistics costs.

AN/SQQ-89 is currently transitioning to an IaaS architecture that supports hardware abstraction (i.e., virtual machines (VM)) to improve fault tolerance, improve resiliency, and lower operational risk due to hardware obsolescence. The Navy is looking for innovative solutions as alternatives to legacy interfaces that can transition to an IaaS architecture. In the IaaS architecture, a VM can run anywhere in a cluster of compute nodes within the architecture. Legacy NTDS applications between Aegis Weapon System (AWS) elements on US Surface Ship combatants require specialized NTDS hardware that was designed in the 1950’s. The linkages between applications are point-to-point (i.e., NTDS cable between two NTDS devices). NTDS MIL-SPEC interfaces and NTDS interface hardware are becoming increasingly harder to manufacture and to maintain. MIL-SPEC NTDS connectors and cables are very expensive. The cost of a typical NTDS cable may be more than $3K per cable.

Research and development (R&D) is in-progress to transition an NTDS interface application to a VM and evaluate the use of a special-purpose Ethernet-to-NTDS device (i.e., an IXI PowerNet device) to demonstrate the feasibility of VM technology for these interfaces.

The Navy is seeking innovative solutions to replace legacy hardware used in tactical systems with software defined solutions supported in an IaaS architecture. Hardware abstraction in software addresses the growing problem of hardware obsolescence and, lowers installation, maintenance, training, and logistics costs. The goal is to eliminate physical NTDS interfaces in favor of software-only, Ethernet based communications between NTDS applications.

The solution will provide software drivers that can be added to tactical operating systems such that no software changes are needed for the legacy NTDS application to work with the new drivers.

Solutions with enhanced CYBER-secure features are preferred. The ability to abstract NTDS interface applications to VMs reduces risk with hardware obsolescence and components that are in limited supply and increasingly difficult to manufacture. This solution will reduce development, logistic, and maintenance costs by eliminating physical NTDS hardware and cabling, thus saving tens of thousands of dollars per installation.

Commercial application for this technology will be limited as this interface protocol is used exclusively for DOD (NTDS - Navy Tactical Data System); however, the concept of developing Ethernet-based drivers to replace physical hardware can be extended to commercial use.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for NTDS over Ethernet designs. Demonstrate the concept meets the parameters in the Description and show the feasibility of NTDS interface communications between two servers.

Feasibility will be shown through analysis and modeling. The concept shall support as a minimum RHEL 7 operating system. The government will provide specific details describing changes that will be required to support the NTDS-over-Ethernet with connections to legacy servers. 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 NTDS over Ethernet solution for testing and evaluation based on the results of Phase I. Demonstrate the prototype meets requirements and parameters in the Description. The prototype will be assessed by the government subject matter experts. Develop procedures for installation and integration.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final product will be the VM-based NTDS over Ethernet that can be extended to support all AEGIS combat system elements on all surface ship combatants. The design of VM-based NTDS applications shall be adapted to current and future AN/SQQ-89A(V) ACB and AEGIS baselines. Future NTDS development efforts will be software development specific as the need for physical NTDS hardware for NTDS interface applications transitions to NTDS-over-Ethernet. Validation and testing will be performed with AN/SQQ-89 integration team and various AEGIS certification authorities.

The potential for dual-use with other Navy developers involved with NTDS interface application development is tremendous. Virtually all Navy systems include NTDS interface hardware. The transition to Ethernet-based NTDS will slowly eliminate the need for these devices. Innovations and development of drivers for transition from physical hardware to Ethernet-based communications may be applied to other communications protocols. Commercial industries that can use this technology include computer and network system builders and any company that has integrated legacy hardware in their networks infrastructure.

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2. “PowerNet™ NTDS to Ethernet Converter.” https://ixitech.com/product/ntds-ethernet-converter/
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KEYWORDS: Naval Tactical Data System (NTDS); AN/SQQ-89 infrastructure; hardware obsolescence; Infrastructure as a Service (IaaS); Cyber-secure; NTDS connectors and cables

N241-049 TITLE: Shipboard Proof Testing Apparatus for Field-Expedient Parts

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

OBJECTIVE: Develop testing equipment for the shipboard environment to enable proof testing of field-expedient parts fabricated in the shipboard environment.

DESCRIPTION: Navy ship platforms are currently outfitted with varying capability for on-board machining, repairs, and fabrication, to include additive manufacturing (AM). With the deployment of AM expanding to the shipboard environment, the manufacturing capability of more complex items are becoming more readily available to the Fleet. With this addition in capability, there is an increased risk of potential inadequate parts being installed in ship systems. There is a need to be able to reduce the risk of installing field-expedient parts designed by the Fleet. Part of this risk reduction can be achieved through proof testing of the designed parts at the point-of-need. This capability would allow shipboard leadership to make a more informed, rapid risk assessment of part viability based on empirical test data from the desired solution.

There are increased needs for AM afloat as it is explicitly identified in the COMNAVSEA Campaign Plan 3.0 as a technology focus area. The Navy directly supports efforts to integrate AM into the Fleet and support a more self-sufficient ship. The Navy seeks to maximize its use of AM to fabricate "hard to source" or obsolete parts, reduce cost, field more effective systems, and reduce reliance on vulnerable supply chains through production at the point of need.

The goal of this project will be to develop a modular proof testing apparatus for locally manufactured components in the shipboard environment. The solution must include the ability to test non-uniform objects, tools, and parts which should be able to be mounted and tested within the same test unit. In addition, different loading conditions and scenarios must be able to be applied to the test part within this apparatus. Example loading scenarios include, but are not limited to: tensile, compression, torque and pressure. The operational conditions within these expeditionary settings include ship motion, ship vibration, shock, ventilation, and electromagnetic interference (EMI). In order to successfully install the test rig and enable adequate operation of the equipment, the machine must not experience severely degraded performance under these conditions. All processing must be completed on the system and must operate in a non-networked environment. Sensor packages supporting tracking of system operation and performance, as well as machinery health monitoring, should be included in the design.

Current test apparatuses of this nature are specialized laboratory equipment that is not designed for use in the dynamic shipboard environment. In addition, current commercial tensile, compression, torsion, and pressure testing systems require a degree of training for interpretation of data that is not feasible for the typical Navy operator. There exist no commercial solutions that can provide easy-to-assess part test responses that allow for rapid risk reduction. Furthermore, simplistic design and usability will be beneficial since most Fleet personnel will not have an engineering or science background. This should include ease of use from a test setup and operation standpoint, but also clear, definitive, and easy to understand results display and interpretation. The designed solution should have on board processing capability, with full traceability and logs available. These systems must include a modular test fixture and load application design to be able to accommodate the variability in types of parts being 3D printed. In addition, since both metal and polymer solutions are being deployed, the solution should be able to accommodate forces necessary for both material types, including, but not limited to, carbon fiber reinforced nylon and 316L stainless steel. The solution should be able to test parts that fit within a 20” Wide x 12” Deep x 12” High volume. The system itself should be hatchable, and take special consideration to minimize footprint of the design. The aforementioned design considerations to overcome the technological gap is paramount as a risk reduction method to enable the Fleet to safely install AM solutions shipboard.

The product will be assessed against the MIL-STDs listed below:

1. MIL-S-901D, Amended with Interim Change #2, Shock Test, H.I. (High Impact); Shipboard Machinery, Equipment and Systems, Requirements for
2. MIL-STD-167-1, Mechanical Vibration for Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)
3. MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
4. MIL-STD-740-2, Structure-borne Vibration Acceleration Measurements and Acceptance Criteria of Shipboard Equipment

PHASE I: Develop a conceptual design of a modular proof testing apparatus that can test shipboard manufactured parts, including Additively Manufactured items as described in the Description section. Demonstrate the feasibility of the conceptual design through detailed modelling, simulation, and analysis for the proposed solution. For example, 3D models, simulations, and/or design documentation to illustrate the work holding/fixturing modularity option to accommodate the various types of applications and loading scenarios. The conceptual design feasibility analyses should also indicate how the apparatus will be hardened for the shipboard environment to be able to accurately apply loads, but also handle the dynamic shipboard environment. Include, in the conceptual design applicable sensors and details on how the machine will be optimized for Fleet use, to include, but not be limited to, operation, maintenance, and results display. The design details should include the on-board processing setup and the proposed results reporting display.

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 and deliver a prototype system that can apply proof testing loads to sample parts that can be operated in the shipboard environment by shipboard personnel. Demonstrate how shipboard environmental mitigation will be applied to account for incoming vibration and shock, and uncontrolled temperature and humidity. Subsequent testing of these mitigation protocols will be needed to evaluate shipboard viability and should be included. Examples of the simplified setup and results should be included in the prototype, with processing occurring local to the proposed solution. The prototype is expected to be installed either shipboard or at a Navy facility for continuation testing and evaluation.

PHASE III DUAL USE APPLICATIONS: Assist the Navy to transition a production ready proof testing machinery optimized for Navy expeditionary environments with modular options for tensile, compression, torque, and mechanical pressure loading applications. The equipment must be able to operate in the shipboard environment (machine shop or welding spaces) and be able to accurately apply loading conditions for various, non-uniform applications of multiple material types including, but not limited to, chopped carbon fiber filled Nylon and 316L Stainless Steel. The solution must be able to simply interpret results to inform a risk-based decision-making analysis for Fleet personnel. All processing must be completed on board the system and must operate in a non-networked environment. The applicability of such a design could be implemented in environments beyond just the shipboard community, to include the local maintenance activities and Shipyards. In addition, commercial applications of the solution for the shipping or oil and gas industry and other Military forward operating bases may be available.

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KEYWORDS: Metal additive manufacturing; 3D printing; Shipboard Additive Manufacturing; Proof testing; Shipboard Validation Testing; Testing of AM manufactured parts; Mechanical part testing

N241-050 TITLE: Forces Afloat Man Overboard Persons in the Water (PIWs) Recovery

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

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

OBJECTIVE: Develop and deliver a prototype technology that leverages existing technologies and improves identification, location and tracking of all persons in the water (PIWs) from afloat assets operating up to sea state five (5) and distances up to ten nautical miles. Later stages of development could seek to integrate the improved performance with other means to support staging and recovery operations.

DESCRIPTION: The proposed technology must be able to work with current systems for recovering PIW on all active afloat assets and be capable of operating with modern Global Positioning System (GPS) technology. It should be able to discriminate individual PIWs but also able to provide continuous accountability for up to five (5) PIWs. The ability to provide uninterrupted live audio/video communication or any display methods such as infrared, thermal, opacity or others in real-time between the afloat asset and PIWs throughout recovery operations would be favorably evaluated.

The current Navy system for Man Overboard / PIWs responds to these incidents that occur when afloat assets with personnel onboard operate at sea is referred to as Man Over-Board Indicator (MOBI) system. MOBI uses a transmitter attached to personal flotation devices (PFDs) that transmit a signal to the MOBI antenna on the afloat asset. The current MOBI system sounds an alarm on the bridge for the PIWs within three (3) seconds of activation and continues alerting for up to one (1) nautical mile (NM), and provides bearing(s) for PIWs for up to five (5) NM or greater depending on the height of the receiving antenna. A secondary indicator for PIWs is a strobe light illuminating from the PFD in the water. The recovery time for PIWs varies as a function of many factors such as maneuverability of afloat asset type, sea state, visibility and skill of the rescue operators executing the recovery mission. The current recovery procedures for PIWs are resource intensive and pose additional risk to rescue personnel. The objective of this topic is to increase probability of detection and maintain situational awareness of PIWs through recovery, with long term objective of increasing safety and effectiveness to PIWs, equipment, and rescue personnel.

Improvements are needed to increase the survivability of PIWs and enhance rescue operations. The objective alert time for PIWs should remain at three (3) seconds with threshold of not more than five (5) seconds. The objective is to maintain positive identification of PIWs at a threshold of (1) NM and objective of (10) NM. The PIWs' location bearing updates must be continuous in order to maintain an accurate track. Other methods of data collection to improve future location accuracy would also receive favorable evaluation.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept to improve the survivability of PIWs with enhanced information and accuracy of location to provide continuous and as near real-time detail as modern technology would enable. The signaling device(s) should have the capability to monitor up to five (5) PIWs in proximal succession, regardless of whether they are outfit with wearable locator technology, at the discretion of rescue operators' to preserve safety of life at sea to the maximum extent possible. Capabilities must demonstrate at least threshold functions up to sea state five (5) and in zero visibility by natural human sight. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy as well as other seafaring vessels. 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 and demonstrate that it can meet the needs of the Navy. Initial testing of the system can be on subscale demonstrators progressing to a full-scale model. The location of and facility for testing will be determined during this Phase. Testing must demonstrate performance, environmental robustness, shipboard shock, vibration, sea-state survivability, and maintainability. Product performance will be demonstrated through prototype evaluation, modeling, and demonstration over the required range of parameters. An extended test in the maritime environment will be used to refine the prototype into a design that will meet Navy requirements. Prepare a Phase III manufacturing and development plan to transition the product for Navy use.

It is probable that the work under this effort will be classified under Phase II. See note in Description.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the new system with operational support systems (hardware and software) to Navy use. Manufacture and install on a candidate Nimitz Class / Gerald R. Ford aircraft carrier or other suitable and available afloat asset for in-situ test and evaluation. Plan to produce units to outfit all naval aircraft carriers initially but should be scalable for commercially-viable military adaptation on any Navy sea platform.

Commercial markets with adjacent technology would be any vendor or technology developer focusing on communication systems and at sea lifesaving equipment or similar related industries that support these.

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KEYWORDS: Man-Over Board; Person in the water; Water Recovery

N241-051 TITLE: Enhanced Radome Design

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

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

OBJECTIVE: Develop a radome capability for providing greater filtering and aid in beam shaping.

DESCRIPTION: Radomes have been used for decades to protect an antenna from the environment and conceal the antenna. The Navy operates in harsh environments where rain, hail, salt, fog, and other natural conditions would harm sensitive electrons like an Actively Electronically Scanned Array (AESA) antenna. So, to protect those AESA antennas, the Navy uses a radome as cover to protect from environmental conditions. Because the radome covers the antenna, it must also allow it to function with minimal impacts when transmitting and receiving radio frequency signals over the frequency band of operation. Since an AESA antenna can scan over a large angle, the radome needs to minimize the distortion of the transmitting and receiving radio frequency signals over the angler range of operation. This is all typical and can be accomplished with ridge low loss dielectric materials.

More complex radomes now have Frequency Selective Surfaces (FSS) worked into the design. As the name implies, these surfaces help to filter out undesirable frequencies by allowing only selected frequencies pass through. Thus, the radome can act as a filter and aid in the reduction of electromagnetic interference.

With the advances in surfaces, the Navy is seeking to improve current radome capabilities to help beam shaping and sidelobe reduction on the edges beyond the field of view. Currently there is no commercial solution. A new capability could be designed into a radome in a passive manner by structuring the FSS or could be an active design where some sort of bias is applied that activates an adaptive surface. Also, a reactive surface could be designed to limit the amount of power that is passed through the radome, thus avoiding saturation of the electronics. This design would be non-reciprocal, in that the transmit power would be allowed to pass through the surface but the receive power would be limited. In terms of a traditional circuit approach this could be thought of as a switch or circulator with a limiter.

The material also must be capable of meeting environmental requirements, quasi planner (can allow for minor curvature,) and meet government objectives for bandwidth, one way roll-off greater than 20 dB, and low losses operating approximately 4 GHz to 6 GHz.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for a radome capability that provides greater filtering and aid in beam shaping. Demonstrate that the concept meets the parameters in the Description. Feasibility will be demonstrated through analysis, modelling, and simulation. 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 radome capability that provides greater filtering and aide in beam shaping based on the results of Phase I. Demonstrate the prototype meets the parameters described in the Description through testing in a laboratory environment. The laboratory environment will be provided by the awardee. At the completion of Phase II, a minimum of six sample articles will be delivered for performance testing purposes.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the radome capability to Navy use. The enhanced radome capability will replace the existing radome on the ASEA. The company will work with the program of record prime contractor for integration onto the ASEA housing.
This technology will also benefit many other Navy and commercial antennas (industries such as telecommunication, aviation, satellite communications, etc.) by providing improved antenna performance and a means to reduce out-of-band rejection of unwanted or interfering incident RF energy increasing system sensitivity of desired signals of interest.

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KEYWORDS: Radome; Filtering; Radio Frequency Beam Shaping; Actively Electronically Scanned Array; Dielectric Materials; Interference with radio frequencies; Reactive Surface of Radomes

N241-052 TITLE: Energy Harvesting for Underwater Persistent Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Renewable Energy Generation and Storage

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

OBJECTIVE: Develop innovative power generation or energy harvesting technologies to extend the life of underwater electrical systems.

DESCRIPTION: Underwater persistent systems are often significantly limited by the availability of onboard energy. The issue of energy limitation becomes more critical for continuously submerged persistent systems due to difficulties of deploying and retrieving systems for maintenance.
The Navy seeks a solution to extend system endurance without mission interruption or manned support. Available underwater persistent system capabilities would be significantly enhanced by innovative approaches to energy extraction in the underwater environment. In particular, underwater in-situ energy harvesting and storage could realize increased system endurance and reduced cost. The Navy is seeking an innovative way of powering underwater persistent systems by energy extraction from the seabed or underwater environment with power level sufficient for continuous reliable operations. The use of energy harvesting eliminates potential operational impacts associated with large, unique, specialized energy storage.

The desired technology centers on harvesting energy from the undersea environment for a long duration, maintenance free power source to fit in a compact form factor without a presence on the ocean’s surface. Long duration mission profile should maximize the continuous available energy as measured in watt hours. This energy requirement could therefore rely on novel methods for continuous energy harvesting to power onboard systems. All other approaches will be considered. The challenge of miniaturizing and incorporating these technologies into the volume constraint and successfully deploying this system in the field remains the dominant technical issue associated with this technology. Currently, no commercial system exists that meets the requirements.

The proposed power source must have a minimum storage shelf life under controlled conditions of six years without maintenance prior to deployment. The system should be autonomous and require no maintenance in while deployed. The desired form factor should be no greater than 1,000 cubic inches.

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 NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security

Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an innovative small scale energy harvesting system from the environment that meets the requirements described above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established by testing and analytical modeling.

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 for evaluation as appropriate. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for the small scale energy harvesting System. Demonstrate performance with a detailed analysis, and live demonstration in a test environment as part of the evaluation. Provide detailed technical documentation of the design, including an interface control drawing and interface specification, to allow successful transition of the product. Prepare a Phase III development plan to transition the technology to Navy use. The company will prepare a Phase III development plan to transition the technology to Navy use.

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

PHASE III DUAL USE APPLICATIONS: Provide technical support for the incorporation of the solution into Navy program(s). Depending on the particular program, support for additional testing may be needed. Explore the potential to transfer the system or technology to other military and commercial systems, including the scientific community.

Technology developed under this effort is applicable to any domain that requires subsea platform autonomy such as subsea oil and gas pipeline inspection.

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KEYWORDS: Extended Life; Underwater Electrical Battery Powered Systems; Energy Harvesting from the Ocean; Waste Energy; Underwater Persistent Systems; Decreasing Energy Consumption

N241-053 TITLE: Additively Manufactured Polymer Tooling for Rubber Compression Molding

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

OBJECTIVE: Develop an additive manufacturing (AM) technology to rapidly create high strength, high temperature, and low-cost polymer tooling for use in rubber compression molding applications.

DESCRIPTION: Compression molding is a common manufacturing process for making rubber products. During this process, uncured rubber stock is placed within a heated mold before the mold is closed. The rubber cures and conforms to the mold cavity before the mold is opened and the finished part is removed. Within the Navy, numerous undersea sensor components, such as cable plugs and connectors, are fabricated using rubber compression molding. The molding process typically uses tooling made from steel due to the high temperatures and pressures required. However, steel tooling can have high costs and lead times. Advances in AM (also known as 3D printing) and new high-temperature polymers may allow these steel molds to be replaced with AM polymer molds, which could significantly reduce costs and lead times and open up new workload capabilities.

Limited research has been done to adapt AM technology and polymer materials to rubber compression molding. Some commercial AM systems have the capability to print room-temperature silicone molds or low-volume injection mold inserts, but the materials used in these systems do not translate well to the high continuous use temperature of the compression molding environment. The Navy is seeking the development of an additive manufacturing process that can rapidly create high strength, high temperature, and low-cost polymer tooling for use in rubber compression molding applications.

Polymer AM was chosen as the preferred process due to its speed, low cost, easy implementation within existing spaces, geometry flexibility, and safety. Metal AM processes will not be considered due to relatively high investment and post-processing costs. Several challenges exist for bringing polymer tools close to parity with traditional steel tools. Surface roughness, dimensional accuracy and precision, durability, and longevity are key focus areas to consider. Surface treatments, coatings, machining, and other post processing techniques may be used, but should be minimized to reduce overall costs. Polymer materials may be thermoplastics, thermosets, composite reinforced, photopolymer, or other novel material and must be non-hazardous. Companies may develop a new material, machine, or process; or adapt a commercial material, machine, or process to meet the Navy's needs. All printed inserts will be used in a metal master unit die (MUD) frame.

The new AM solution will be utilized in a production setting to enable the rapid turnaround time for time- or cost- sensitive tasking, reduce project costs, and develop new products. Proposed concepts should meet the following thresholds:

1. Process:
    - a. Process: additively manufactured
    - b. Material: Polymer or composite; surface coatings, treatments, or other post-processing permissible but should be minimized; non-hazardous
    - c. Build size: 6 in x 3 in x 3 in Threshold, 12 in x 12 in x 6 in Objective
2. Tool:
    - a. Inserts will sit in metal MUD frame
    - b. Continuous use temperature: 300°F
    - c. Typical clamping force: 15 tons
    - d. Duty cycle: 1 hour minimum cycle time under required temperature and pressure
    - e. Reusability: 100x minimum, molded part must meet requirements
    - f. Mating face flatness: 0.010 in Threshold, 0.005 in Objective
    - g. Chemical resistance: no special considerations

3. Molded part:
    a. Dimensional tolerance: 0.010 in Threshold, 0.005 in Objective; or 0.05 in/in Threshold, 0.002 in/in Objective; whichever is greater
    b. Surface Roughness: 250 microinch Threshold, 125 microinch Objective
    c. No physical defects, bumps, or voids > 0.030 in

PHASE I: Develop a concept for an AM process to create rapid, low-cost polymer tooling for use in rubber compression molding as detailed in the Description. The concept shall include proposed material(s), machine(s), and post-processing technique(s) needed to meet the Navy's requirements and how they address the challenges of high temperature, high pressure, surface finish, dimensional accuracy, and durability. Demonstrate the feasibility through modeling, simulation, analysis, or other formal methods. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop, demonstrate, and deliver an AM prototype to create mold inserts that meet the Navy's requirements. The proposed material(s), machine(s), and post-processing technique(s) will be evaluated to determine their capability and feasibility. Perform detailed testing and analysis addressing required performance. Deliver a minimum of five prototype mold inserts for rubber parts chosen by the Navy for evaluation and demonstrate the flexibility of their concept to apply to various rubber part shapes and sizes.

PHASE III DUAL USE APPLICATIONS: Apply the knowledge gained in Phase II to further develop a complete turnkey AM system capable of producing polymer inserts suitable for rubber compression molding and assist the Navy in transitioning the technology for use. The AM system may include commercial-off-the-shelf (COTS) parts or equipment, and need not include equipment for typical or readily available post-processing steps such as machining. Support the Navy in implementation of the system within Navy production spaces and qualifying the system for production use. The complete AM solution will be used to support production of undersea sensors components aboard various surface ships and submarines.

Explore the potential to apply the solution to other military or commercial rubber molding shops or do further research to apply advancements to similar molding applications, such as injection or composite layup molding.

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KEYWORDS: Additive manufacturing; rubber compression molding; high temperature polymers; composite reinforced plastics; master unit die; undersea sensors.

N241-054 TITLE: Probabilistic Forecasts of High Impact Weather on Medium Range to Subseasonal Timescales using Artificial Intelligence

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

OBJECTIVE: Develop a robust artificial intelligence/machine learning (AI/ML) based numerical weather prediction (NWP) system capable of generating skillful high resolution forecasts globally at the medium range (5-14 days) and subseasonal (14-90 days) timescales. System should meet or exceed conventional NWP metrics for skill and computational expense, especially for high impact weather events and high error scenarios.

DESCRIPTION: Rapid progress has been made in the past few years in the development and application of AI/ML meteorological models, especially with respect to mirroring capabilities of state of the art dynamical NWP models. There is recent evidence that AI/ML models can be as skillful as state-of-the-art NWP using standard metrics (e.g., anomaly correlations, root-mean-square errors, etc. – see Weyn et al. 2020, 2021; Lam et al. 2022; Bi et al. 2022, 2023; Zhang et al. 2023). However, it remains unclear how well these models perform using more complete metrics that incorporate high-impact weather events (e.g., rainfall, peak winds, etc.), smaller scale atmospheric features, and high sigma (i.e., uncommon) weather pattern scenarios. Furthermore, many of these AI/ML models are trained with relatively coarse resolution reanalysis data. A challenge remains how to better use volume of data (including from commercial sources) for better initial conditions and forecasts. While certain aspects of traditional NWP infrastructure may be difficult to change (such as data assimilation and model analysis states), other aspects such as parameterized physics, construction and diversity of ensembles toward probabilistic forecasts, and identification of forecast uncertainty are ripe for improvement by AI/ML methods. This topic aims to bolster strong development of AI/ML NWP techniques by soliciting targeted research and development to robustly improve skill and resolution of weather forecasts. Specifically, we seek to improve scientific understanding and forecast capability at the medium range (5-14 days) and subseasonal (14-90 days) timescales for both state variables and derived metrics (e.g., clouds, precipitation, etc.). While it is anticipated that weather feature fidelity will be achieved via large ensemble development, use of downscaling towards high resolution techniques would also be considered. Robust methods to resolve high impact cases and development of verification statistics that do not smooth/average out those signals will be necessary. Finally, a significant component of this effort involves development of understandable (explainable) AI/ML infrastructure and techniques that support refined physics improvements and the ability to substitute newer methods as routines evolve.

PHASE I: Perform a comprehensive feasibility study on the proposed end-to-end software architecture as well as demonstrations of AI/ML technique effectiveness to address this problem. Study should include a comprehensive literature review including the state of the science and trajectory, an analysis of alternatives on different AI/ML methods and their strengths and weaknesses, and a discussion on the most challenging research and development parts of the problem (focusing on physics representation, skill challenges with lead-time, and representativeness of weather features at different resolutions). Analysis must include potential for large ensemble and probabilistic approaches and/or high resolution and downscaling techniques and the potential need to use coupled earth system models (that include atmosphere, ocean, land and/or ice) to foster longer range skill. Requirements on computational architecture/software/data should be outlined, as well as proposed metrics to improve beyond point-based averaged metrics towards emphasizing high impact weather events, skill dropouts, and bifurcating scenarios.

PHASE II: A prototype system capable of running real-time forecasts comparable with state of the art dynamical weather prediction systems shall be delivered at the end of Phase II. Development of this capability includes building out the appropriate data ingest, physics representation, forecast propagation, and data output. Architecture components must conform to leveraging processes available to traditional dynamical modeling platforms. Throughout this development, computational efficiency benchmarks should be provided to assess acquisition hardware needs. For more mature efforts, there should be a strong focus on developing very large ensembles and/or high resolution and/or other proposed novel/innovative use of NWP, data assimilation and initial condition sensitivity to demonstrate fidelity for high impact events on 5-90 day time scales. Software must incorporate potential to train/retrain model or model elements. Verification and validation (V&V) will be emphasized throughout the Phase II, with multiple retrospective and real-time V&V development check points. System should be flexible enough to have iterations of skill improvement, validated using impact-based probabilistic metrics with concurrent ONR field campaigns (that may include one or more of analysis of tropical cyclones, atmospheric rivers, boundary layer, and air-sea interaction). There will be particular interest in comparison of skill with other NWP models and analysis of high error/dropout events when AI/ML technique is superior to the traditional NWP model (and vice versa). Sensitivity to grid resolution, initial conditions, and training versus validation datasets (seasons, years, models) will need to be tested and reported.

PHASE III DUAL USE APPLICATIONS: Primary Naval transition opportunity would be to the Fleet Numerical Meteorology and Oceanography Center as an operational weather forecast model run in real-time production. Phase III efforts toward this goal would entail building out the software infrastructure needed to run on local compute, dedicated HPC, and/or government cloud compute solutions. Careful consideration would be needed to develop an environment conducive to upgrades, such as from new data sources, retrained AI/ML equations, and application to varied use cases (such as regional domains, output variables, verification statistics, etc.). Phase III, or alternate projects, would also coordinate with partner Air Force and Army numerical weather prediction programs for other DoD use cases and spin-off efforts. There will also be opportunity and potential to partner with other government agencies outside of the DoD, such as NOAA, NASA, and DoE for their weather modeling use cases. Commercialization beyond government services would support a growing industry with varied needs for computationally efficient and highly specialized meteorological forecasts, including demonstration of commercial weather data services, tailored platforms spanning multiple industries (e.g., agriculture, insurance, aviation, etc.), and general public interests.

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KEYWORDS: Numerical Weather Prediction; Machine Learning; Artificial Intelligence; Subseasonal to Seasonal; Forecasting; Reanalysis; Mesoscale; Meteorology; Oceanography; Earth System Modeling

N241-055 TITLE: Generative Text Engine for Form Completion

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

OBJECTIVE: This SBIR topic is soliciting tools and techniques to facilitate generating semi-structured text reports with free-form text. There is a research interest in exploring the application of Generative Text artificial intelligence (AI) (such as Chat GPT, GPT3/4, etc.) to facilitate the filling in of text-based data collection forms; however, other tools and approaches will be considered if it is explained how they would contribute to the requested capability. The data generated by this general purpose form completion engine will lead to reduced data curation for subsequent analytics. The desired solution will:

(1) generate a general-purpose curation/creation text engine that facilitates completing a variety of text-based forms.

(2) describe a mechanism for incorporating technical terminology & phrasing appropriate for a specific usage domains (potentially including sensitive or classified terminology and phrases) along with a general baseline generative text engine.

(3) be designed to be useful with minimal compute, and without immediate or sustained connection to cloud-based processing resources. Cloud-based Processing intense resources may be used in developing the general-purpose engine and achieving threshold performance, but the proposal must describe how the initial capability will be refined to be useful with minimal computer and storage footprint. Further, the proposal must state the size and capabilities for processing that shall be required to achieve with threshold and objective (final) performance in the desired system.

(4) describe any key technologies being used in creating the capability, and clearly characterize the data usage rights associated with those capabilities.

The concept being proposed in this SBIR topic shall demonstrate the use generative text algorithms to curate the text entries as they are being created. The desired solutions should:

(1) focus on a workflow / process for a prompting dialog between the generative text engine and the user vice developing large language models. It is expected that some tuning of large language models may be required to address a specific technical domain, but that should be as constrained as possible to focus on the process whereby users interact with the models to facilitate form completion.

(2) be easily adapted for incorporating technical jargon and domain specific phrases for different usage domains. The technique(s) for incorporating specialized technical language into the application must be described.

(3) address anticipated prompt tuning techniques to adapt to specific technical domains enabling techniques for one-shot or few-shot learning.

(4) generate appropriate phrases/descriptions (an understanding of what is being described) in different task domains that are correctly structured and generate consistent and appropriate technical descriptions.

(5) be scalable for use from PCs/Tablets/Phones with limited connectivity to a local server and be cloud- connected, not cloud-dependent.

(6) provide for the use of instructions + answers as a sustainable workflow for maintaining / utilizing the authoring / curation engine.

DESCRIPTION: This effort is aimed at enabling the creation of text-based forms with consistent terminology and phrasing by applying generative text artificial intelligence (AI) technology during the authoring of form content. The desired technology will assist content creators by offering interactive curation during the content authoring. The application of the developed technology will result in more consistent form content that is amenable to automated analytics on the generated text and will therefore accelerate and improve accuracy of ship maintenance reporting.

New advances in integrating Large Language Models (LLMs) in application pipelines have demonstrated the potential to support a wide range of technical reporting domains; however, there are significant challenges in generating text with relevant content and terminology when completing maintenance reports. While LLMs show impressive performance in general knowledge and reasoning capabilities, they have inherent limitations and lack capabilities required for broad language understanding and use in the real world (e.g., specialized or proprietary knowledge of terms, facts and concepts). Fine tuning, parameterizing, and combining LLMs with external tools should produce capabilities that enable LLMs to be more useful in real world settings, such as that of facilitating completing form-based descriptions of technical problems and their impacts. The desired applications will provide customized content to support maintenance reporting workflows and answer technical questions across a variety of maintenance reporting use cases.

PHASE I: Conduct research in open source LLMs with commercially permissive license (e.g., Apache 2.0, MIT) to identify, select, and track appropriate models that have the potential to perform well for the Navy domain and desired downstream tasks. Selected models must be usable in both research and commercial settings. The solution will need to work on resource constrained devices (e.g., tablets, laptops), which may be disconnected from the Internet and cloud-based resources during form authoring. To improve the performance of models in deployment environments, different techniques (e.g., distillation, supervised fine-tuning, parameterization) should be identified, explored, and evaluated to ensure correct information is generated for the defined downstream tasks. Define the task and data sources that will be used to act as a suitable proxy for ship maintenance reporting, which involves consistently generating text necessary to fill-in ship maintenance forms. The longer-term technical objective is a general-purpose form-completion engine that can be readily adapted to various technical domains and terminologies and utilize alternative technical jargon and phraseology. The selected LLM and a systems-based approach will minimize model behaviors that generate incorrect content for the selected domains and defined tasks. It is assumed that the task being performed will require new knowledge that was not part of the pre-training data of a general large language model. Successful approaches will securely combine new private data into the workflow and customize the LLM for a target domain and authoring task. Phase I should result in proof of concept demonstrations of key capabilities so as to show how a prototype tool will be built and demonstrated during Phase II. The primary metrics for Phase I success will be quality of proposed workflows for user interaction and a demonstrated use case to show how forms would be completed using a representative large language model.

PHASE II: Build on the tools and results of Phase I to create a viable prototype tool for form completion. Utilize real world forms completion tasks. Ideally the problems and real-world data sources would relate to Navy ship maintenance reporting and ship material readiness, although use cases for other transition customers would be acceptable. A prototype tool will be built and tested to demonstrate a proof of concept involving a user interacting with the system to produce a complete and accurate report. The Ship's Maintenance Action Form (OPNAV 4790 or two-kilo) is an example of a primary maintenance data system (MDS) form that would be of interest, which is used to report both deferred and completed maintenance actions. The mission-degrading casualty report (CASREP), is another example that is used to report an equipment degradation to the operational commander which impacts mission readiness. Automated tools will (1) generate text and fill in these semi-structured forms with free-form text fields, (2) reduce data curation requirements, and (3) enable analytics on the curated data.

For Naval applications, the contractor will need to be able to process Controlled Unclassified Information (CUI) and/or classified data sources up to the Secret level. The government team will provide contractor access to historical reports to support development and evaluation of the proposed techniques, automated tools, and analytics (e.g., text generators, classifiers). The historical text was often written inconsistently and therefore making it challenging to automate analytics across this data. Address inconsistencies and unique language in the various text reporting workflows and describe how the proposed capabilities will support generation of high-quality data for reporting. Describe and demonstrate analytics/metrics on the text data generated to assess the quality of the text being generated. Assess how the tool will run on resource constrained hardware (e.g., tablets, laptops) with reasonable compute capabilities and document its ability to run on-line and off-line (i.e., that the developed technology would be suitable for shipboard/at sea use with limited access to cloud/remote computing capabilities). The tool will provide a tailorable vocabulary database suitable for use across different technical reporting domains (e.g., electrical systems, distillation systems, turbine mechanics, etc.). The workflow and user interface will be fully described and demonstrated as appropriate. The workflow shall be demonstrably easy to use and will demonstrate valid, predictive results. Technical evaluations, capability demonstrations, and metrics will focus on the quality of the human machine interaction (HMI), completeness / correctness of reports, and generalizability of approach across technical reporting domains shall be addressed at the completion of Phase II.

PHASE III DUAL USE APPLICATIONS: Integrate and transition the developed tools for support of the NAVSEA SEA21 Ship Maintenance Data Improvement Initiative (SMDII) Program of Record (POR) to support automated text processing requirements for Navy ship maintenance reporting and ship material readiness. The tools being developed are expected to be applicable to a broad range of form completion applications, including for medical, maintenance, and other domains reliant on text-based data entry.

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KEYWORDS: Automated Text Curation, Large Language Models (LLM), 2-Kilos, CASREP, Casualty Report, Form authoring, Artificial Intelligence, AI

N241-056 TITLE: Autonomous, Mission-based Traffic Engineering

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

OBJECTIVE: Develop autonomous, mission-based traffic prioritization mechanisms/techniques and orchestration to ensure network priorities are aligned with the Commander's Intent – especially during contested operations when there will not be sufficient network resources to satisfy all of the operational needs.

DESCRIPTION: Tactical networks typically contain an admixture of critical, essential, and non-essential traffic. Criticality of the traffic depends on the types of missions that are currently being executed, mission phase, etc. and is, consequently, highly dynamic. Reference (1) outlines command and control (C2) constructs for the U.S. Navy and Army. These constructs have different warfare commanders, functional commanders, and coordinators – with different network applications / priorities – that must be synchronized to achieve operational objectives. The Navy seeks technical solutions for (1) identifying different types of traffic, (2) associating each traffic type with specific platforms as well as functions/missions, (3) enabling the Commander to prioritize these functions/missions, and (4) translating the Commander's prioritization into network policies that can be implemented across the network to ensure, to the extent possible, end-to-end delivery of mission-critical traffic.

There are two main technical challenges that must be solved:
(1). Reliable mapping of Commander's intent and mission objectives into structured data forms that can be combined with policy representations and reasoned with by machines. Supervised Natural Language Processing (NLP) training requires more exemplars than may be available given the highly dynamic nature of Commander's intent or mission objectives. Machine representations need to precisely capture the original human meaning within the intent as well. Reference 2 provides an overview of the application of artificial intelligence in different areas of the private sector.
(2). How to combine machine representations of policies? Ontologies can be used to capture schema but live tactical feeds for situation awareness, which may be ad hoc, are also critical.

PHASE I: Develop a framework/approach to address the challenges outlined above. Prepare a report documenting the proposed framework/approach along with any preliminary results or data that help demonstrate the viability of the proposed approach. Include in the report a proposed set of benchmarks for assessing performance of the framework and a clear articulation on how the framework is viable with incomplete training data sets. The latter is important because warfare commanders are individuals who have different preferences for receiving and displaying information to support a decision.

PHASE II: Implement the proposed framework using representative data sets for different functions or missions. Demonstrate how the framework correctly interprets intent and then translates that intent into traffic engineering policies. Show how this intent is met both with dynamic network demand and changing circumstances (e.g., priorities change due to a triggering event). Prepare a report documenting the framework implemented, how it was tested, the resulting performance, and recommendations or lessons learned for future implementations.

PHASE III DUAL USE APPLICATIONS: Integration and transition into ADNS is the objective of Phase III. The commercial sector has historically relied on fixed, terrestrial networks and can either easily procure more bandwidth to alleviate congestion or add redundancy. For truly mission critical traffic, the commercial sector builds dedicated networks with dedicated resources to guarantee performance. However, the push towards 5G deployment and increasing need for real-time control systems for autonomous vehicles, automated manufacturing, smart city concepts, etc. are pushing the commercial sector to develop prioritization mechanisms and how to orchestrate their employment across the network to ensure end-to-end delivery of mission-critical traffic. A potential commercial transition option that can be explored is to integrate the algorithms developed into the zero-touch network management solutions developed for 4G/5G mobile services by ZTouch.

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KEYWORDS: Command, Control, Network, Prioritization, Mission, Automated, Dynamic, artificial intelligence/machine learning, AI/ML

N241-057 TITLE: Networking Platform for Real-time Communication of Personnel Health Status and Location during Shipboard Emergencies

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

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

OBJECTIVE: Develop a prototype networking platform capable of relaying real-time information on personnel health status and location during shipboard damage control activities. This platform should be fully capable of pushing continuous data steams through shipboard spaces to Surface Forces supported wireless systems, such as ship’s Wi-Fi, land mobile radio (LMR) leaky coax antenna system, or the Command Readiness, Endurance and Watchstanding (CREW) platform hardware and integrating data into a flexible graphical user interface (GUI) positioned at command and control nodes throughout a ship and robust data management and analytic capabilities for post-event assessments (e.g., mishap investigations).

DESCRIPTION: Due to new enemy weapon systems (e.g., hypersonic missiles) and the heightened risk for engagement at-sea with near-peer adversaries, shipboard combat-related emergencies and subsequent damage control response capabilities will be a defining feature of future US Navy operations [Refs 5, 6, 7]. Damage control (DC) activities involve containment of shipboard damage; managing consequences; recovery capabilities; and sustaining the ship’s combat effort [Refs 1-4]. DC activities include firefighting; flood control; structural support/repairs; combat system repair; ordnance clearance; and causality care [Refs 1-4]. These activities are largely performed by Sailors trained in various DC functions and conducted in the extremely hazardous conditions present in damaged shipboard compartments [Refs 1-4]. Hazards may include exposure to extreme heat (> 1500 °F at point of fire), burns, and inhalation of smoke and/or toxic compounds [Refs 1-4]. DC crew casualties may prevent efficient or complete damage containment and repair which may lead to loss of ship and high casualty rates among the ship’s crew during combat operations. The goal of this SBIR topic is to optimize DC responses and mitigate crew casualties by developing a capability to automatically relay DC responder health/equipment stati and movement/location data within shipboard spaces and provide real-time actionable data streams to shipboard emergency response command nodes, such as DC Central and/or the bridge. Such capabilities are required to enable more efficient utilization of personnel resources during DC operations; more efficient containment/repair of combat damage to ships; and reduced casualty rates among shipboard personnel.

Current systems utilized aboard US Navy ships for communication between DC teams and command nodes consist primarily of verbal communications and sound power telephone circuits augmented by short-range radios and ship’s intercoms [Refs 3, 4]. Tracking of damage, personnel movements, and damage containment/repair progress is currently conducted by command node personnel via hand annotation of whiteboard schematics of shipboard spaces in response to input through standard communication circuits and ship-integrated environmental sensing systems [Refs 3, 4]. Currently no automated real-time system for comprehensively tracking DC responses on Navy ships exists [Ref 6]. This recognized capability gap prompted Naval Surface Warfare Center – Philadelphia Division to develop the prototype Advanced Damage Control System (ADCS) designed to track shipboard damage and containment/repair progress with inputs from environmental sensors and DC crew annotation of a portable tablet-based interface positioned at damage scenes that is designed to exploit the Wi-Fi capabilities of next generation combat ships [Ref 6]. However, the ADCS has not been designed to directly or automatically provide real-time tracking of DC crew health status and location/movement during DC operations.

Technical challenges/requirements:
1) The essential requirement for successful responses to this topic call will be development of a prototype networking platform capable of real-time relay of DC crew health status and location/movement during DC activities and communication of actionable data streams to shipboard command nodes.
2) A major limitation encountered by platforms designed to transmit data from handheld or wearable devices onboard ships is the difficulty with radio transmission through metal bulkheads, aka the 'metal box problem' [Refs 1, 3, 6]. Communication security concerns also restrict decentralized data transmission tolerance aboard ships [Refs 1, 3]. Thus, the prototype platform must be capable of integrating into modern shipboard wireless communication systems and may require innovative approaches to meet all general DoD and US Navy afloat-specific cybersecurity requirements. Ship Wi-Fi or systems, such as CREW, which utilizes networks of centralized hubs placed strategically throughout ships, are capable of receiving inputs from wearable monitoring devices and pushing aggregate data to GUI dashboards for command view. Though not necessarily designed to collect data from personnel in every shipboard space, such systems represent a potential relay point for DC-specific tools to move data streams from wearable sensors on DC personnel out of shipboard spaces to command nodes. Successful respondents to this topic will develop a prototype platform that networks with established wireless systems through portable or wearable hardware that does not require structural modification to shipboard spaces; develop all software required to integrate data from prototype hardware to established systems allowing for continuous data processing; and develop all software required to display real-time summary data of DC crew health status and location/movement on dashboard type interface.
3) Further, due to the unique suite of environmental and procedural factors inherent to shipboard DC, identifying key biometric factors that are most relevant to shipboard DC crew performance decrement and safety, and thus summary 'health status', remains an active area of research. As such, the resulting prototype platform does not require unique sensor development and must be functionally agnostic to biometric sensor choice and amenable to post-development selection/substitution of sensors.

PHASE I: Demonstrate feasibility of a proof-of-concept networking platform that is capable of real-time relay of DC crew health status and location/movement during DC activities and communication of actionable data streams to shipboard command nodes through limited laboratory testing/demonstrations. The resulting platform should be capable of pushing and relaying data streams within and through bulkheads of modern US Navy ship compartments to established wireless systems, and may consist of portable or wearable pucks carried to damage sites by DC crew or other innovative solutions. Further the platform should be fully functional in ambient temperatures up to 150 °F. Provide cost-effective design and reliability estimates, to include lifetime cost estimate and service life expectancy. Phase I deliverables in addition to standard Phase I deliverables outlined in the BAA, will include: 1) design plans for the prototype platform based on the Phase I proof-of-concept design; 2) an RDT&E plan to develop and validate the final platform in Phases II-III; and 3) a preliminary prototype (physical or virtual) that is capable of demonstrating feasibility of the Phase I proof-of-concept design.

PHASE II: Develop, demonstrate, and validate the prototype networking platform based on the Phase I proof-of-concept design. The resulting platform should be able to perform collection and analysis of data under the relevant environmental conditions (as cited in the Description and Phase I sections). The platform should be capable of processing data continuously for 48 hours or longer utilizing on-device processing, and include all software required to integrate data from prototype hardware to established wireless systems. Platform outputs must be integrated into flexible GUI dashboard-type displays that can be positioned throughout ships for command monitoring of DC crews. Resulting prototype platforms will be tested on human participants at US Navy DC training centers or other acceptable fire training facilities which may include civilian firefighter training centers. The Phase II platform design may be intended for experimental or training use and need not be fully adapted and ruggedized for operational use. Phase II deliverables will include: 1) at least 2 prototype units; and 2) detailed design specifications and technical data package drawings that ensure IP protection.

PHASE III DUAL USE APPLICATIONS: ONR will support the small business with transition of a resulting successful prototype platform for additional development to the Naval Advanced Medical Development and/or the Naval Sea Systems Command 05P5 DC/PPE Tech Warrant Holder, which maintains DC equipment authorized for Naval use. Discussions with corresponding POCs at these offices have been initiated and are ongoing. Operationally relevant conditions will likely necessitate additional development and testing of the platform, which may require greater temperature tolerances, extended data collection, and/or enhanced security capabilities. A successful respondent to this topic call shall support the US Navy in developing the resulting technology for use across the full spectrum of operationally-relevant conditions/environments and account for applicable ship-class specific variations that might impact functionality (e.g., in-hull designs and metallurgy). The small business shall also develop a plan to commercialize, mass produce, and deploy the technology and its associated operating procedures.

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4. United States Government Accountability Office, Report to Congressional Requestors, NAVY SHIP FIRES: Ongoing Efforts to Improve Safety Should be Enhanced, April 2023.

KEYWORDS: Damage control; shipboard firefighting; flood mitigation; wearable monitoring device; personnel protection equipment; wireless shipboard communications

N241-058 TITLE: Multi-Sensor Prototype for Non-Destructive Corrosion Evaluation and Characterization

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

OBJECTIVE: Develop a multi-sensor unmanned aerial vehicle (UAV) system that can assess the condition of a guy wire in situ (in place/position) and identify degradation and potential areas of repair needs before major damage has occurred.

DESCRIPTION: Current UAVs include visual cameras, making visual inspection easily attainable, but cannot view below the surface. Ultrasonic inspection of corrosion on cables requires direct contact with the surface along with the application of a water-based gel, neither of which are easily adapted into a UAV for cable inspection [Refs 1, 2]. Infrared (IR) thermography cannot view more than a few centimeters below the surface and may require high temperatures to provide useful data [Ref 3]. X-ray fluorescence requires extra safety considerations given the outdoor environment. Eddy current testing requires direct contact or near direct contact [Ref 4]. Magnetic flux analysis may require large magnetic fields to provide useful results.

The desire is for a mobile platform that combines multiple sensors and measurement/analysis technologies to provide subsurface corrosion detection along with surface corrosion characterization up to hundreds of feet away from the operator. Basic requirements:

• Travel height above ground: 1000ft (T), 1500ft (O)
• Travel length in one direction: 1500ft (T), 2300ft (O)

PHASE I: Develop a concept for a UAV system with a multiple Nondestructive Evaluation (NDE) sensor configuration to characterize corrosion and identify areas of further interest. Demonstrate the feasibility of the concept. Prepare a report to ONR / NIWC Pacific on system concept design(s) and sensor output modeling and prepare a Phase II production and testing plan.

PHASE II: Construct a prototype UAV system and assess the accuracy of the corrosion characterization. Provide a report that documents the design options for a prototype system that includes results of operations and type/level/fidelity of corrosion inspection performance. Provide a Phase III plan to ONR 35 / NIWC Pacific for prototype evaluation. Produce a prototype system for NIWC Pacific evaluations.

PHASE III DUAL USE APPLICATIONS: Refine the UAV system and demonstrate corrosion identification, characterization, and analysis. Deliver a UAV system to NIWC Pacific and provide a report containing designs and test data to ONR / NIWC Pacific. The development of a more available option for UAV corrosion assessment would enable remote inspections for a variety of commercial infrastructure applications. Current commercial infrastructure (wind turbine blades, ship hulls, etc.) makes use of a variety of sensor outfitted unmanned systems (UxS); however, none are currently optimized for stand-off, large scale corrosion inspection to the best of our knowledge. Most of the existing commercial options are predominantly fee for service options, vice a complete, off-the-shelf hardware/software asset that is available for procurement.

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KEYWORDS: Corrosion identification; unmanned aerial vehicle; UAV; infrared imaging; eddy currents; magnetic flux; ultrasonic testing; non-destructive materials

N241-059 TITLE: Wideband Interference Suppression

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

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

OBJECTIVE: Define, develop, and demonstrate a microelectronics made interference suppression system for use in a single antenna system that can operate simultaneously over a wide spectral bandwidth that contains multiple independent and uncooperative loud signals as well as many small signals which are both of significant interest (SOI) and of low interest (NSOI) categories.

DESCRIPTION: The radio frequency spectrum has become increasingly crowded due to the rapid expansion of wireless networks and growth of the expectation, even in the military, that discussion of alternative response behaviors will occur during decision making. The proximity and overlapping frequency allocations of multiple wireless systems inevitably lead to communication interference. Military environments, both on land and at sea, face additional challenges with constantly shifting transmitters that change location, transmission direction, and frequency. The move toward every platform doing many operations simultaneously drives up the number of functionalities each platform engages in and each has its own transmitter. The resulting electromagnetic environment is complex and carries a significant risk of unintentional interference, especially given the likelihood of signal reflections from neighboring platforms within the battle group. Design and placement of antennas alone cannot sufficiently address the issue.

While digital signal processing techniques have made great advances in enhancing modern electronic warfare, communications, and radar systems, the most efficient approach to interference mitigation is to protect the receiver from exposure to interferers. This requires hardware that can suppress interference as close to the receive antenna as possible, typically at the front end. And as future receivers aim to eliminate analog down-conversion stages and ingest wider bandwidths for direct digitization, the demand for front-end filtering becomes even more critical. Meanwhile the pace of battle has accelerated and the sheer bulk of signals needing attention drives the priority of shrinking the time it takes to respond to any one scenario. Speed of adaptation becomes a critical system parameter.

One possible solution is provision of a number of fast tuning, analog filters. Individually they need to possess steep band edges, highly attenuating stop bands, and low insertion loss. All proposals should quantify their expectations regarding these parameters. Static filters are a well-established and reliable technology. They would be sufficient if the interferers’ frequency, spectral width, and power were known and consistent, which unfortunately is no longer the case. Effectively addressing the challenges posed by today’s electromagnetic environments demands the use of multiple fast tuning or self-generated notch filters. These filters should be generated independently (in linear fashion) and adjusted in terms of center frequency. A mechanism should be defined to control the bandwidth and depth, which may be interdependent parameters. If active control is required, the same control parameters must produce the same response independent of the previous control settings (i.e., no history effects). The time between the arrival of a new interfering signal and the beginning of its suppression within the total signal needs to be less than a microsecond and ideally less than 1 nanosecond. Additionally, the passband of the total filter should exhibit transmission losses of << 1dB when on and less when parked/inactive/off. The technology selected for demonstrations should imply the net total device insertion loss upon signal Input/Output (I/O) should not dominate the system behavior. Furthermore, the filters need to demonstrate characteristics such as reliability, environmental temperature stability, and resistance to mechanical vibration. To succeed as a product, a high level of as fabricated device-to-device repeatability is needed, or testing and calibration costs can balloon.

Both innovation of the proposed notch filtering mechanism and a lack of distortion of acceptable amplitude signals are sought. Device concepts requiring a reference signal for the signal to be removed must describe how to obtain same for uncooperative transmitters. Systems requiring signals analysis to determine the frequencies at which filters should be tuned need to include that processing time in their turn on/off time estimates. The production of out of signal band interference is not an acceptable byproduct.

The solutions proposed will also be judged on the processing latency they introduce and their design complexity and Size, Weight and Power (SwaP) when the functional instantaneous bandwidth (IBW) contains hundreds of simultaneous signals of interest and there is only one antenna available. The ultimate IBW will exceed 20 GHz. Photonic approaches are acceptable but not required. Such proposals should indicate the expected required optical power of the photonic carrier. All proposals should be careful to define the acceptable range of Radio Frequency (RF) carrier frequencies, estimate wall plug power costs of implementation, describe all during operation circuit trimming required, and provide a discussion of the individual contributions to the system's overall noise figure in a technical risks section.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: In the base, develop the approach, as outlined in the Description, toward the ultimate demonstration for more than two interferers of different bandwidths, including spread spectrum noise like signals, and both narrow and wide band desired signals spread over the entire proposed input IBW simultaneously. The initial demonstration of a multi-notch filtering system should focus on the 3 MHz to 6 GHz communications dominated band, and provide up to 10 independent notches, tunable across the entire band with > 40 dB stop-band rejection and 3-dB bandwidth of < 1 MHz per notch, self or externally adjustable up to > 20 MHz. The Phase I base period should include sufficient performance measurements to allow estimation of the performance expected if the Phase II preliminary plan is accepted. In the Phase I option period, if exercised, further optimize the circuit design and test the prototype more completely with all kinds of signals of interest and interferers.

PHASE II: Review whether the Phase I choices of materials and approach is optimal for wide band ingest performance. If not, consult with the government sponsor whether a change in materials is warranted and if yes, develop a new brass board demonstrator. If not, proceed toward a full IBW demonstration aiming for minimum size, weight and power while including additional C(G)OTS components to be named by government. If the Phase II Option is exercised, continue progress toward integrating this circuit with other required parts in a system.

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

PHASE III DUAL USE APPLICATIONS: The successful result of this SBIR topic will be an enabling technology. Interference suppression is necessitated by the common issue of co-site interference when many transmit antennas are closely collocated with receive antennas without sufficient free space isolation for Simultaneous Transmit And Receive (STAR) to be possible. Moreover, many commercial base-stations have the antennas of many vendors collocated on the same tower and are increasingly bothered by co-site interference.

REFERENCES:

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2. Poor, H.V. “Adaptive Interference Suppression for Wireless Multiple-Access Communication Systems.”Circuits and Systems for Wireless Communications In: Helfenstein, M., Moschytz, G.S. (eds). Springer, Boston, MA, 2002. https://doi.org/10.1007/0-306-47303-8_27

KEYWORDS: Co-site interference; photonic interference cancellation; actively tuned filters; RF isolation; ultra-wide instantaneous bandwidth reception; spurs; intermodulation distortion

N241-060 TITLE: Ultra-High Reliable and Efficient Unmanned Surface Vessel (USV) Modular Generator System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Renewable Energy Generation and Storage; Sustainment

OBJECTIVE: Develop and demonstrate a megawatt (MW) scale, ultra-high reliable and efficient Unmanned Surface Vessel (USV) modular generator concept configured with smaller KiloWatt (kW) scale building block power units in a high-density package to achieve a 4,000 hour no touch maintenance periodicity for continuous operation in a naval environment.

DESCRIPTION: Unmanned surface platforms are expected to become an indispensable part of Naval operations, yet current power system technology does not satisfy future long-duration USV mission needs. Current power generation system technology for USVs supports missions on the order of days to weeks, but many future missions will be measured in months.

One of the most critical enabling capabilities for USVs is reliability of the Hull, Mechanical, and Electrical (HM&E) systems. A significant part of HM&E systems is power generation, which is presently leveraged from manned platforms. These power generation systems, primarily diesels, are not specifically designed for high reliability and maintainability without human intervention.

Modular generators are functionally equivalent to single engine based shipboard diesel or gas turbine generators. The modular configuration enables a common flexible design approach to meet USV cross platform needs, both large and small, to be scalable to total power needs; enables graceful degradation of the system rather than a complete system shutdown in the event of a component failure; and can also be configured as needed to adapt to available platform space.

Innovation is sought to configure and optimize smaller kW scale power units to achieve the following:
• Modular Generator Total Power Output: 1 MW or greater
• Fuel: Navy Logistics Fuel including NATO F76
• Building Block Power Unit Scale and Type: 10's-100's kW High Density Diesels, Stirling Generators, Fuel Cells, Gas Turbine Generators. Note that innovation will be sought on how to configure installation of multiple power units to allow for easy access for maintenance, quick removal and replacement as well as optimize operating life via controls.
• Maintenance Interval: 2000 hrs
• MTBF: 4000 hrs
• Modular Generator Electrical Output: 800-1000VDC
• Operate in a marine environment conditions such as salt air ingestion, ships motion in high sea states, shock, vibration, etc.
• Modular generator volumetric and gravimetric density will be equal to or greater than equivalent power level marine diesel generator sets. Note that innovation will be sought on how to configure installation of multiple power units to maximize density as much as possible.
• Modular single point connections for power, fuel, cooling, exhaust, and controls. Note that innovation will be sought on how to best optimize design to combine multiple power unit connections to a single ship interface.

PHASE I: Develop a Modular Generator conceptual design accounting for innovations and requirements stated in the Description with a defined building block power unit.

PHASE II: Develop a Modular Generator package. Demonstrate innovations identified in the Description. Further demonstrate high risk marine environment conditions as required.

PHASE III DUAL USE APPLICATIONS: Build a MW scale Navy modular generator incorporating innovations identified in the Description. Perform land based testing to prove operational capability with potential for subsequent at sea demonstration. Dual use application includes commercial marine and land-based generators.

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KEYWORDS: Modular Generator; High Density Diesel; Stirling; Fuel Cell; Gas Turbine Generator; USV

N241-061 TITLE: Multi-variable Unmanned Anti-Submarine Warfare (ASW) system assessment and optimization toolkit

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

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

OBJECTIVE: Develop an analytical toolkit that allows identification, examination, and optimization of tradeoffs of proposed unmanned Anti-Submarine Warfare (ASW)platforms (and their hosted systems), enables comparison of their performance to that of existing manned counterparts, and provides performance metrics for various combinations of unmanned and manned assets in conducting selected theater ASW missions.

DESCRIPTION: The toolkit will enable analysis of the performance of potential unmanned ASW platforms, balancing their unique capabilities and constraints (e.g., self-noise, endurance, operating speed, payload capacity, etc.) with different sensors/sensor configurations, different numbers of platforms, viability of various acoustic and RF communications paths, and performance against selected real-world targets in relevant operating environments. The tool will allow examination of search area, coverage rate, probability of detection vs probability of false alarm, cost per unit area covered, etc. The tool will account for the inherent mobility of unmanned maritime vehicles to optimize area coverage, based on vehicle capabilities and sensor payload selections.

The toolkit will be applicable to all potential phases of ASW operations, including barrier search, wide area open ocean search, classification, localization, and engagement. Environmental variability will be taken into account to provide sensor coverage estimates for various theater ASW scenarios. Based on environmental variables and constraints and expected target detection and classification parameters, the tool will assess sensors of differing modalities and optimize sensor selection and asset allocation. The tool will account for both acoustic and non-acoustic means to detect, classify, and localize targets. Inputs from oceanographic field forecasts will be used to optimize ASW laydowns of assets, manned and unmanned. The tool will enable direct comparison of performance to manned counterparts but will also analyze performance of unmanned systems working in conjunction with manned platforms to enhance theater ASW. The tool will allow an operator to simultaneously examine the performance of multiple platforms (manned and unmanned) and explore different deployment options (i.e., different force laydown/formations) against a number of threat options. The system will determine optimal placement of these assets and associated sensors, and be used to inform development of critical technologies. For scenarios involving multiple unmanned surface and undersea vehicles, the toolkit will consider track synchronization requirements across multiple platforms, defining communication paths required to achieve contact correlation and coherent target track formation. Track synchronization shall be timely, robust, and accurate enough to support automated contact correlation. The toolkit will be able to take into account cases where one or more unmanned platforms or sensors fail or are unable to communicate during mission execution, resulting in the need to reallocate and redistribute assets to provide the best area coverage for the scenario. Shifts from a benign communications environment to a degraded communications environment will be considered and taken into account. Toolkit assessments and theater-level allocation recommendations will be able to be dispersed across Commands via assured server to server communication.

The toolkit will provide information via a map-based graphical display that is intuitive and easily understood by a trained operator. The toolset will provide waterspace management capability for manned and unmanned platforms, allocating undersea assets by depth in addition to latitude and longitude position. The toolkit will provide graphical means to display analysis products for areas of interest (two dimensions) or for volumetric water spaces (three dimensions). The toolset will have the ability to easily update ASW target characteristics in order to predict ASW performance of selected platforms and sensors. Although not the focus of this SBIR topic, the basic technology will be extensible to Anti-Surface Warfare (ASUW) and Anti-Air Warfare (AAW) targets and scenarios.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop the algorithmic baseline that will underlie the analysis toolkit, showing that the algorithms work for a small number of variables (on the order of ten distributed vehicles, either surface or undersea in nature, working with one or more manned platforms). Demonstrate that the system is capable of learning or accepting performance data for each variable. Demonstrate the optimization of the variables against a pertinent ASW mission scenario in a realistic acoustic environment. Algorithms can be in Matlab or other code development tools for this demonstration.

PHASE II: Develop a software system that can handle thousands of variables. Key types of variables including but not limited to platforms, sensors, communication, costs, environment, and targets. Each type of variable will have performance metrics associated with the system. The final system should be a graphics-based input output with touch screen capability. The system will allow the operator to enter the ASW platforms, unmanned vehicles, and the sensors available to them. The system will allow ingestion of environmental modeling data necessary to develop realistic coverage estimates for all sensors against the range of targets in the data base. The system will then compute the optimal placement of platforms against metrics such as probability of detection, probability of classification, probability of false alarm, area coverage, and weapons engagement capability.

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

PHASE III DUAL USE APPLICATIONS: The transition project would be to a mission planning system for use by the ONR 321 ASW team for analyzing new technology development potentials.

REFERENCES:

1. EFFECTIVENESS OF UNMANNED SURFACE VEHICLES IN ANTI-SUBMARINE WARFARE WITH THE GOAL OF PROTECTING A HIGH VALUE UNIT, Naval Postgraduate School
2. STUDY OF INTEGRATED USV/UUV OBSERVATION SYSTEM PERFORMANCE IN MONTEREY BAY, Naval Postgraduate School

KEYWORDS: Operations analysis; anti-submarine warfare; multi-variable optimization; multi-sensor; unmanned system; unmanned surface vessel (USV)

N241-062 TITLE: Innovative Low Profile, Foldable, High Power Microwave Antenna

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

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

OBJECTIVE: Develop a lightweight, affordable, foldable/stowable, frequency-scalable, gain/aperture scalable, steerable, low-profile antenna design to improve the performance of High Power Microwave (HPM) weapons. The threshold Radio Frequency (RF) range of interest is 1-to-20-GHz. The antenna system must be capable of High Power use = 100 MW peak power, and waveguide fed.

DESCRIPTION: Components for HPM weapons often work well in the laboratory, but fail in the tactical environment (e.g., dirt, shock and vibration, extreme temperature, exposure to salt water). The objective of HPM weapons is generally achieved by maximizing the Radio Frequency (RF) power density (PD) (PD in units of W/m^2) at the target. PD on target depends on power handling capabilities and gain of the antenna system. A limitation on HPM weapons is achieving appropriate even gain across a large enough bandwidth while maintaining high peak power handling capabilities. The current systems, which couple to HPM antennas, utilize a waveguide output and a wide variety of high-power mode converters already exist, thus any waveguide input can be considered but fundamental modes are encouraged.

While high power antennas exist, most have not been designed with harsh military environments or lightweight steerable mounts in mind. Considerations such as materials that support lighter weights while maintaining mechanical strength to combat wind and water loads (i.e., watertight, wave slap, salt fog, etc.), foldability for storage when not in use, and precise steering to quickly engage multiple targets. Producing high RF power density at the HPM source (in order to produce high PD at the target) will require a multi-disciplinary investigation. Electrical engineering and physics will be required to achieve the objective for high electric field (E) in the antenna input as well as the mechanical requirements needed to survive the harsh military environments. The high power and pulse repetition rate present potential for electrical breakdown in the antenna systems. The pulse duration and maximum size of the aperture can lead to reduced aperture efficiency due to pulse traversal time across the aperture. Current designs feature vacuum-insulated overmoded waveguide feeding a reflector-type antenna. Of course, innovative designs must not introduce unwanted effects; for instance, a voltage standing wave ratio (VSWR) sufficient to damage the source. An innovative design must be able to handle the stress environment of tactical employment, including reducing side lobes to minimize potential Electromagnetic Interference (EMI) to nearby assets and systems, manufacture, transport, storage, launch and operation. The evaluation of the stress environment should include, but is not limited to, shock, vibration, fatigue, water tight, wind loads, corrosion, etc.

KEY ANTENNA PARAMETERS
Will be negotiated with each proposal depending on submitted design. After award a more specific design case may be provided.

- Operating frequency in the range of interest between 1-20 GHz.
- Reliable, operating at peak power levels = 100 MW.
- Maximum possible gains for specific use cases.

• Aperture Area: 10m^2 or greater but scalable and foldable (collapsible) for stowage and transportation when not in use.
• No electrical breakdown inside the antenna, especially at or near the source.
• Waveguide fed and steerable in azimuth and elevation.
• Radome structure to account for sea-state loading, green water load, and sea spray or salt fog corrosion, water tight, etc.
• Radome structure properties specifically beneficial to SOW-negotiated frequencies.
• Compact or low profile design, to-be-determined in SOW negotiation.
• Sufficiently low side and back lobes to permit operation within and near the desired platforms or systems. This will vary but a reasonable expectation may be -30 dB from the well-defined main beam.
• Unique radome designs to reduce side-lobes to ease EMI challenges with platform integration.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Consult with ONR to identify a nominal, perhaps-hypothetical, platform-payload configuration with operational parameters, to include SWAP-C, Effective Radiated Power (ERP), parameters for pulsed RF power, mechanical stress objectives and environmental considerations.
Consult with ONR to identify potential front-end HPM source systems (e.g., including pulsed power) that shall be configured to work with the innovative antenna subsystem.
Develop design strategies, Modeling and Simulation (M&S) and experimental validation for:
• Mechanical Stress analysis
• Mechanical concept design to include steering capabilities and limitations
• Weight analysis, environmental considerations, and transportability
• High power handling capabilities
• Low probability of electric breakdown with respect to previously stated considerations
• Innovative structural design and validation without unacceptable effects such as high VSWR
• Dielectric insulation choices
• Polarization choices, including but not limited to linear polarization (horizontal or vertical) or circular-elliptical polarization
• Feed network, mode converter
Conduct initial iterations of design, M&S and experimental validation.
Provide a convincing way forward for a Phase II effort.

PHASE II: Design, build and test (at low power) the innovative antenna subsystem. Provide low-power characterization to include sidelobe characterization and steering in azimuth and elevation. Perform the preliminary work necessary to prepare for high-power testing and characterization in Phase III.

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

PHASE III DUAL USE APPLICATIONS: Support ONR to configure the antenna subsystem with a high-power HPM source. Test and characterize at high power. ONR may also dictate the location and government assets used to verify the test and characterization.

REFERENCES:

1. Balanis, Constantine A., Antenna Theory: Analysis and Design, Third Edition, Wiley Interscience, ISBN 0-471-66782-X, 2005.
2. Benford, James, Swegle, John A., and Schamiloglu, Edl, High Power Microwaves, Third Edition, CRC Press, 2019.
3. Skolnik, Merrill I. (ed) Radar Handbook, Third Edition, Mc-Graw Hill Education, February 12, 2008, ISBN-13: 978-0071485470.
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5. Kuffel, E. "High Voltage Engineering: Fundamentals." Pergamon, 2016. ISBN 0-7506-3634-3. https://www.amazon.com/High-Voltage-Engineering-Fundamentals-Electricity/dp/008024212X
6. Milligan, Thomas A. "Modern Antenna Design, 2nd Ed." Wiley-Interscience, John Wiley & Sons. ISBN 0471720607 (2005).

KEYWORDS: High Power Microwave (HPM) weapons, High Power Wideband Antenna, Electric Field Breakdown in an RF environment, Mechanical Structure Tolerance, Shock, Vibration and Fatigue Testing, Modeling and Simulation (M&S), Electric Polarization, Antenna Mount, Fold

N241-063 TITLE: Naval Shipboard Embedded Battery Containment System

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

OBJECTIVE: Develop shipboard containment for embedded lithium batteries in standard containment dimensions, to support the integration of large batteries that scale up to the megawatt (MW), and up to MW-hour (MWh) scales. The batteries have interfaces up to 1000VDC, and containment must account for protection from shock, vibration, internal/external fire, overpressure, managing battery gas release, kinetic effects, etc. The containment system should provide a modular construct to enable a level of isolation between battery modules of different form factors, inside of the container so that propagation potential is minimized.

DESCRIPTION: Energy storage systems, comprised of high power and energy-density batteries, offer the potential for numerous benefits as applied to power systems of different types. However, high density storage systems, which may present electrical, chemical, and flammability/explosive hazards, must be able to be simply and effectively installed in locations which can be populated by personnel and sensitive equipment. Because of this, robust and rugged enclosures must be designed that are capable of overcoming effects related to temperature, pressure and internal/external effects, at the same time. Battery systems will need to be enclosed in containment structures that protect from internal (e.g., other failing modules) and external (e.g., fires, weapons effects, moisture) threats. Containment should not be tied to a specific cell size or chemistry, nor to a specific battery module design or form factor, as it is likely that battery technology approaches and designs will change in time. Thus, containment approaches that are universally useful (e.g., standard containment rack widths or designs that can intrinsically be adapted to various battery designs) are recommended. However, the approaches must provide substantial innovation because the effects upon size and weight due the enclosure and containment cannot substantially adversely affect the power and energy density of the storage systems. Innovative R & D to support the creation of compact, lightweight, and high performance enclosure structures should support the evaluation of means of enclosing and isolating energy storage systems from the surrounding environment.

The overall structural approaches should be amenable to large shipboard-embedded systems. Approaches must be considerate of the conditions of release, including MW thermal flux from failed components, overpressures, and flame effects. The system should include a directed ventilation approach to allow gasses generated to escape into a specific, acceptable location or direction. The enclosure shall not require substantial volume above that already taken by the storage system itself, thus an enclosure system will not expand the volume by more than 10% of the racked storage components. Ultimately the design should ensure strength of the shelving and resilience to shock, vibration and environmental effects as defined in the MIL specifications provided in the References. Any design should be able to support devices enclosed with voltages up to 1000VDC (including arcs and plasmas) and power capabilities up to 1MW, and provide penetrations to allow cabling sufficient for moving energy in and out of the enclosure. Cooling may also be assumed to be available, but no colder than 40 degrees Celsius at a flow rate proportional to the volume of the box. It should not be assumed that copious quantities of cooling liquid are available to cool the enclosure itself, but rather the items placed inside. However, small amounts could be utilized by the enclosure itself to support internal environmental characteristics. Aspects of packaging of components internal to the enclosure could be manipulated to support the overall requirements of the enclosure system; however, the design must be flexible and adaptable to specific components or combinations of components inside.

PHASE I: Perform advanced modeling and analysis to define the energetic characteristics of cascading battery failure conditions, where it is assumed that a device fails on the order of one per minute continuously. The basis of the analysis will utilize the thermal and inertial effects from released gas and ejecta from cells. The evaluations will be utilized to determine the requirements for scalable architectures which create minimal impact on device density. Utilizing this information, a conceptual design will be provided with traceable simulation basis to demonstrate performance. If possible, validation of simulated performance parameters will be provided prior to the Option phase. This work will be used to help define a containment volume of sufficient dimensions to be considered a standard rack, with dimensions of ca. 25"W x 48"D x 72"H.

PHASE II: Scale any conceptual enclosure design artifacts and material selections produced under Phase I and its Option period, if exercised, to relevant size, which provides dense rack-mount capability and serviceability aspects. All input and output interface points will be defined and performance simulations evaluated with a greater level of detail. An interface Control Document (ICD) will be created to define clearly all connection points, types, dimensions, model numbers, etc. The complete containment equipment will be built to the designs produced, and validation of the performance aspects (inertial, mechanical, thermal, chemical resilience) will be demonstrated via failure of Li-ion batteries.

PHASE III DUAL USE APPLICATIONS: Design and build full-scale flexible rack-mount enclosures for a particular military application, with the internal modular structure built to a specific battery. The containment will be designed to the intent of meeting appropriate MIL-SPEC operational requirements, and a combination of detailed analytical evaluations and specific test events will be performed.
A scalable, cost-effective enclosure scheme that provides local isolation from energetic release will enable lighter, more compact energy storage to be implemented onto a greater number of platforms and operational equipment.

Dual use applications are anticipated for commercial marine large scale battery applications.

REFERENCES:

1. "Maritime Risk Focus: Lithium-ion batteries fire risks and loss prevention measures in shipping", 3/21/2023, https://maritimecyprus.com/2023/03/21/maritime-risk-focus-lithium-ion-batteries-fire-risks-and-loss-prevention-measures-in-shipping/
2. NAVSEA S9310-AQ-SAF-010, Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures, http://everyspec.com/USN/NAVSEA/NAVSEA_S9310-AQ-SAF-010_4137/

KEYWORDS: Battery, Thermal Runaway, Containment, Enclosure, Fire

N241-064 TITLE: Advanced Wearable Integration and Synchronization Hub (AWISH)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Human-Machine Interfaces; Integrated Network Systems-of-Systems

OBJECTIVE: Develop a hub system that optimizes data capture, synchronization times, and integrates data collected from physiological wearable devices.

DESCRIPTION: It is well known that insufficient sleep quality and quantity lead to health and performance decrements – which can be catastrophic in military settings. In response to the Government Accountability Office recommendations to Congress on fatigue in the Navy (GAO-21-366), the Command Readiness, Endurance, and Watchstanding (CREW) program is advancing a fatigue monitoring and mitigation solution for the Navy. An initial prototype of a wearable-based infrastructure has been developed and tested with several ships (e.g., USS San Diego, USS Montgomery). However, technical improvements are required to move this product from a research and development phase to a pre-commercialization phase to support at scale deployment.

The objective of this SBIR topic is to develop a standalone hub system capable of capturing data off physiological wearable devices (e.g., Oura ring, Polar Grit X Pro, PowerWatch, etc.) and then to push the data to the backend data infrastructure. These data captured shall provide an early indicator for fatigue and sleep deficiency for which mitigation strategies may be implemented. The hub system should reduce active human interactions which in turn will reduce human error; as well as optimize sync transfer times between wearables and the hub, increase data throughput, extend bluetooth range for Pi devices evaluate (and/or identify alternative device to use), and create a system dashboard U/I that provides real time stats and allows ease of access/control over the networked system (primary/lead hub and subordinate hubs) to push time updates, monitoring system a stand-alone light weight server. The hub should create a solution for message queuing and automated pushing of files upon restoration of network connectivity following lost network access. The hub should improve or replace automated method for wearable device pairing. The awardee will deliver complete technical documentation and a complete user manual for both the primary and secondary hubs.

PHASE I: Define and develop a concept for a hub that can meet the hardware and software performance constraints listed in the Description. The hub concept should develop means and methods that advance the current mechanisms for data capture and transfer from wearable physiological devices. The hub concept should be backend architecture agnostic, meaning that it should be able to push to a multitude of data management architectures. The Phase I option, if exercised, would include the initial layout and capabilities description to build the hub in Phase II.

PHASE II: Develop a prototype hub based on Phase I work for demonstration and validation. The prototype hub should be delivered at the end of Phase II, ready to be fielded by the Government.

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II developed hub prototype into deployed Naval vessels and transition finalized product to Naval Surface Force (SURFOR). The Phase III hub should integrate with the CREW data infrastructure used by the Navy. Dual uses in the commercial sector include sporting teams and emergency services (e.g., Fire, EMS).

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3. Stamatakis, K. A., & Punjabi, N. M. "Effects of Sleep Fragmentation on Glucose Metabolism in Normal Subjects." Chest. Vol. 137, Issue 1, 2010, pp. 95.101. Elsevier BV. https://doi.org/10.1378/chest.09-0791
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KEYWORDS: Physiological monitoring, sleep, fatigue, wearables, human performance, data integration

N241-065 TITLE: Advanced Nondestructive Inspection System for Detection and Characterization of Corrosion under Thick Coatings

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

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

OBJECTIVE: Develop a new Nondestructive Inspection (NDI) system capable of: (1) detecting decohesion of a thick coating from its substrate and (2) characterizing the presence of corrosion under very thick polymer coating sections. The system will be used to inspect the entire immersed portion of a ship hull autonomously (either tethered or autonomously) and map the location and extent of corrosion without damaging the coating.

DESCRIPTION: Some situations exist where the condition of the substrate needs to be assessed in situ under thick polymeric coatings. This assessment includes the degree of adhesion of the coating to the substrate and the condition of the substrate from a corrosion perspective. There are several potential non-destructive technologies that may be able to “see” through thick coatings. The SBIR topic includes assessment of select non-destructive technologies to monitor interfacial coating/substrate phenomena and substrate corrosion as a function of coating thickness. The accuracy and reliability should also be addressed. The system will be used to inspect the entire immersed portion of a ship hull autonomously (either tethered or autonomously) and map the location and extent of corrosion without damaging the coating.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Explore the various non-destructive technologies through a literature search and downselect to the two or three most promising Non-destructive evaluation (NDE) options or propose a new inspection methodology. Selection will be based on the potential of the NDE processes to penetrate coatings thicknesses to evaluation coating adhesion, substrate conditions, and coating defects over various conditions of surface roughness. The proposed methods should be validated via modeling and simulation or experimentally by fabricating and testing of simple coupons. For validation purposes, coatings of various thicknesses will be applied to steel plates using a specified standard. The coupons should have at least one surface defect region with a diameter no larger than half the coating thickness, but smaller size defects would be preferable. The NDE methods should be assessed as to the quality and accuracy of the objective measurements. There should be minimal loss of signal responses as a function of coating thickness. The speed at which the requisite information can be obtained (ft2/minute) will also be an evaluation parameter. Offerors must show at least one NDE technology that can reliably characterize the quality of the adhesive interface layer as a function of coating thickness, assess the spatial resolution of the technique, and assess the substrate surface conditions such as corrosion including at site with significant surface roughness.

During the Phase I Option period, if exercised, identify key areas of the proposed solution that need further improvement or development, and depending on the availability of funds, validate the modifications. Evaluate possible methods to autonomously inspect the entire submersed portion of the platform. Plan for Phase II.

PHASE II: The NDE technology(ies) selected in Phase I should be further tested using larger coated coupons of the size necessary to better gauge what the speed (ft2/minute) of detection of decohesive sites, coating defects, and substrate corrosion, if present. Work with a Navy laboratory for collaborations in assisting the offeror in maturing and transitioning the NDE technologies. Further modeling validation will be required and further testing to assert the reliability and sensitivity of the NDE technology will be needed. Other acceptance testing as dictated by the Navy Laboratory should also be done.

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

PHASE III DUAL USE APPLICATIONS: The ability of some NDE methods to penetrate most non-metallic materials allows non-contact examination of materials that are opaque in the visible range such as concrete, insulating foam, and alloy surfaces. The properties of interest across the industries may be broadly categorized into three areas—layer thickness, defects and contamination, and material characterization. Although the key parameters of interest are application-specific, the advantage of some NDE methods over other mature technologies is in providing new information. There may be commercial applications for the technology developed during Phase II, depending on the type of information obtained by employing this NDE technology. The possible use will depend on the degree of attenuation through an alternative medium. Potential uses could be the condition of rebar (degree of corrosion, if any through concrete pillars for a bridge).

REFERENCES:

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KEYWORDS: Non-destructive evaluation; corrosion; decohesion; coatings; welding; sensors

N241-066 TITLE: Laser Magazine

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

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

OBJECTIVE: Develop a compact, battery powered, uncooled, tens of kilowatt (tens of kW), one micron wavelength, high energy laser (HEL) integrated solid state laser (SSL) subsystem utilizing concepts such as a reloadable magazine "clip", or "replaceable" rechargeable, man serviceable, cooling and battery magazines. These "replacement" magazines offer an opportunity to forgo "near infinite life" requirements and examine the potential benefits of limited life (tens to hundreds of shots) and potentially expendable, quickly replaceable munition type power and cooling sub-assemblies.

DESCRIPTION: For the Navy and Marine Corps, the demand on "infinite duty cycle" cooling by water chillers deteriorates causing limited operational employment. Relieving the design and alignment constraints of separating the systems and examining "rechargeable magazines" for cooling and electrical power in the deployment of such kW-class HEL systems may have benefits on small platforms (ground or airborne, including unmanned weapon platforms) and offers some unique research opportunities. The Navy seeks development of a solid state laser that is compact, battery powered, uncooled and on the order of tens of kilowatts (kW) operating at one micron wavelength, and able to produce continuous wave high energy laser (HEL) energy as an integrated subsystem.

Currently, prototype HEL systems are being deployed in a variety of platforms as laser weapons; prototype systems have been deployed by the Navy platforms as laser weapons to destroy targets and threats. These are each separately developed subsystems (power, cooling, laser) – but the interest is a combined small size, weight, and integrated power with cooling (SWaP-C) for tens of kilowatt class HEL systems limit utility from those combined systems. Use of systems that are "direct diode" or "pixel/vixel" based are of primary interest, possibly using coherent, spectral, or incoherent power beam combination techniques due to their inherent high efficiency, whereas fiber or other gain amplification systems are seen as less efficient and require higher levels of optical integration risk.

For the Navy and Marine Corps, the demand on "infinite duty cycle" cooling by water chillers deteriorates causing limited operational employment. Relieving the design and alignment constraints of separating the systems and examining "rechargeable magazines" for cooling and electrical power in the deployment of such kW-class HEL systems may have benefits on small platforms (ground or airborne, including unmanned weapon platforms) and offers some unique research opportunities.

Using the same concept as a reloadable magazine "clip", this SBIR topic seeks innovation in "replaceable" rechargeable, man serviceable, cooling and battery magazines. These "replacement" magazines offer an opportunity to forgo "near infinite life" requirements and examine the potential benefits of limited life (tens to hundreds of shots) and potentially expendable, quickly replaceable munition type power and cooling sub-assemblies. The Navy seeks a compact battery powered, uncooled, tens of kilowatt (10's of kW), one micron wavelength, HEL integrated solid state laser (SSL) subsystem. High cooling capacity and thermal requirements have driven HELs to focus on water chilled systems that are heavy and operate within tight tolerances for temperatures. The potential to dissipate the heat generated by the laser amplifier medium and externally pump, or exhaust, the resulting heat from the sources of heat - to areas or materials that dissipate the heat, have only been explored to a limited extent. Similarly, the potential to “dump” heat (for example, by exhaust or release of superheated water vapor) are seldom contemplated. However, in some circumstances, this may be a preferable and acceptable trade for the purposes of reducing subsystem weight.

The DoD has a great demand for compact and robust unmanned weapon platforms. Therefore, DoD has a resulting great demand for more compact and robust uncooled kilowatt - class laser systems for a variety of short time use cases and applications, if temperature tolerant designs for one micron wavelength lasers can be found. Industry will benefit as class laser system for a variety of short duty cycle power and thermal applications, as well from the reduced well SWaP-C requirements for technology in applications where lasers are used to cut, weld, or ablate and clean substrates with limited surface areas. At present, an air cooled, compact battery power kW class HEL system is not a known commercially available item used with laser subsystems.

KEY PARAMETERS – Laser Magazine
Power Threshold: 10 kW (Objective: 20 kW); ability to focus light at a range of kilometers with minimal atmospheric turbulence (Cn2
HEL wavelength: one (1) Micron (1020-1095 um)
Technology: Solid State Laser (Preference for high efficiency laser semiconductor based diodes or similar pixel LED emitters)
Laser beam output quality (M2): Threshold: 2, (Objective < 1.4, vertical & horizontal, Gaussian or top hat.)
Laser Weight: Threshold: 120 lbs (Objective 20 lbs)
Volume: Threshold: 50 cubic inches (Objective < 20 cubic inches);
Air cooled compact HEL prototyped system with input air 60°C and 90% humidity
Audible Noise: under 60 dB
Operating Temperature: Threshold: 15°C to 30°C, Objective 10°C to 70°C

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by 32 U.S.C. § 2004.20 *et seq*., National Industrial Security Program Executive Agent and Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material during the advanced phases of this contract IAW the National Industrial Security Program Operating Manual (NISPOM), which can be found at Title 32, Part 2004.20 of the Code of Federal Regulations. **Reference:** National Industrial Security Program Executive Agent and Operating Manual (NISP), 32 U.S.C. § 2004.20 *et seq*. (1993). https://www.ecfr.gov/current/title-32/subtitle-B/chapter-XX/part-2004

PHASE I: Develop a concept for an innovative laser magazine. Validate the product-market fit between the proposed solution and with the Navy stakeholder define a clear plan for trial and/or test with the proposed solution and the focus area.

The proposed solution should directly address:

1. Identify the components and likely configuration and explore the extents of the benefit area(s) compared to identified objectives, which are to be addressed by the proposed solution(s),
2. Define clear objectives and measurable figures of merit for the proposed solution(s) – specifically how the proposed solution(s) will be developed into a compact subassembly or "laser magazine,"
3. Define any inherent risks to achieving objectives and measurable figures of merit for the proposed solution(s) as well as potential risk mitigation strategies,
4. Describe the cost and feasibility of integration with current mission-specific subsystems,
5. Describe how the component or solution(s) can be used by other government customers, both DoD and non-DoD, and the impacts of "expendable" solutions, and
6. Describe technology related development that is required to successfully field the proposed solution(s) with a preliminary set of incremental - steps or milestones over subsequent phases of the effort.

PHASE II: Develop, integrate, and demonstrate a prototypical laser magazine (unit) in a laboratory environment, as determined to be the most feasible solution during the Phase I period. The demonstration should focus on:
1. Evaluating the proposed solution against the operational system requirements, objectives and measurable results as defined in Phase I
2. Describing in detail how the solution can be scaled to be adopted widely
3. A clear transition path for the proposed solution that takes into account input from stakeholders
4. Specific details on how the proposed solution can be integrated and how it will be supported/sustained
5. Laboratory experimentation, with incremental and final technical reports.

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

PHASE III DUAL USE APPLICATIONS: Make additional improvements in manufacturing and development of a compact size demonstrator at a scale showing laser performance with focus on manufacturing methods to continue to improve component packaging, yield, production time, and individual component contributions to size, performance, and cost. Criterion for the laser performance in Phase III is dependent on the progress made in Phase II. New criterion for Phase III includes the time and cost to produce small quantities (100), and individual first unit components.

Small, miniature laser magazines offer potential in multiple commercial applications including remote sensing, metal fabrication/cutting, and for long range telecommunications or remote powering. There is some potential for some solid-state lasers developed to be used in a next generation laser weapon system, which have less dependency on physical and environmental challenges seen with current systems.

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KEYWORDS: Laser, photon, light, battery, cooling

N241-067 TITLE: Common Software Platform for Learning-based Robots

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

OBJECTIVE: Develop an open-source common software platform that is independent of robotics hardware and can be widely used to incorporate artificial intelligence (AI) skills, such as perception and manipulation, for robots that learn to facilitate transfer of research in robotics into application products in a short time.

DESCRIPTION: In recent years, significant advances in AI have been made from image recognition to generation, from large-scale language models to dialogues, and from locomotion to diverse manipulation. A key feature of this advancement has been the rapid transfer of technology—transition time from fundamental research to deployment is unusually short, typically taking only a couple of months. Examples include Jasper AI (for fast content generation), Stability AI (image generation), Photoshop, Hugging Face (natural language understanding), and others. Interestingly, while advances in computer vision (CV) and natural language processing (NLP) have shown this rapid deployment, AI research in robotics has seen little transition to application products and across a very narrow segment of table-top grasping. Most other robotic products, either for defense or consumer, service or industry domain, still exploit and rely on classical control-theoretic and optimization-based approaches and have difficulty with machine learning (ML) and generalization. In learning-based control, assessing safety and performance limits are still challenging. A common software platform will enable expedited research in these issues. The absence of a common software platform has created an increasing gap between robot learning research and deployment. One of the key reasons is the lack of infrastructure and software platforms for reproducibility and fast transfer of robot learning technology. Robotics hardware vary across tasks in their capabilities and do not enjoy independence in hardware variability, unlike CV or NLP. Hence, as a result, it has become a standard practice in robotics companies to proceed full stack from hardware to software. This not only lengthens the development cycle, but also results in most robotics companies needing to develop their own AI infrastructure and expertise, which makes it difficult to keep up with cutting-edge advances in research.

The above issue has created a unique opportunity. ONR is seeking development of a common software platform for the rapid technology transfer of data-driven robotic algorithms. Such a software platform would go beyond current platforms such as the Robot Operating System (ROS) framework, which focuses on resource scheduling and communication but does not focus on AI capabilities, or Mission Oriented Operating Suite Interval Programming (MOOS-IvP) with similar capabilities. The proposed software platform would build a mid-level AI layer with state-of-the-art perception, locomotion, and manipulation skills. The goal is to abstract low-level robotic skills so that the developers do not need robotics expertise and can focus on the creative applications of the robots. Ideally, this platform could be shared by different robotics companies allowing them to focus better on their application vertical with faster iteration cycles while having a way to easily incorporate the latest algorithmic developments in robot learning. Selected references related to certain skills such as manipulation and locomotion are included below.

PHASE I: Design and demonstrate the feasibility of a shared platform for efficient transfer and implementations of data-driven robotic algorithms. Validate the platform's ability to meet key parameters on a custom reference hardware which is to be scaled to multiple platforms in Phase II. The key parameters to be met in Phase I: 90% success rate on simple terrain locomotion, 80% on complex rough terrain locomotion, 85% success rate for point to point navigation for both legged and wheeled robots, 70% grasping rate for at least a selection of 50 everyday objects. Produce detailed design specifications and capabilities descriptions for Phase II prototype development.

PHASE II: Develop and deliver a deployable prototype of the platform, including perception and action capabilities such as locomotion, navigation, and targeted class-conditioned manipulation. Validate the prototype's ability to run on multiple hardware configurations such as Franka robotic arm, UR5 arm, X-arm as well as legged robot with arms and wheeled robot with arms in home and warehouse settings. The key parameters to be met at this stage are: work on multiple hardware including a total of at least 5 different commercial hardware platforms across tasks, more than 98% success rate on simple terrain locomotion, more than 95% success rate on rough terrain locomotion, 95% accuracy of point to point navigation, 75% grasping rate for at least a selection of 100 everyday objects. In parallel, produce a detailed Phase III plan for partnering for commercial as well as DoD applications.

PHASE III DUAL USE APPLICATIONS: Perform additional experiments in a variety of situations and environments. Begin testing with external partners.

This technology could be used in commercial sectors such as medical robotics, warehousing, and delivery, for developing versatile robots capable of performing maintenance, service robots at home or work places, and other tasks.

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KEYWORDS: Software platform, robot manipulation, robot perception, robot Artificial Intelligence skills, learning robots

N241-068 TITLE: Fast Micro-Electromechanical Systems (MEMS) Shutters for Stellar Sensing Applications

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

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

OBJECTIVE: Develop a fast (< 0.1s) global optical imager micro shutter (minimum size 0.5 x 0.5 cm2) capable of operating in high radiation, strategic environments over 30-year mission timelines. Control of individual shutter elements or in groups is desirable, but not required.

DESCRIPTION: Star trackers are in use on strategic systems, which must survive and operate in harsh radiation environments. Calibration via a closed shutter allows for the direct characterization of radiation induced detector noise apart from the target star. The development of this technology will help enable more capable star trackers to operate with increased reliably in higher radiation environments than currently capable.

Existing Micro-Electromechanical Systems (MEMS) shutters have been demonstrated to be reliable in a variety of environments, including space-borne missions such as the James Webb Space Telescope (JWST) [Ref 3]. The existing technology has been improved with a shift from magnetic to electrostatic operation [Ref 1]. Additional micro-mechanical geared shutters have been developed by industry for applications from TVs to imagers [Ref 2].

The objective of this SBIR topic is to develop MEMs shutters that can eventually be utilized to provide live calibration functionality to in-flight calibration sensors in hostile environments. Live calibration data provides options for making strategic missions less sensitive to radiation and allowing them to perform in increasingly hostile environments, with increased precision. The lack of advancement will come at a direct cost to the performance of the strategic systems in terms of performance and concepts of operations with regard to stellar sighting.

PHASE I: Develop a design for a fast (< 0.1s) global optical imager micro shutter (minimum size 0.5 x 0.5 cm2) capable of operating in high radiation, strategic environments over 30-year mission timelines. Control of individual shutter elements or in groups is desirable, but not required. Include in the design the plans/methodologies for microfabrication and testing to demonstrate the capabilities desired in Phase II. 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: Based on the Phase I design and execution plan, fabricate and characterize a small lot (up to Qty: 5 wafers) of global optical image micro-shutters. This characterization may include a dynamic/force assessment [Ref 4] and thermal/radiative sensitivity for sample MEMS devices. The prototypes, test samples, and characterization results should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes developed in Phase II, continuing development leads to productization of the MEMs micro-shutter device. While this technology is aimed at military/strategic applications, micro-shutters are used more broadly in the space-based astronomy industry. The devices incorporating the MEMS micro-shutters may be subject to several common test environments for strategic sensors, including radiation and vibration environments.

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KEYWORDS: Micro-Electromechanical Systems; MEMs; Microshutter Arrays; Space Telescopes; Star Trackers

N241-069 TITLE: Deterministic Precision Machining of Miniature Optics in Hard Ceramics

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

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

OBJECTIVE: Develop the manufacturing capability to fabricate miniature, high-precision, high-numerical aperture optical components in hard ceramic materials.

DESCRIPTION: The Navy requires enhanced capabilities for precision machining of hard ceramic optical mirror surfaces with high numerical aperture (NA). In spite of fabrication challenges, hard ceramics such as silicon carbide are seeing increasing adoption as substrate materials for optical mirrors due to their high thermo-mechanical stability and high stiffness. These products find use in applications such as space-based telescope primary mirrors, for instance. Grinding and polishing are traditional methods of achieving final surface form and are well-suited to a broad range of materials, including hard ceramics. Traditional grinding methods, however, are limited to relatively low-NA optical surfaces. For soft metals, single point diamond turning (SPDT) can produce a wide range of surface forms, including high-NA and aspheric surfaces, while achieving extraordinarily precise surface form tolerances [Ref 1]. SPDT has also recently shown promise as a method for machining certain hard ceramics, although further research may be required to optimize cutting parameters [Ref 2]. Techniques such as ion etching and magnetorheological finishing (MRF) may also be used to produce arbitrarily precise surface forms in a variety of materials [Ref 3], although they are slow and labor-intensive. The Navy has an interest in developing a deterministic and cost-effective fabrication capability for high-NA optical surfaces in hard ceramics (such as silicon carbide, silicon nitride, or similar) with optically precise surface form tolerances. In addition to the machining challenge, high-NA surfaces add challenges to the process of validating the achieved surface form (interferometry and profilometry are common methods) which must also be overcome. The capability will be demonstrated by the production of small (sub-centimeter-scale) convex and concave hemispherical mirror substrate test articles to be delivered at the conclusion of Phase II.

PHASE I: Develop methods for producing hemispherical mirror substrates in hard ceramic materials. Perform a feasibility study for achieving the target surface form and radius of curvature thresholds listed below for two types of mirror substrates: a concave hemispherical mirror (substrate A) and a convex hemispherical mirror (substrate B). Assess the scalability of the proposed approach in terms of per unit labor hours and throughput. Material and threshold mirror surface specifications for test articles to be produced in Phase II include:
• Material: Hard, non-porous ceramic (such as silicon carbide, silicon nitride, or material of similar hardness)
• Radius of curvature (both convex and concave): 3 mm +/- 500 nm
• Nominal outer diameter (OD) of mirror surface: 3mm
• Spherical surface irregularity may not exceed 500 nm
• Surface roughness may not exceed 30 nm RMS • Mirror substrates shall be uncoated
• Localized surface imperfections (scratch and dig): Best effort (Goal is 10-5 per mil spec MIL-PRF-13830)

Methods that provide a path toward deterministic production of aspheric surfaces are of interest, but not strictly required. Methods of metrology for validating the final surface form must also be proposed and assessed for scalability for arbitrary surface forms and numerical aperture. A detailed risk assessment of the proposed fabrication and metrology methods should be provided.

PHASE II: Implement the methods proposed in Phase I for the production of a set of test articles for delivery to the Navy by the conclusion of Phase II. These deliverables consist of five (5) prototypes of substrate A and five (5) prototypes of substrate B with key specifications listed in Phase I above. Parts will be evaluated based on the form of the primary hemispherical surface; other dimensions and surfaces are not critical. Each prototype must be delivered with metrology data indicating the achieved surface form.

PHASE III DUAL USE APPLICATIONS: The machining capabilities demonstrated in Phase II advance the state of the art for optical component fabrication in durable materials. Support the Navy in transitioning the technology to Navy use. The prototypes will be evaluated for compatibility with existing and planned strategic system component designs. The technology will be used in Phase III to develop components according to specific design requirements for strategic sensors. The end product technology is applicable to a range of dual use applications that benefit from the stiffness and thermal stability properties of hard ceramics. These include space-based and airborne optical systems and high power laser applications.

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KEYWORDS: Non-porous Ceramic; Silicon Carbide; Silicon Nitride; High-precision Machining; Precision Optics, High numerical aperture