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

IMPORTANT

- **The following instructions apply to STTR topics only:**
  - **N21A-T001 through N21A-T018**
- **The information provided in the DON Proposal Submission Instruction document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).**
- **DON Phase I Technical Volume (Volume 2) page limit to not exceed 10 pages.**
- **Proposers 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 proposers are detailed in the section titled ADDITIONAL NOTES.**
- A Phase I proposal template specific to DON topics will be available to assist small businesses to generate a Phase I Technical Volume (Volume 2). The template will be located on 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.
- The Supporting Documents Volume (Volume 5) is available for the STTR 21.A BAA cycle. The Supporting Documents Volume is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. DON will not be using any of the information in Volume 5 during the evaluation.

INTRODUCTION

The Program Manager of the DON STTR Program is Mr. Steve Sullivan. For program and administrative questions, contact the SYSCOM Program Manager listed in Table 1; **do not** contact them for technical questions. For technical questions about a topic, contact the Topic Authors listed within the topic during the Pre-release period. During the Open period the DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions) must be used for any technical inquiry. Review section 4.13 of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) for further information related to Direct Contact with Topic Authors and the Topic Q&A platform. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-703-214-1333 (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET) or via email at dodsbirsupport@reisystems.com.

TABLE 1: DON SYSTEMS COMMAND (SYSCOM) STTR PROGRAM MANAGER

Topic Numbers	Point of Contact	SYSCOM	Email
N21A-T001	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	jeffrey.a.kent@usmc.mil
N21A-T002 to N21A-T004	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	navairsbir@navy.mil
N21A-T005 to N21A-T008	Mr. Dean Putnam	Naval Sea Systems Command (NAVSEA)	dean.r.putnam@navy.mil
N21A-T009 to N21A-T018	Mr. Steve Sullivan	Office of Naval Research (ONR)	steven.sullivan@navy.mil

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 program can be found on the DON SBIR/STTR website at www.navysbir.com. Additional information pertaining to the DON's mission can be obtained from the DON website at www.navy.mil**.**

PHASE I GUIDELINES

Follow the instructions in the DoD SBIR/STTR Program BAA at https://www.dodsbirsttr.mil/submissions for requirements and proposal submission guidelines. Please keep in mind that Phase I must address the feasibility of a solution to the topic. It is highly recommended that proposers follow the Phase I Proposal Template that is specific to DON topics as a guide for structuring proposals. The template will be located on https://navysbir.com/links_forms.htm. Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.

Proposals that are not successfully certified in the Defense SBIR/STTR Innovation Portal (DSIP) prior to BAA Close will NOT be considered submitted. Please refer to section 5.1 of the DoD SBIR/STTR Program BAA for further information.

PHASE I PROPOSAL SUBMISSION REQUIREMENTS

The following SHALL BE MET or the proposal will be REJECTED for noncompliance.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR BAA section 5.4(a).

- **Technical Proposal (Volume 2).** Technical Proposal (Volume 2) must meet the following requirements:
  - Content is responsive to evaluation criteria as specified in DoD SBIR/STTR Program BAA section 6.0
  - Not to exceed **10** pages, regardless of page content
  - Single column format, single-spaced typed lines
  - Standard 8 ½" x 11" paper
  - Page margins one-inch on all sides. A header and footer may be included in the one-inch margin.
  - No font size smaller than 10-point*

- Include, within the **10-page limit of Volume 2**, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified.

*For headers, footers, listed references, and imbedded tables, figures, images, or graphics that include text, a font size smaller than 10-point is allowable; however, proposers are cautioned that the text may be unreadable by evaluators.

Volume 2 is the technical proposal. Additional documents may be submitted to support Volume 2 in accordance with the instructions for Supporting Documents Volume (Volume 5) as detailed below.

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 or any subsequent award, the proposer 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. Simply identifying fundamental research in the proposal does NOT constitute acceptance of the exclusion. All exclusions will be reviewed and noted in the award. NOTE: Fundamental research included in the technical proposal that the proposer is requesting be eliminated from the requirements for prior approval of public disclosure of information, must be uploaded in a separate document (under "Other") in the Supporting Documents Volume (Volume 5).

Phase I Options are typically exercised upon selection for Phase II. Option tasks should be those tasks that would enable rapid transition from the Phase I feasibility effort into the Phase II prototype effort.

- **Cost Volume (Volume 3).** The Phase I Base amount must not exceed $140,000 and the 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.

- **Period of Performance.** The Phase I Base Period of Performance must be exactly six (6) months and the Phase I Option Period of Performance must be exactly six (6) months.

- **Company Commercialization Report (Volume 4)**. DoD requires Volume 4 for submission to the 21.A Phase I BAA. Please refer to instructions provided in section 5.4.e of the DoD SBIR/STTR Program BAA.

- **Supporting Documents (Volume 5)**. Volume 5 is available for use when submitting Phase I and Phase II proposals.

  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 proposals must include as a part of their**

submission a written certification in response to the NDAA clauses (Federal Acquisition Regulation clauses 52.204-24, 52-204-25 and 52-204-26). 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 instructions provided in section 5.4.g of the DoD SBIR/STTR Program BAA.

A proposal that has an answer of "Yes" to any question regarding foreign investment disclosure in the Firm Certifications section of Volume 1 (Proposal Cover Sheet) must then include as part of their submission a Foreign Disclosure Addendum. The Foreign Disclosure Addendum can be found in Attachment 2 of the DoD SBIR/STTR Program BAA. The addendum, if required, must be completed by the authorized company representative and uploaded as a separate PDF file in Volume 5. Please refer to instructions provided in section 5.4.h of the DoD SBIR/STTR Program BAA.

Volume 5 is available for small businesses to submit additional documentation to support the Technical Proposal (Volume 2) and the Cost Volume (Volume 3). A template is available on https://navysbir.com/links_forms.htm. DON will not be using any of the information in Volume 5 during the evaluation.

- Letters of Support relevant to this project
- Additional Cost Information
- SBIR/STTR Funding Agreement Certification
- Data Rights
- 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
- Majority-Owned VCOC, HF, and PEF Certification, if applicable

NOTE: The inclusion of documents or information other than that listed above (e.g., resumes, test data, technical reports, publications) may result in the proposal being deemed "Non-compliant" and REJECTED.

A font size smaller than 10-point is allowable for documents in Volume 5; however, proposers are cautioned that the text may be unreadable.

- **Fraud, Waste and Abuse Training Certification (Volume 6)**. DoD requires Volume 6 for submission to the 21.A Phase I BAA. Please refer to instructions provided in section 5.4.i of the DoD SBIR/STTR Program BAA.

DON STTR PHASE I PROPOSAL SUBMISSION CHECKLIST

- **Subcontractor, Material, and Travel Cost Detail.** In the Cost Volume (Volume 3), proposers must provide sufficient detail for subcontractor, material and travel costs. Enter this information in the "Explanatory Material" field in the online DoD Volume 3. 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. 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).

For Phase I a minimum of 40% of the work is performed by the proposing firm, and a minimum of 30% of the work is performed by the single research institution. The percentage of work is measured by both direct and indirect costs.

To calculate the minimum percentage of effort for the proposing firm the sum of all direct and indirect costs attributable to the proposing firm represent the numerator and the total proposals costs (i.e. costs before profit or fee) is the denominator. The single research institution percentage is calculated by taking the sum of all costs attributable to the single research institution as the numerator and the total proposal costs (i.e. costs before profit or fee) as the denominator.

- **Performance Benchmarks.** Proposers must meet the two benchmark requirements for progress toward Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that the DON applies performance benchmarks at time of proposal submission, not at time of contract award.

- **Discretionary Technical and Business Assistance (TABA).** If TABA is proposed, the information required to support TABA (as specified in the TABA section below) must be added in the "Explanatory Material" field of the online DoD Volume 3. If the supporting information exceeds the character limits of the Explanatory Material field of Volume 3, this information must be included in Volume 5 as "Additional Cost Information" as noted above. Failure to add the required information in the online DoD Volume 3 and, if necessary, Volume 5 will result in the denial of TABA. TABA may be proposed in the Base and/or Option periods, but the total value may not exceed $6,500 in Phase I.

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 the technical risks associated with SBIR/STTR projects; and commercializing the SBIR/STTR product or process, including intellectual property protections. Firms 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 $1,700,000 or lower limit specified by the SYSCOM). As with Phase I, the amount proposed for TABA cannot include any profit/fee application by the SBIR/STTR awardee and must be inclusive of the applicable indirect costs. 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.

Approval of direct funding for TABA will be evaluated by the DON SBIR/STTR Program Office. A detailed request for TABA must include:

- 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
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must NOT:

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

TABA must be included in the Cost Volume (Volume 3) as follows:

- Phase I: The value of the TABA request must be included on the TABA line in the online DoD Volume 3 and, if necessary, Volume 5 as described above. The detailed request for TABA (as specified above) must be included in the "Explanatory Material" field of the online DoD Volume 3 and be specifically identified as "Discretionary Technical and Business Assistance".
- Phase II: The value of the TABA request must be included on the TABA line in the DON Phase II Cost Volume (provided by the DON SYSCOM). The detailed request for TABA (as specified above) must be included as a note in the Phase II Cost Volume and be specifically identified as "Discretionary Technical and Business Assistance".

TABA may be proposed in the Base and/or Option periods. Proposed values for TABA must NOT exceed:

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

NOTE: Section 9(b)(5) of the SBIR and STTR Policy Directive requires that a firm receiving technical or business assistance from a vendor during a fiscal year submit a report with a description of the technical or business assistance received and the benefits and results of the technical or business assistance provided. More information on the reporting requirements of awardees that receive TABA funding through the DON can be found on https://www.navysbir.com/links_forms.htm. Awardees that receive TABA funding through the DON will upload the report to https://www.navysbirprogram.com/navydeliverables/.

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

All Phase II awardees not receiving funds for TABA in their awards must attend a one-day DON STP meeting during the first or second year of the Phase II contract. This meeting is typically held in the spring/summer in the Washington, D.C. area. STP information can be obtained at: https://navystp.com. Phase II awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

EVALUATION AND SELECTION

The DON will evaluate and select Phase I and Phase II proposals using the evaluation criteria in Sections 6.0 and 8.0 of the DoD SBIR/STTR Program BAA respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. As noted in the sections of the aforementioned Announcement on proposal submission requirements, proposals exceeding the total costs established for the Base and/or any Options as specified by the sponsoring DON SYSCOM will be rejected without evaluation or consideration for award. Due to limited funding, the DON reserves the right to limit awards under any topic.

Approximately one week after the Phase I BAA closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, the e-mail address on the proposal Cover Sheet must be correct.

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 firm proposal 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 of Phase I and II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 1. If the protest is to be filed with the GAO, please refer to the instructions provided in section 4.11 of the DoD SBIR/STTR Program BAA.

Protests to Phase I and Phase II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information or the Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 1. If the protest is to be filed with the GAO, please refer to the instruction provided in section 4.11 of the DoD SBIR/STTR Program BAA.

CONTRACT DELIVERABLES

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

AWARD AND FUNDING LIMITATIONS

Awards. 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 Section 4.14.b of the DoD SBIR/STTR Program BAA 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 firm per topic. Additionally, to adjust for inflation DON has raised Phase I and Phase II award amounts. The maximum Phase I proposal/award amount including all options (less TABA) is $240,000. The Phase I Base amount must not exceed $140,000 and the Phase I Option amount must not exceed $100,000. The maximum Phase II proposal/award amount including all options (including TABA) is $1,700,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $1,700,000 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 in a minimum of 30 days prior to the due date for submission of their Initial Phase II proposal.

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 STTR may transition in Phase II to SBIR and vice versa. Please refer to instructions provided in section 7.2 of the DoD SBIR/STTR Program BAA.

ADDITIONAL NOTES

Majority Ownership in Part. Proposers 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.

For proposers 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 concerns must register with the SBA Company Registry Database.
b. The proposer within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. The SBIR VC Certification must be included in the Supporting Documents Volume (Volume 5). A copy of the SBIR VC Certification can be found on https://navysbir.com/links_forms.htm.
c. Should a proposer become a member of this ownership class after submitting its application and prior to any receipt of a funding agreement, the proposer 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 proposers register in SAM, https://beta.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, proposers should confirm that they are registered to receive contracts (not just grants) and the address in SAM matches the address on the proposal.

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 proposer 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 http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections/Human-Subject-Research.aspx**.** 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 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).

Support Contract Personnel for Administrative Functions. Proposers 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.

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

PHASE II GUIDELINES

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

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

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 firms (e.g., the DON STP).

PHASE III GUIDELINES

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

NAVY STTR 21.A Topics

N21A-T001	Military Uniform Fabric Produced with Hemp Fibers
N21A-T002	Commercial Scale Methods for Reclamation and Reuse of Carbon Fiber
N21A-T003	Combined Electro-Optics/Infrared and Radar Sensor System for Detect and Avoid of Non-Cooperative Traffic for Small Unmanned Aerial Systems
N21A-T004	Integrated High-Frequency Analog-to-Information Receiver
N21A-T005	Ground Fault Detection System
N21A-T006	Compact, Efficient 2-Band Underwater Optical Communications System
N21A-T007	Defect-Tolerant High-Temperature Superconductor for Coil Applications
N21A-T008	Low Cost High Performance Efficient Uncooled or Thermoelectric Cooled Night Vision (NV) Infrared (IR) Imaging System
N21A-T009	Organic Solar Cell Processing and Product Development
N21A-T010	Novel Acoustic Source Concepts for Target Identification and Classification
N21A-T011	Enhancement of Detonation Wave Dynamics in Rotating Detonation Combustors (RDC)
N21A-T012	Advanced Thermal Management of Power Converters
N21A-T013	Real-time Monitoring for Decompression Sickness
N21A-T014	Self-Healing Ship Systems
N21A-T015	Aerosol Spectral Absorption Measurement for Near UV through Near Infrared Wavelengths
N21A-T016	Peer-to-Peer Knowledge Sharing: Curation Automation Engine
N21A-T017	Compact Electric Compressors for Aerospace Applications
N21A-T018	Airborne Radar-Based Detection and Discrimination of Small Unmanned Aerial Systems and Birds For Collision Avoidance and Force Protection

N21A-T001 TITLE: Military Uniform Fabric Produced with Hemp Fibers

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a higher performing uniform fabric using hemp fibers.

DESCRIPTION: Hemp fibers have been used for thousands of years in textile products such as sacks, ropes, and fishnets. Today, hemp fibers are woven into clothing, cordage, curtains, rope, carpets, burlap, sacking, and shoes. Clothing produced with hemp fibers are strong, UV and mold resistant, making it an excellent fiber for outdoor wear. Hemp, due to its propensity to have a rougher hand than some other natural fibers, such as cotton, is typically blended with other fibers for clothing end uses. Compared to cotton, hemp is more environmentally friendly and less costly to cultivate; it does not require pesticides or fertilizers, needs less water, and renews the soil with each growth cycle. Its long roots prevent erosion and help retain the topsoil. As a result of these favorable properties, university research within the United States into hemp plant production, fibers, and fabric is rising.

The desired end result would be a uniform fabric with significant performance benefits, compared to the current Marine Corps Combat Utility Uniform (MCCUU) fabric. The significant performance benefits may include, but not be limited to, a lower cost, lighter weight, more durable, more comfortable, and environmentally friendly fabric. The fabric would need to be produced with standard textile manufacturing processes and be Berry Amendment compliant. In order to demonstrate the performance benefits, the hemp-containing fabric would be compared to the existing uniform fabric (i.e., MCCUU fabric). The fabric should meet and exceed many of the requirements as defined in the MCCUU requirement document, the MCCUU Purchase Description [Ref 4]. Some fabric properties, such as a lower fabric weight and improved durability as compared to the current MCCUU fabric, are highly desired. A lighter weight uniform will reduce the load Marines need to carry and a more durable uniform will be less likely to fail (e.g., tear) in the field.

Additional desired attributes are the ability to provide vector protection (e.g., protection from insects), improved flame resistance (i.e., ability to self-extinguish), and camouflage protection beyond the current visual and near infrared requirement.

All hemp products must comply with 21 USC 802(16). Only hemp products containing less than 0.3 percent tetrahydrocannabinol (THC) on a dry weight basis are allowable.

PHASE I: Conduct research on and determine the performance levels of hemp fabric, as compared to existing MCCUU fabric. Validation/tests should demonstrate where the fabric meets and exceeds the MCCUU fabric requirements, as defined in the MCCUU Purchase Description [Ref 4]. Develop a Phase II plan for prototype production.

Provide at least one MCCUU set (blouse and trouser) or an equivalent amount of fabric to the Marine Corps for Marine Corps testing and evaluation.

PHASE II: Optimize the material properties based on Marine Corps evaluation results and feedback in Phase I, and scale up the production process to reduce manufacturing costs. Provide at least an additional 10 MCCUU sets to the Marine Corps for evaluation based on the performance criteria in the MCCUU Purchase Description.

PHASE III DUAL USE APPLICATIONS: Demonstrate the suitability of the material in a clothing design and field evaluation. Integrate the material into relevant items for system level testing, evaluation, and demonstration. Provide at least 100 MCCUU sets to the Marine Corps for evaluation.

Commercial potential of this technology for use in durable outdoor wear is significant and may have a pronounced benefit to the United States garment industry as hemp-contained fabric could be used in cotton-blend clothing. The growth of hemp to support this industry would be more environmentally friendly and potentially have far lower cost due to lower demands for fertilizer and pesticides as compared to cotton.

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KEYWORDS: Hemp; MARPAT; MCCUU; military uniform

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N21A-T002 TITLE: Commercial Scale Methods for Reclamation and Reuse of Carbon Fiber

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Materials / Processes

OBJECTIVE: Design and develop methodologies to reclaim and reuse carbon fiber from in-process waste and scrap parts generated in the manufacturing of advanced aircraft, and from end-of-life aircraft.

DESCRIPTION: Manufacturing waste (pre-impregnated edge trimmings, trimmed cured composites, etc.) and scrap, generated during the manufacturing of advanced composite parts for aircraft and rotorcraft, is currently landfilled. This situation arises because there are no commercial methods to reclaim the fiber from these composites. Additionally, as current aircraft reach the end of service, they need to be deconstructed and recycled, by as high a degree as possible, rather than landfilled. Robust, commercial scale methods are sought for reclaiming carbon fiber from end-of-life parts, in-process excess materials, and scrap.

The scrap generated during advanced composite manufacturing consists largely of aerospace-grade carbon fiber and advanced thermoset resins, including epoxies and bismaleimides (BMI). Other materials may also be present, including but not limited to, fiberglass and aramid fibers, metallic fasteners, wires, and mesh. Any process proposed under this STTR topic must be capable of handling these non-ideal sources of carbon fiber [Refs 1, 5].

Any approach proposing to process the composites’ waste, scrap parts, and end-of-life parts must be cost-effective and follow all appropriate environmental regulations. Business case analysis should include, but not be limited to, data such as cost, energy input, and CO2 emission, as compared to current composite usage and disposal methods.

Once the carbon fiber is recovered from the composite waste and parts, it must be converted into raw material that would be of interest to the Navy and to non-military customers such as commercial aircraft, automotive, or sporting goods industries. Recovered carbon fibers can be continuous or discontinuous. Prototype demonstration of viable, large scale, composite forming processes is desired.

Although not required, it is highly recommended to work in coordination with the original equipment manufacturer (OEM) to ensure proper design and to facilitate transition of the final technology. It is also recommended that awardees to work directly with aircraft fabricators to determine the potential types and amounts of scrap and in-process excess materials to be processed.

PHASE I: Define and develop a pilot scale approach to reclaim carbon fiber from carbon fiber reinforced composites that is directly scalable to commercial practice. Candidate approaches should include processes for the deconstruction of waste and scrap composite materials, and for recovery and separation of fiber from the polymer matrix. The use of reclaimed fiber in making composite test parts should use multiple fabrication methods, and mechanical properties obtained from parts fabricated using the recycled material should be comparable to parts fabricated using its original non-recycled materials [Ref 2]. Data comparison of the developed recycling method to traditional composite waste disposal from a financial as well as an environmental prospective should be included. The Phase I effort will include any prototype plans to be developed under Phase II.

PHASE II: Demonstrate the methodology to reclaim and reuse carbon fiber from in-process waste and scrap with data to include, but not be limited to, cost, energy input, and CO2 emissions versus current composite usage and disposal methods. Define and validate a process evaluation, process modeling, and process economics for the selected approach.

PHASE III DUAL USE APPLICATIONS: Finalize and mature the technology for transition and insertion into aircraft component fabricators and end-of-life aircraft processors. The technology developed under this STTR effort has direct applicability to the commercial aircraft industry. Other applications for this method may include the automotive industry. Remaining fibers that cannot be used in either aircraft or automotive may benefit sporting goods manufacturers.

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KEYWORDS: reusable; composites; waste; fibers; carbon fiber; recycling

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N21A-T003 TITLE: Combined Electro-Optics/Infrared and Radar Sensor System for Detect and Avoid of Non-Cooperative Traffic for Small Unmanned Aerial Systems

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Electronics

OBJECTIVE: Develop dual-sensor, electro-optics/infrared (EO/IR) and radar, non-cooperative, traffic sensor concepts that will provide sufficient performance and balanced size, weight, power, and cost (SWaP-C) for small unmanned aerial systems (sUAS) where sufficient performance is unachievable by any single-sensor concept.

DESCRIPTION: DAA cooperative sensors that have been developed for manned aircraft, for example, Traffic Collision Avoidance System (TCAS) and Automatic Dependent Surveillance-Broadcast (ADS-B), are nondevelopmental and off the shelf. Detect and avoid (DAA) non-cooperative sensor subsystems, which take the place of a pilot's eyes, are a new construct whose role and employment has not been previously defined. Airborne Collision Avoidance System Xu (ACAS Xu) is a new DAA technology being developed by the Federal Aviation Administration (FAA) that processes inputs from both cooperative and non-cooperative sensors and provides alerts to the UAS operator to Remain Well Clear (RWC), and in the future will provide automatic maneuvers. Radar is the only current sensor actively being procured by the Navy as a non-cooperative DAA sensor with Radio Technical Commission for Aeronautics (RTCA) Do-366 addressing radar's Minimum Operational Performance Standard (MOPS) in the National Air Space (NAS). No other non-cooperative sensor has a MOPS. The radar development and production costs are high and dependent on its assigned role and the associated performance requirements. As such, a complete assessment of SWaP-C must be included in the establishment of safety requirements. EO/IR sensors are a desired alternative due to potentially lower SWaP-C. They are currently being considered for non-cooperative traffic surveillance as a part of RTCA Special Committee 228; however, they have performance challenges in low-visibility conditions and difficulty estimating range and range rate measurements that are essential for projecting Closest Point of Approach (CPA) and Time of CPA (TCPA). There is interest by civilian authorities (e.g. Federal Aviation Administration)and by the Navy for a dual sensor EO/IR and radar non-cooperative traffic sensor that will provide sufficient performance, but with less SWaP-C. A camera alone is not sufficient nor suitable for integration with ACAS Xu due to these shortcomings, and a radar, capable of doing the job, would not fit on board. A lower performing radar, providing suitable range and bearing information, to be combined with an EO/IR sensor, to meet the stringent SWaP-C limitations of sUAS is desired. All airborne hardware should weigh less than 3 lbs (1.36 kg) (Threshold) and 12 oz (340.2 g) (Objective); and consume less than 64 $in.^3$ (0.00105 m^3) Threshold) and 27 $in.^3$ (0.000442451 m^3) (Objective) of total space, with a power draw of less than 50 W average (Threshold) and 25 W average (Objective).

Critical evaluation criteria include the ability to provide sufficient tracking range and accuracy in order for an RQ-7 Shadow or RQ-21 Blackjack to avoid midair collisions and near midair collisions with other aircraft such as a Lancair Evolution, Cessna TTx, or Cessna 150. In general, radars provide highly accurate range and range rate information, but their angular resolution is inferior to EO/IR sensors. A dual-sensor system approach for sUAS must operate in lower altitude (<10,000 ft), overland environments, which present challenges for radar systems as slow-speed traffic may not separate well from the clutter and sources of false alarms. Likewise, performance of EO/IR systems suffer their own false-alarm problems, and performance is highly dependent on atmospheric conditions. An effective dual-sensor system must be able to detect and track targets in a range of atmospheric conditions, manage false alarms and clutter effects, and provide high enough accuracy to predict and avoid collisions. Such a system must consider multisensor data fusion approaches, multiband imaging system for all-weather operations, algorithms for mitigating false alarms and enhancing detection, sensor resource management (SRM) and feature-aided target characterization and tracking.

PHASE I: Design, develop, and demonstrate feasibility of dual-sensor detection, tracking, and false-alarm mitigation algorithms for expected operational environments and conditions. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Based on Phase I results, candidate concept(s) will be matured through more detailed, high-fidelity analyses and the development of dual-sensor detection, tracking, and false-alarm mitigation algorithms for expected operational environments and conditions. Examine sensor-integration concepts suitable for candidate sUAS. Assess hardware, software, and firmware impacts to accommodate the dual-sensor system, onboard candidate, sUAS. Identify critical technical challenges, perform necessary analysis, and as required, experimentation to understand the associated risk. The Phase II deliverable must provide a dual-sensor concept of sufficient detail to support the fabrication of a prototype demonstrator system.

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, integrate, and transition the final solution to Navy airborne platforms. The dual sensor system is suitable for use on commercial small unmanned aircraft.

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KEYWORDS: electro-optics/infrared sensor; radar sensor; airborne detect and avoid; non-cooperative airborne traffic; small unmanned aerial systems; collision avoidance

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N21A-T004 TITLE: Integrated High-Frequency Analog-to-Information Receiver

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop and demonstrate a compressive sensing receiver fabricated from photonic integrated circuits (PIC) that can recover arbitrary Radio Frequency (RF) signals in the K (18-27 GHz), Ka (27-40 GHz), V (40-75 GHz), and W (75-110 GHz) bands.

DESCRIPTION: Few Analog-to-Digital Converters (ADCs) are commercially available which can digitize RF signals up to 100 GHz, such as the LeCroy 10-Zi-A at 240 GS/s. However, these ADCs are designed to be laboratory test instruments, and as such are bulky (several cubic feet), have high-level power consumption (hundreds of watts), have a low effective number of bits (ENOB), and generate data at such a high rate that it cannot be transmitted to the ground from a remote platform. For example, the 240 GS/s ADC with 8 read-out bits has a data rate of 1.92 TeraBits Per Second (Tbps). While extensive work on photonic ADCs over the past 4 decades has shown progress towards higher data rate ADCs with higher ENOB and compact form by leveraging photonic integration [Ref 1], the systems are still impractical for remote platforms due to the high data rate. Compressive sensing (CS) provides an alternative solution for detecting wide bandwidth sparse signals [Refs 2-4]. In CS, the input RF signal is mixed down in dimension through an analog measurement matrix (MM) and Nyquist sampling rate is replaced by sampling random projections of the wideband signal at a rate on the order of the sparsity of the RF signal.

An implementation is sought of a high-performance, integrated, photonic solution to analyze RF signals in real time over a wide-frequency range, acquiring basic properties such as frequency, phase, and amplitude, or signal-specific properties such as chirp rate, pulse location, or modulation format. This will establish the technical and commercial foundation for the development of a fully integrated compressed-sensing system for direct RF-to-information conversion. One possible solution is based on interrogation of optical speckle in multimode planar waveguides, an ultra-broadband signal processing capability (i.e., taking advantage of the large signal bandwidth inherent in optical systems), integrated with a broadband pulsed optical source [Ref 5]. The integrated module will be specifically targeted to form an integrated RF receiver with the capability of resolving arbitrary properties (including, but not limited to, frequency, phase, and amplitude) of RF signals without direct digitization at the Nyquist rate with the following performance objectives: (a) real-time signal monitoring of 0.5-40 GHz RF spectrum (extendable to 100 GHz); (b) compact and ruggedized implementation,

PHASE I: Design, develop, and demonstrate feasibility for a fully integrated photonic integrated, circuit (PIC)-based, compressive sensing system. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Perform detailed development of the prototype and demonstrate it in terms of operational feasibility. Develop necessary PICs and integrate in a module to demonstrate and validate the PIC-based, compressive sensing system. Complete bench top integration and characterization to include a comparison of results to design objectives.

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, and integrate and transition the final solution into naval aviation operational environments. Finalize the design for desired PIC performance and satisfying volume constraints. Demonstrate in naval aviation operational environments. PIC-based compressive sensing in a low size, weight and power configuration would be of benefit to multiband commercial satellites.

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KEYWORDS: Analog to Digital Converters; Photonic Integrated Circuit; compressive sensing; radio frequency; optical speckle; ultra-broadband signal processing

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N21A-T005 TITLE: Ground Fault Detection System

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a ground fault detection system to quickly detect and localize all ground faults on 440 VAC 3 phase shipboard distribution systems that are either ungrounded or high resistance grounded.

DESCRIPTION: U.S. Navy shipboard electrical distribution systems typically include 440 VAC 3 phase power distribution systems where the power system neutral is either ungrounded or high resistance grounded. MIL-STD-1399-300-1 provides characteristics of the 440 VAC power. These systems enable continued operation with one of the three phase conductors grounded. However, if a second ground fault on another phase were to occur, then two phases of the power system will be grounded, resulting in a line-to-line fault, circuit breakers tripping and loss of power to loads. Fixing line to ground faults quickly is critical to avoiding a double ground fault and loss of service to loads.

Commercial distribution systems use solidly grounded systems so that when a single ground fault occurs, the circuit breaker trips and power is lost to loads. In a well-designed commercial power system, the circuit breaker that is on the source side of the ground fault and nearest to the ground fault will trip, thus providing a crude approximation of where the ground fault is located. Navy ungrounded and high resistance grounded power systems enable continued operation with a single line-to-ground fault, improving the overall survivability of the electrical plant. However, because a circuit breaker does not trip, localizing the ground fault is much more difficult.

Ungrounded and high resistance grounded power systems are used in commercial medical facilities, in process control industries, and where continued operation with a single line fault is of significant value. These applications have not typically employed ground fault localization methods; they have instead focused on inspection and preventative maintenance to reduce the risk of a ground fault. These systems are not expected to continue operation following battle damage, or can schedule system down time to locate the ground fault manually.

Commercial power transmission systems do employ ground detection methods because in high voltage transmission systems, circuit breakers can be hundreds of miles apart. These transmission systems are generally point-to-point and do not resemble the radial or zonal distribution seen on naval ships. Much of the academic research on ground fault localization has focused on these systems. Naval power systems are considerably different.

While existing ground fault detection circuits onboard naval ships can identify that a ground fault exists and identify which phase is experiencing the ground fault, identifying the specific feeder cable and location on that feeder cable is currently difficult. A typical process for identifying which feeder cable is faulted is to open the circuit breaker for the feeder cable and seeing if the “upstream” ground fault detection circuit no longer identifies a ground fault. This method however, requires a time and labor intensive process of sailors tagging out equipment and securing power to loads. Often operational necessity prevents securing loads and locating the ground fault is deferred to a later less critical time. Furthermore, this method will fail if two different feeders have the same phase grounded. Additionally, the method will usually fail for intermittent ground faults, such as one that depends on the roll-angle of the ship (loose bolt in an electrical connection box for example).

The Navy seeks to develop a system capable of correctly identifying which feeder cable is ground-faulted at least 90% of the time, and identify the location of the ground fault on that faulted cable within 3 meters at least 75% of the time. The shorter lengths of cables on shipboard systems differentiates them from terrestrial power systems for which most ground fault localization method research has concentrated on. The ability to achieve these requirements should be demonstrated first in dynamic simulation, then in a shipboard representative land-based system with a three phase generator and multiple feeders and loads.

Technologies that have been proposed in the past for localizing ground faults in terrestrial systems include common mode current monitoring, common mode current transient feature extraction, and travelling wave identification. None of these technologies have been incorporated into products for naval power systems. Applying these or other technologies to reliably detect and localize ground faults in shipboard systems should enable a significant reduction in time that a ground fault exists and exposes the ship to risk of a double ground fault and loss of power to mission critical equipment. [Refs 1,3,4,5]

PHASE I: Develop a design for an intermittent and persistent ground fault detection and localization system for naval shipboard 440 VAC three phase radial power systems. Identify risks and knowledge gaps and conduct analysis and/or experiments to eliminate the knowledge gaps and mitigate the risks. Prepare a dynamic simulation of a naval shipboard 440 VAC system and the ground fault detection and localization system to validate the concept. The Phase I Option, if exercised, will include the initial design specifications and capabilities description for the ground fault detection and localization system. Develop a test plan and test procedures for the prototype to be developed in Phase II.

PHASE II: Develop a functional prototype of the intermittent and persistent ground fault detection system for a naval shipboard 440 VAC three phase radial power system. Test the prototype and validate the dynamic model created in Phase I. If necessary, the dynamic model shall be updated and validated with new test data. The validated model shall be used to demonstrate performance of the system in a representative naval system. Work with the Navy to develop the draft specifications. After completing the company testing, deliver the prototype to the Navy to be tested at a Government or academic facility. These Navy conducted tests will be in addition to the company conducted tests and potentially much more comprehensive The Navy will provide results of Navy conducted tests to the company.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Develop and test a production ready intermittent and persistent ground fault detection system in accordance with the draft specification. Update the draft specification and dynamic model based on lessons learned from the production and testing of the system. Deliver the production ready system to the Government for testing at a Government or Academic facility.

Explore non-Navy markets for the ground fault detection system. Ungrounded and high resistance grounded power systems are used in medical facilities, in process control industries, and where continued operation with a single line fault is of significant value.

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KEYWORDS: Ground fault localization; Ground fault detection; Ungrounded power system; High resistance grounded power system; Common mode current; Feeder cable

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N21A-T006 TITLE: Compact, Efficient 2-Band Underwater Optical Communications System

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Battlespace Environments

OBJECTIVE: Develop a compact electro optic efficient, 2-band efficient, pico second mj energy per pulse scalable blue (450 nm)-green (550 nm) laser transmitter/receiver that can be used for underwater optical communications with optical link > 100m and data rate > 1 Gb/s.

DESCRIPTION: Underwater optical wireless communication with long optical link and high data rate is in great demand by the Navy due to the increased information transfer between submarines, unmanned vehicles and devices deployed underwater. Although tremendous progress has been made in the field of acoustic wireless lines, due to the attenuation of acoustic waves in water and the bandwidth of acoustic communication (10 kb/s), it is still far below the requirement of current applications. Radio Frequency (RF) communication has improved bandwidth but the link distance is generally < 10 m and limited by the very short penetration depth of RF signal in the water. Optical wireless communication with sufficient bandwidth, high security, and low time latency is believed to be the most promising approach to realize reliable long-distance and high-speed underwater communication links. Optical wireless communications with Gb/s bandwidth have been demonstrated by light in the blue (450 nm)-green (550 nm) spectrum. However, the optical links cannot meet the requirement of the Navy's applications due to low output power of the compact laser transmitters currently available and the large attenuation of sea water even in the blue-green spectrum region. Therefore, compact, high electro optic efficient powerful pulse laser transmitters at the low attenuation wavelength are in high demand for underwater communication with optical links > 100 m. The pulse laser transmitter shall operate in advance pulse code modulation technique to preserve the electrical power and able to increase the pulse energy and peak power that may require to transmit data at required distance. In this STTR topic the proposer and/or academia should develop the system architecture, modeling, management, documents and implementation of the design based on Open Model Based Engineering Environment (MBEE). This STTR topic will increase mission capability by enhancing underwater communication links and increasing communication data rate and bandwidth, while providing secure and stealthy communication.

This topic looks for a prototype with the following parameters:
Wavelength: Wavelengths that transmit through the sea water with low attenuation
Average Power Output: Threshold: 10 W; Objective: 50 W
Pulse width: pico second (ps), threshold < 5 ps; Objective < 1 ps
Pulse energy >1 mJ per pulse
Pulse Repetition rate ~ kHz
Bandwidth: Threshold: 1 Gb/s; Objective: 5 Gb/s
Achievable link distance: Threshold: 100 m; Objective: 200 m
Beam Quality (M2): Threshold: 1.5, Objective <1.1
Weight: Threshold: 2 lbs, Objective 1 lb
Volume: Threshold: 4 inch3, Objective <2 inch3

PHASE I: Design and analyze a concept of compact electro optic efficient pico second pulse laser transmitter and detector for laser receiver with > mJ per pulse per band architecture for underwater optical communication with optical link > 100 m and data rate > 1 Gb/s. The pulse laser receiver shall be able to decode the information from pulse code transmitter. Provide compact innovative efficient approach of transmission of optical information based on advanced pulse code modulation and detection. Demonstrate the feasibility of the concept with a power-scalable laser transmitter at a wavelength for underwater wireless communication in a bench top experiment. The Phase I Option, if exercised, will provide the prototype design and provide the specifications to meeting Phase II goals. Use the Open Model Based Engineering Environment (MBEE) method to develop a solution like modeling, design and document generation.

PHASE II: Develop and deliver a prototype of a 2-band blue/green laser system based on the concept developed in Phase I and the Phase II Statement of Work (SOW). Optimize the design and development of the Phase I laser concept to prototype a portable laser transmitter capable of producing up to 10 W output power > 1 mJ per pulse. Deliver the optical transmitter and detector system for evaluation at a Navy lab. If a Phase II Option is exercised, work with the Navy to test and evaluate the initial prototype product (hardware and software) at a Navy facility. If the Phase II Option II is exercised, perform further test and evaluation at a Navy facility and modification if necessary to meet the performance benchmarks before the fieldable prototype product (hardware and software) shall be delivered to the Navy.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning optical transmitting/detection system to Navy submarine platforms. Assist in the development and transition of the laser transmitter/detector for underwater optical communications. This technology is applicable on other DoD platforms and commercial applications such as environmental monitoring, offshore exploration, and disaster precaution.

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KEYWORDS: Underwater optical communication; laser transmitter; blue-green laser; Pulse code modulation; pico second laser; laser detector.

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N21A-T007 TITLE: Defect-Tolerant High-Temperature Superconductor for Coil Applications

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop advanced manufacturing techniques for a high-temperature superconductor that minimize the impact of defects during its fabrication with the goal to use it in high-temperature superconducting (HTS) magnet coil applications.

DESCRIPTION: The Navy has been developing HTS systems over the past few decades using HTS coils. The coils are made from HTS wire that has the ability to pass large electrical currents with essentially no voltage drop due to its zero resistance when below the transition temperature. Therefore, there is tremendous advantage to use HTS technology in applications that require generating magnetic fields such as large-bore magnets, high-field magnets, motors, generators, and superconducting magnetic energy storage (SMES) systems.

One risk to HTS-based magnet systems is the quench of the superconductor. A quench is when an HTS wire transitions from its superconducting state to its normal-conducting resistive state. Typically, the transition initiates in a local region referred to as “normal zone” that no longer has zero resistance, and behaves as a conventional conductor with joule heating. A quench is critical in a magnet-based system since magnets inherently store large amounts of inductive energy that will be converted to heat at the location of the quench. If the onset of a quench cannot be prevented the heating of the superconductor to an elevated temperature can cause irreversible and catastrophic damage to the magnet.

There has been research in the area of attempting to protect HTS coils by integrating a quench detection and protection system. Investigations have been performed in the past on criteria for quench detection that looked at the origin of a quench in an HTS wire. Most recently, there has been work on estimating the impact of fluctuations in the transport of current in HTS wires and its performance on superconducting devices. High-field HTS magnets have large electrical inductances that store mega-joules of energy. When a quench occurs, this energy converts to heat in the normal zone of the conductor and has the potential to cause a burnout in the HTS coil. Defects in the HTS conductor that manifest during the manufacturing process can go unnoticed and contribute as a weak point prone to quench initiation. Experiments and simulations have been completed to find limits of quench where the conductor may be operated stably and protected from damage by adding additional material to the conductor. When the conductor is used in a coil application, some alternate techniques are employed when winding a coil to better tolerate defects in the conductor, such as no-insulation wind approaches.

The Navy’s desire is for a defect tolerant HTS wire capable of continued operation through a partial quench enabling additional time for a quench detection system to react and protect the HTS magnet system. Therefore, proposed solutions must address the HTS wire itself, and NOT the method for winding HTS coils. This is imperative so the end product may be applicable to not only superconducting magnet coils as found in HTS motors, generators, or SMES systems, but eventually in power distribution cables.

The proposed solution to create defect tolerant HTS wire may be by either alternate wire manufacturing techniques, or by alternate HTS wire topologies. The solution must retain all aspects of conventional HTS wire and operate with a minimum engineering current density of 200 Amps/square millimeters [A/mm2] while at operating temperatures of 30-40 Kelvin [K] in a 1-3 Tesla [T] background field. The final form of the HTS must be compatible with lamination of alternate materials, (i.e., copper, brass, stainless steel) other than the substrates used during manufacturing to give the final wire structure suitable for winding a coil. It must also follow conventional laminated HTS wire dimensions and have a width between 4-

12mm, and a thickness approximately 0.05-0.2mm to enable the use of conventional HTS wire insulating machines. The HTS wire solution must also be producible in lengths with a minimum of 300m. The final product will need to demonstrate the ability of the conductor to continue operation (through a partial quench) even if it has local defects, by introducing known defects to the proposed conductor and comparing against known defects in a traditional HTS wire.

PHASE I: Develop a concept for a defect tolerant HTS wire that addresses defect mitigations during fabrication, or for alternative HTS topologies to increase defect tolerance in the conductor that meets the objectives stated in the Description. Demonstrate the feasibility of the proposed concept through modeling, analysis, and concept demonstrations. Quantify the clear benefits in the alternative fabrication techniques or HTS wire topologies. Since no industry standards exist for verification of defect tolerant HTS conductor, develop a plan and method of testing to be performed in Phase II to ensure defects are mitigated or tolerated; and that includes the cost to implement changes to fabrication or HTS wire modification, and a schedule with milestones to implement changes. The Phase I Option, if exercised, will include the initial layout and capabilities description to fabricate HTS wire in Phase II.

PHASE II: Fabricate sample prototype length HTS wire with minimal defects based on the Phase I work and Phase II Statement of Work (SOW) for demonstration and characterization of key parameters of the conductor in the Description. Demonstrate manufacturing process defect tolerance through introduction of known defects to compare against known defects in a traditional HTS conductor. Execute plans for methods of testing identified in the Phase I effort to prove the full-scale metrics. Based on lessons learned through the conductor testing, develop a substantially complete design and stand-up of the manufacturing process for long length conductor fabrication. Ensure this design includes all ancillary equipment required for fabrication and a means for testing the final product. Final deliverables should include samples of the conductor to be tested by the U.S., either the Navy or an alternate facility identified by the Government.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Although defect tolerant HTS conductor is initially targeted for use in HTS coils for large-bore magnets, acquisition programs utilizing HTS coils, either as a major system or as a sub-system, in larger programs such as motors or generators.

The desired defect tolerant HTS wire has applications in commercial large-bore superconducting magnets used in the medical field, or in large-particle accelerators, as well as, commercial wind generators, and fusion systems. The conductor may also be applied to superconducting power distribution, superconducting electric grids, or alternative energy technologies using superconducting systems.

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KEYWORDS: High-Temperature Superconductor; HTS; HTS wire defects; defect-tolerant HTS wire; HTS conductor reliability; alternate HTS wire topologies.

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N21A-T008 TITLE: Low Cost High Performance Efficient Uncooled or Thermoelectric Cooled Night Vision (NV) Infrared (IR) Imaging System

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Design and develop an advanced uncooled or thermoelectric (TE) cooled high performance wide band mid-wave infrared (MWIR) sensor at 5 µm and a long-wave infrared sensor (LWIR) at > 8 um, compact imaging sensors that will be cost-effective and smaller than current night vision infrared (MWIR-LWIR) imaging systems available.

DESCRIPTION: Imaging at MWIR (4-6 µm) and LWIR (8–12µm) wavelengths is challenging because the bandgap of the semiconductor material is close to the thermal energy at room temperature. Current detection and imaging technologies in broadband sensors that cover the 5 to 12 µm regime have to operate at cryogenic temperatures of 77 K or less in order to overcome the limitations of thermally generated noise. This requires expensive and bulky cooling systems that increase the overall size, weight, and power (SWaP) of imagers in MWIR/LWIR regime. The dominant technologies in this region are uncooled detector technology based on Silicon Carbide (SiC), amorphous silicon (aSi) and vanadium oxide (VOx) and cooled detector technology based Mercury (Hg)-Cadmium (Cd) –Telluride (Te) (MCT known as HgCdTe) compounds, as well as the more recent type-II superlattices. Conventional Focal Plane Array (FPA) fabrication methods are complex and often require complicated photodetector array hybridization onto Silicon-based Read on Integrated Circuits (ROIC), which reduces the final yield, increases the overall cost significantly, and limits the application. Consequently, there exists a demand for migration to an alternative technology for LWIR detection that can address the following two fundamental challenges: High-performance uncooled/TE cooled operation and a simple/cost-effective integration at the wafer-scale with commercial ROICs. Also, current MWIR sensor cost is in the order of $50 to $100k with < 6000 hours of lifetime operation. The major drawback of these MWIR sensors is their employment of the stirling cryo cooling pump to improve imaging performance.

One of the innovative approaches the Navy is interested in to overcome the physical limitations of bulky MWIR/LWIR photodetectors is the application of functionalized low-dimensional nanostructures, e.g., quantum wires and dots. These nanostructures incur favorable properties for high-performance uncooled detection, such as a higher absorption coefficient, elimination of phonon-assisted excitation (phonon bottleneck), and lower mean kinetic energy per particle. Quantum dot (0D) Nanostructures or 1D (one-dimension) nanowire structure offer three main advantages, as compared to conventional bulk- or thin film-based devices. They permit enhanced absorption of radiation by extending the absorption cross-section beyond the geometric footprint of a single nanostructure. The proposed topic shall not be limited to any of the technologies described in this Description; the Navy is looking for any new advanced next generation broadband high performance TE cooled or uncooled FPA for this application.

This proposed technology will be used to enhance all Navy systems requiring precision optical verification and identification of subjects of interests. The smaller form factor enables employment in unmanned autonomous systems (UxV), and integration with non-organic sensors.

PHASE I: Provide an innovative concept for a broadband (MWIR-LWIR) FPA sensor modeling, design, epitaxial growth, fabrication, and characterization of MWIR/LWIR broad band photodetectors based on quantum dot (0D), nanowire (1D), or nanostructure-contained quantum disks based on aSi, VOx, MCT, or any new next generation technology for uncooled or TE cooled high-performance MWIR/LWIR photo-detection. The Phase I Option, if exercised, will include the initial design specifications and capabilities description for the ground fault detection and localization system and develop a test plan and test procedures for the prototype developed in Phase II.

PHASE II: Based on successful Phase I modeling results and the Phase II Statement of Work (SOW), in Phase II the company shall process wafer-scale integration of the MWIR/LWIR devices with readout integrated circuit (ROIC) and making TE cooled high-performance MWIR/LWIR focal plane array as described in the Description.

Deliver the prototyped MWIR-LWIR FPA to the Navy for the sensor evaluation at a Navy facility to measure the imaging performance, Noise equivalent temperature , noise equivalent power, and detectivity of the sensor.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use (undersea and surface) and shall focus on large area (wafer scale) integration of high-density 0D nanostructure-contained quantum disks thin film for fabrication of TE cooled high-performance MWIR/LWIR photodetectors for device area greater than 100cm2 and quantum efficiencies greater than 50%. Demonstration of uncooled 320×256 MWIR/LWIR FPAs based on integration of sensors with commercially available ROICs. Specific industry applications are in the automobile, aerospace, and oil & gas industries.

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KEYWORDS: Midwave Infrared; MWIR; Long wave Infrared; LWIR; Quantum dot; 0D; Focal plane array; FPA; Nanostructure; ROIC

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N21A-T009 TITLE: Organic Solar Cell Processing and Product Development

RT&L FOCUS AREA(S): Autonomy; General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop and demonstrate, on increasing scales, solar cell designs and manufacturing processes for production of low cost, lightweight, and flexible organic solar cells with power conversions efficiencies greater than 13%. Materials in the solar cell stack should have inherent stability (i.e., photo, chemical (air and moisture), morphological, mechanical) to enable a reasonable lifetime with lightweight packaging. Solar cell packaging should support applications on fabric and enable associated folding/rolling without cell damage.

DESCRIPTION: Solar power is an integral part of forward operations, especially those relevant to future Expeditionary Advanced Base Operations (EABO), where austerity requires a high-performance, lightweight solution. Currently, the USMC uses Copper Indium Gallium Diselenide (CIGS) thin film cells that do not meet the rated power conversion efficiency (PCE) or durability. Single junction organic solar research cells have achieved PCE of 16% using conjugated polymer donors and non-fullerene acceptors bulk heterojunction materials with the promise of even higher performance [Ref 1]. While still below silicon, the promise of roll-to-roll manufacturing on flexible substrates with intrinsic stability enables minimal packaging and more versatile applications beyond the rigid (rooftop) market that silicon dominates. For the domestic market there are opportunities for opaque, colored, or semitransparent architectural solar films. For the military, durable and foldable laminates on tarps, tents, and backpacks that do not add weight are highly desired.

Existing organic solar cell commercial products were developed based on prior generation polymer/fullerene bulk heterojunction systems that peaked with research cell efficiencies of 10% for single junction and higher for multijunction. These have not established a stable market, but it is likely the higher performance materials can do this, especially for the market niches described above. However, academic research has focused on high overall power conversion efficiencies and not on product development efforts. Solar cell developers will need to pay attention to material issues associated with attaining desirable and stable bulk heterojunction morphologies, in addition to the series resistance and packaging issues associated with going from a research cell toward a practical module [Ref 2]. Past development efforts have pursued manufacturing using both vacuum deposition and roll-to-roll printing processes. Either approach is acceptable here so long as a realistic and defensible cost model is presented for the military/recreational applications identified above.

The proposed STTR team should already have demonstrated ability to produce research cells with verified overall power conversion efficiency of 13% or higher and should present and explain the selection of all the materials in their device stack (for performance, stability, processing) that could be scaled with cost-effective processing. The goal of Phase I is to move from a research cell to depositing multiple 1 square centimeter cells using processing approaches that will be scaled in Phase II. This can be done on rigid or flexible substrates. The cells should show power conversion efficiencies of 13% with less than 10% performance loss to break-in over 100 hours unpackaged and 1000 hours packaged. The deliverable for Phase I will be a device that meets those specifications and can be made available to third party testers.

PHASE I: Develop processing approaches for depositing multiple 1 square centimeter cells on either rigid or flexible substrates connecting them in series to form a module. Ensure that the cells show power conversion efficiencies of 13% with less than 10% performance loss to break-in over 100 hours unpackaged and 1000 hours packaged. Characterize module level performance and series resistance. Produce a final report that includes plans for a 50 square centimeter module on non-rigid substrate with modeled performance, the processing and packaging approach for this module and larger modules, and an updated cost analysis. Develop a Phase II plan.

PHASE II: Develop and process a 50 square centimeter module on a flexible substrate, targeting >11% overall power conversion efficiency, flexible packaging, and packaged lifetimes of 5-10 years. Fully test the stability of rigid and flexible cells and mini-modules. Study the mechanical stability of the mini-modules. Push processing to larger modules. Ensure that the prototype is available for validation. Develop product concepts for military and recreational applications. Update cost analysis for appropriate markets. Seek partnerships for product development.

PHASE III DUAL USE APPLICATIONS: Scaling of device fabrication to cost effective processes. Develop larger modules targeting specific products. Work with DoD and partners towards maturing products. DoD and commercial products would be solar cells that can be applied to tents and backpacks without adding substantial weight, could survive the normal uses of these products, and realize performance and lifetime detailed in this topic description.

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KEYWORDS: Organic solar cells; flexible solar cells; non-fullerene acceptors; low cost; lightweight; robust; Copper Indium Gallium Diselenide; CISG

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N21A-T010 TITLE: Novel Acoustic Source Concepts for Target Identification and Classification

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Develop a concept, design, and prototype of an acoustic source capable of directly exciting resonances in a wide variety of targets on or suspended from the seafloor.

DESCRIPTION: Manmade objects such as mines and unexploded ordnance (UXO) are subject to resonances when excited by the right forces. These resonances can provide classification and identification information, even in the presence of clutter. Acoustic Radiation Force (ARF) methods have been developed and adopted in the medical ultrasound community for clinical use. Using ultrasonic transducers, ARF methods have been demonstrated in the laboratory to induce target resonances for classification and identification purposes. Research under this topic seeks to develop the necessary hardware and operational concepts for demonstrating the potential for ARF methods to incite resonances in full-scale targets in real-world conditions. Demonstrating achievable acoustic intensity values given the frequency dependent absorption of the medium is a risk.

PHASE I: Develop a concept for an acoustic source capable of directly exciting resonances in some canonical target shapes such as plates or cylinders. Produce a technical report detailing the mathematics and physics supporting the concept, including the conditions under which the concept is expected to work. The technical report shall include requirements or specifications for an acoustic transducer capable of demonstrating the concept. It is preferred that the concept be demonstrated by small-scale laboratory experiments verified by numerical modeling, however results from numerical modeling only results would be acceptable. Develop a Phase II plan, including, if applicable, analysis and considerations for exciting resonances in full-size targets based on results from small-scale experiments.

PHASE II: Demonstrate the concept developed in Phase I in controlled conditions on more realistic target shapes and sizes. This phase will require the procurement, or the design and construction, of an acoustic source capable of exciting target shapes and sizes that might be expected in operations. For example, shapes might include 2' x 1' cylinders and or unexploded ordnance (UXO) sitting proud on the sea bottom. The contractor shall also demonstrate the concept's ability to reject clutter in controlled conditions. The expected deliverable is a report on the demonstration and requirements for a prototype system for demonstrating the concept in realistic conditions. For the Phase II option, if exercised, design, build, and demonstrate a prototype transducer capable of exciting target shapes representative of mines and/or UXO in a realistic ocean environment against targets both proud on the bottom and partially buried (< 50%). The demonstration shall include an assessment of performance for targets in environments with sandy bottoms, muddy bottoms, and high clutter areas (mine countermeasures doctrinal bottom type clutter category 4). The prototype transducer can be demonstrated from any type of platform, fixed or moving (up to 5 knots), such as a rail or a ship.

PHASE III DUAL USE APPLICATIONS: The expected transition will be a novel acoustic transducer design capable of exciting target resonances for identification purposes in cluttered underwater environments. The transducer shall be capable of exciting resonances from heights of up to 3 yards above the target. The design should be applicable across a range of applications for detecting and classifying objects on the seabed including remediation of UXO dumping sites, naval mine hunting, and underwater archaeology. Across these applications target sizes may range from less than 1 inch diameter for UXO to 20 inches or more in diameter for mines that may be over 4 feet in length. The design characteristics of the transducer may specify a range of target sizes, but shall be flexible enough to mount on a variety of different platforms including unmanned underwater vehicles. The final design/build specifications, to include size, weight, and power requirements along with design of mounting configurations shall be tailored to a mission specific platform with requirements provided by the transition sponsor.

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KEYWORDS: Acoustics; Vibrations; Modal Analysis; Transduction; Radiation Forces; Target Classification

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N21A-T011 TITLE: Enhancement of Detonation Wave Dynamics in Rotating Detonation Combustors (RDC)

RT&L FOCUS AREA(S): Hypersonics; General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Weapons

OBJECTIVE: Develop a Rotating Detonation Combustor (RDC) with passive acoustic control technology such as lining the augmentor duct, capable of suppressing unwanted secondary waves that subtract energy from the main precessing detonation wave, resulting in increased combustion efficiency.

DESCRIPTION: Currently, military gas turbines use subsonic deflagration (not detonation) thrust augmentors to reheat the core flow prior to expansion through the engine nozzle. This requires the use of bluff body flame stabilization methods that are achieved by the insertion of mechanical structures into the core flow near the exit of the turbine. These flame stabilization methods anchor the flame near the turbine exit and establish an environment for constant pressure combustion or "pressure loss" combustion. These features cause significant flow disruption and an unnecessary total pressure loss when the augmentor is not in operation.

Alongside the performance issues of conventional thrust augmentors there exists a prevalent combustion instability issue which manifests itself in the form of transverse and longitudinal waves inside the augmentor duct. Combustion instabilities are caused by heat release fluctuations that excite natural acoustic modes in resonating chambers. These fluctuations give rise to powerful pressure oscillations that lower the combustion efficiency of the device and ultimately may damage engine hardware [Ref 4]. One acoustic mode of interest is the transverse (or radial duct) mode typically occurring in the range of 1-10 kHz. In some cases, transverse mode pressure oscillations can exceed 9% of the base pressure, equivalent to pressure amplitudes of 0.6-0.8 bar (peak-to-peak) in a 7 bar combustor.

An RDC will also show signs of transverse instability wave modes however at a lower magnitude. To attenuate combustion instability modes generated by the RDC, a passive suppression technology, such as acoustic absorption coatings will be applied to the inner walls of the RDC duct. These absorption coatings can be comprised of porous high-temperature composites engineered to absorb a given frequency range.

Addressing the core issue of conventional augmentors, an RDC-based augmentor does not require a mechanical structure for flame stabilization and would eliminate this performance and durability loss. By replacing the typical flame stabilization geometry with an RDC-based augmentor the mechanical complexity is greatly reduced and "pressure gain" combustion can be exploited by harnessing detonations which are shock-coupled, supersonic combustion waves trapped in a continuous 'spin mode' about an annulus [Refs 1-3]. During pressure gain combustion, there is an effective rise in pressure across the RDC which allows for greater thermal power efficiencies to be achieved compared to constant pressure combustors while using the same amount of fuel.

By utilizing detonation waves, higher rates of reactant mass consumption are achieved due to wave propagation speeds that are typically three orders of magnitude greater than deflagrations of the same reactant mixture. This indicates an overall enhancement in combustion power density. The benefit of enhanced power density can be appreciated by engine size and mass reductions. Typical deflagration-based thrust augmentors require exceedingly long augmentor ducts due to the reduced levels of oxidizer, which attenuate chemical kinetic rates. This in turn leads to low efficiency combustion and an exceptionally low combustion power density.

By implementing RDC-based thrust augmentors, naval aircraft engines will showcase increased power thermal density and increased thermal efficiency as much as 7% of a standard Brayton cycle while providing a safer mode of operation [Ref 5].

PHASE I: Develop a passive acoustic suppression technique, such as a coupon-sized acoustically absorptive lining material tuned to the frequency range of interest and verify its performance via an appropriate demonstration, such as the design and fabrication of a real-ultrasonic, pressurized impedance tube. Both radial and axial modes spuriously triggered in an RDC environment should be targeted, as well as various base pressures. A broadband characterization of the acoustic performance of such material is expected. The technology solution should survive in the RDC environment experiencing pressures from 1 to 20 atmospheres and temperatures in excess of 2000o K [Ref 6]. Develop a Phase II plan.

PHASE II: Develop an RDC benchtest demonstrator with an acoustic suppression technique, such as a coating, proving enhancement of detonation wave dynamics and reduced structural loading of the augmentor duct. Testing will involve a range of fuel-to-oxidizer ratios and base pressures. High speed diagnostics will be used to assess the RDC response. Upon successful completion of benchtest experiments, the developed RDC technology should be integrated in a combustor test facility to demonstrate operations at sea level conditions.

PHASE III DUAL USE APPLICATIONS: Integrate the RDC into an engine for ground-based demo. Develop plans for flight worthy hardware. RDC technology can also be developed for commercial gas turbine applications for aviation, marine, and land-based power generation.

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KEYWORDS: Augmentor; deflagration; detonation; rotating detonation combustion, combustor

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N21A-T012 TITLE: Advanced Thermal Management of Power Converters

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics; Ground / Sea Vehicles

OBJECTIVE: Develop thermal management technologies to increase the power density of high-voltage power converters.

DESCRIPTION: Advanced sensors and effectors are driving shipboard power distribution systems toward higher voltages, resulting in greater thermal demands on the power conversion modules. Utilizing wide bandgap (WBG) semiconductors, such as silicon carbide (SiC) and gallium nitride (GaN), can help reduce the thermal inefficiencies through use of high-frequency switching topologies, but heat generation is still a primary limiting factor in their implementation. Modules with power densities approaching 100 kW/L and device level heat fluxes in excess of 500 W/cm^2 have recently been demonstrated. However, the increased power density results in much higher temperatures at the device and package level, reducing the reliability of such systems and driving the need for more aggressive cooling solutions.

This topic seeks improvements in thermal packaging technology to enable higher power density, lower cost systems employing WBG devices. In particular, approaches utilizing thermal/electrical co-design, integrated cooling, and cold plates with surface enhancements and novel flow passage geometries, enabled by additive manufacturing, could lead to significant reductions in thermal resistance and pressure drop. Novel cooling approaches and packaging improvements should be compatible with state-of-the-art (SoA) WBG devices. Cold plate technologies, in addition to having good thermal characteristics, must also provide good structural support. Any new packaging material proposals must consider tradeoffs between thickness and thermal resistance, as well as coefficient of thermal expansion (CTE) and durability. Finally, fabrication reliability and cost will ultimately drive commercial adoption.

PHASE I: Develop concepts to reduce the volume of power converter packaging and improve heat transfer performance. Validate thermal design performance through analytical modeling and/or subscale demonstration. Identify technical risks with an emphasis on manufacturing and fabrication processes required to implement the approach. Develop a plan for Phase II demonstration of the concept.

PHASE II: Refine the Phase I design and fabricate a prototype DC-DC modular multilevel converter (MMC) using SoA WBG devices. The prototype should be based on Power Electronic Building Block (PEBB) technology at a power level of at least 100 kW. Experimentally validate the unit’s performance over a variety operating conditions (partial to full power and bi-directional power flow), while maintaining device operating temperature below 175°C, and refine models as needed. Complete a cost analysis of concepts established to ensure the selected technology is competitive with conventional packaging technologies.

PHASE III DUAL USE APPLICATIONS: Complete the final design and manufacturing plans using the knowledge gained during Phases I and II, in order to support transition of system to Navy platforms. Ensure that the final system meets Navy unique requirements, e.g., shock, vibration, and electromagnetic interference (EMI). WBG power modules are seeing increased usage in a wide variety of commercial applications from electric vehicles to renewable energy storage.

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KEYWORDS: Thermal Management; High-Voltage Power Electronics; Electronics Packaging; Cold Plate

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N21A-T013 TITLE: Real-time Monitoring for Decompression Sickness

RT&L FOCUS AREA(S): Biotechnology

TECHNOLOGY AREA(S): Biomedical; Human Systems; Sensors

OBJECTIVE: Real-time biomonitoring capabilities that predict risk of Decompression Sickness (DCS) onset have the potential to improve safety for military divers and at the same time expand operational capabilities.

DESCRIPTION: DCS is a leading risk and time-limiting factor for diving operations. Avoiding DCS requires ascending in accord with often lengthy decompression schedules that are designed for the majority of divers and the most arduous diving conditions. Currently, there is no technology to tailor decompression schedules to the physiological state of individual divers. DCS is assumed to result from the formation of bubbles in tissues and blood, and there is an association between bubbles detected in the blood (VGE) post-dive and the occurrence of DCS. Detection of VGE in real time during diving may improve prediction of DCS and potentially could be used for real-time control of decompression. Development of technology for monitoring VGE during diving could enable optimization of decompression to the diver's physiological state.

PHASE I: Demonstrate feasibility through analysis and limited laboratory demonstrations, a noninvasive sensor device that is capable of measuring blood and tissue bubbles and is to be worn by pool swimmers/divers, surface supplied divers, and free swimming divers underwater. Note: Ideal features for the final product would be non-invasive, of similar size and weight to a diver worn dive computer, records bubble events along with dive time and dive depth for later analysis, and has sufficient autonomous power and data storage to record bubble events for at least 20 hours of diving. Provide cost of system, cost per dive, and reliability estimates, including lifetime expectancy and lifetime cost estimate. The required Phase I deliverables (in addition to those outlined in the DON 21.A Proposal Submission Instructions) will include: 1) a research plan for engineering the design of the waterproof device with embedded sensors; 2) a preliminary prototype, either physical or virtual, capable of demonstrating effectiveness (accurately and reliably predict and capture changes in bubbles as measured against those established in the scientific literature) of the proof-of-concept of design; and 3) a test and evaluation plan to validate accuracy of data collection including identification of proper controls. Consider projections regarding the latency of data collection. Device should target bubbles in micron scales as is possible with capacitive micromachined ultrasound transducer (CMUT) technology, and capable of capturing bubble formation and presence in both blood and tissue. Provide key information about the uses and limitations of the system and could include rapid prototyping and/or modeling and simulation. Develop a Phase II plan.

PHASE II: Develop, demonstrate and validate an underwater ultrasound sensor prototype. Ensure that the system can be used submerged in water temperatures from 32 °F to 90 °F to collect and analyze data and test detection algorithms during diving activity. Design the initial prototype for use in a dive computer or as an independent wearable device compatible with and not to interfere with traditional dive gear; and may be intended for experimental or training use and need not be adapted for operational use. It is expected that the algorithm development for real-time closed-loop feedback capabilities will require data collection first so this will be an iterative staged product development.

PHASE III DUAL USE APPLICATIONS: Transition prototype to a functional unit to the U.S. Navy's Naval Sea Systems Command Supervisor of Salvage and Diving (NAVSEA SUPSALV), Naval Special Warfare (NSW), and/or Naval Air Systems Command (NAVAIR) Aircrew Systems Program Office (PMA-202). Operationally relevant conditions may necessitate additional parameters such as greater depths, prolonged data collection, and eliminating motion artifacts. Technology could be commercially developed as a civilian dive computer.

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KEYWORDS: Decompression Sickness; DCS; Bubbles; Venous Gas Emboli; Ultrasound; Waterproof; Physiological Monitoring; Hyperbaric Gas Physiology

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N21A-T014 TITLE: Self-Healing Ship Systems

RT&L FOCUS AREA(S): Cybersecurity

TECHNOLOGY AREA(S): Ground / Sea Vehicles; Information Systems

OBJECTIVE: Design self-healing computing systems for use on Navy vessels to keep a ship's primary functions operational in combat should the original computing system be damaged during an attack.

DESCRIPTION: What if, during combat, a ship is attacked by an enemy missile? The ship's physical weapon and propulsion systems are still intact but the computers that control them have been damaged. Ships cannot have several redundant racks of computers providing full operational capabilities as it is impossible to predict physical damage locations. Proposals simply based on virtual machines will not be considered competitive. What if other remaining computing platforms and network capabilities could be leveraged and prioritized to provide important functionality during combat? A commercial analogy would be a primary application runs on a user's laptop, but the user also has a smartphone and smartwatch. The laptop gets destroyed. The two remaining computing platforms could be leveraged to provide the primary functions of the original laptop application. A research institution can provide approaches such as mobile code, code analysis, and distribution of computing functionality.

PHASE I: Develop an approach and conduct a feasibility study on self-healing computing systems. Conduct analysis such as modeling and/or simulation. Provide a proof-of-concept demonstration with associated metrics of performance. The Proof of Concept should be able to identify key/essential components from the original application and successfully demonstrate how those components would execute on a system of lesser capabilities (processor, storage, and RAM) and distributed processing if necessary. The concept should also identify how to locate and migrate code around surviving computing and networking components left on the vessel. Develop a Phase II plan.

PHASE II: Prototype the concept using real hardware, applications, and networks. Conduct benchmark evaluations of the implementation. Analyze performance of remaining application as a function of computing platform and remaining code. Examine resultant network traffic for distribution and execution. Provide demonstration of prototype using scenarios of increasing complexity. Document approach, limitations, and metrics in final report.

PHASE III DUAL USE APPLICATIONS: In current commercial disaster contingency planning modalities, backup data is kept far away at one or more offsite locations. Bandwidth during normal operations is largely sufficient. Backup operations cells or centers for operations also may exist remotely elsewhere for resiliency. However, during natural or manmade disasters these approaches may be insufficient. This technology could be relevant to many commercial scenarios to include enterprise networks and cyber-physical systems that will require resiliency and survivability in a crisis.

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KEYWORDS: Mobile code; system analysis and optimization; application resiliency; resilient computing

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N21A-T015 TITLE: Aerosol Spectral Absorption Measurement for Near UV through Near Infrared Wavelengths

RT&L FOCUS AREA(S): Directed energy; General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; Sensors

OBJECTIVE: Develop an instrument or measurement technology that can measure light absorption by ambient aerosol particles (~0.05 to 20+ μm) including pollution, smoke, irregular dust, complex obscurants, etc. at user-defined wavelengths over the wavelength range of 340 nm to 2.2 um and can show good fidelity for both fine and coarse mode particles, preferably based on in situ rather than filter-based methods. What is required is the bulk absorption coefficient, and developers are free to pursue integrating single particle measurements or bulk volumetric methods.

DESCRIPTION: Light scatter and absorption by aerosol particles can impact numerous Navy systems, from retrieval errors or biases in satellite-based radiance measurements used for sea surface temperature and aerosol data assimilation to atmospheric attenuation and beam quality degradation related to absorption and thermal blooming for directed energy systems. Spectral absorption is also often used to estimate the chemical composition of aerosol types (e.g., dust, black carbon, brown carbon). However, each of these applications examines a relatively small wavelength range over the total spectrum that the Navy utilizes. This STTR topic is for the development of instrumentation or technologies that can measure or derive aerosol absorption over wider wavelength ranges from 340 nm to 2.2 um at multiple wavelengths, with a minimum of three and preferably more wavelengths as requested by the buyer at the time of construction. If the entire range cannot be met in a single instrument design, preference will be given to the 500 nm to 2.2 um range, followed by the 340 nm to 670 nm range. All proposed methodologies will be considered but in situ technologies suitable for rapid response field site applications or aircraft use are preferred. Technologies can be direct measurements of absorption or the difference between extinction and scattering.

PHASE I: Develop a concept for an instrument or measurement technology that can measure light absorption by ambient aerosol particles at user-defined wavelengths over the wavelength range of 340 nm to 2.2 um and can show good fidelity for both fine and coarse mode particles, preferably based on in situ rather than filter-based methods, but proposals of all manner of technology solutions will be considered. Target uncertainties are +/- 20% in absorption coefficient or 0.5 Mm-1, whichever is greater. By the end of Phase I awardee is expected to demonstrate efficacy of the proposed technology in controlled laboratory conditions. Develop a Phase II plan.

PHASE II: Demonstrate the working prototype instrument at Navy field sites or in conjunction with earth science field campaigns of opportunity including comparison with a commercially available mid-visible band instrument. Several stages of refinement are expected based on field test findings. We expect the instrument to be man portable (e.g., individual components <50 lbs), with reasonable site installation requirements (e.g., <600 W). Housing design for open celled instruments must be able to withstand reasonable marine weather conditions (rain, sea salt corrosion, winds to 60 knots). Closed cell or filter based methods must include a plan for sampling to ensure ambient conditions are being represented.

PHASE III DUAL USE APPLICATIONS: The need for this technology is in association with Navy test range and operational system support for optics applications sensitive to aerosol absorption. However, we expect the instrument to be useful for Earth system science research (such as remote sensing and climate research), air quality composition monitoring, and combustion systems engineering. Instrument refinement for all of these applications would be expected in Phase III.

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KEYWORDS: Aerosol sensing; atmospheric characterization; meteorology; light attenuation measurement; remote sensing

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N21A-T016 TITLE: Peer-to-Peer Knowledge Sharing: Curation Automation Engine

RT&L FOCUS AREA(S): 5G; Machine Learning/AI

TECHNOLOGY AREA(S): Human Systems; Information Systems

OBJECTIVE: The Navy is seeking ways to enable machine-facilitated peer-to-peer knowledge sharing among Sailor and Marine warfighters. Warfighters have locally learned knowledge that needs to be shared with each other. The knowledge takes the form of practical knowledge and expertise gained through experience. The Navy envisions a set of software solutions that enable the capturing, curation, distribution and consuming of web-enabled, multi-media content. This STTR topic specifically seeks software and a supporting concept of operation for solutions that enable curation and distribution of knowledge of multi-media knowledge products, and build machine learning- and/or artificial intelligence-based agents that link knowledge products based upon natural language understanding and content analytics. Curation could entail two principle applications: one for informal peer-to-peer comments, corrections, and clarifications; and a second for formal, authoritative review of content prior to wider dissemination. Automation would assist in finding related multi-media content so that old and new content could be presented together and compared. The objective would be the development of a composable, semi-automated, scalable, structurally sound, mechanism capable of dynamically curating multi-media content based on formal rules, heuristics, and machine learning algorithms. The desired tools would also allow competent authorities the ability to properly vet, edit, and manage distribution of content created by warfighters with legacy, formally created, learning content in order to maximize the relevance, utility and timeliness of shared content.

The desired solution would enable Commands to compose multi-step curation workflows and enable management through assigned roles of cognizant personnel through an intuitive user interface. The Dynamic Curation Engine would: enable the rapid curation and routing of video/graphic/audio/text materials to specific individuals based on role assignments; support automated and manual content tagging; display side-by-side comparison of content; and create/store curation meta-data efficiently for managing content in a federated cloud-based distribution system.

DESCRIPTION: The current approaches for collecting and sharing knowledge among warfighters is inadequate. The traditional focus has relied exclusively on training content delivered either via schoolhouses or to Naval commands as formally prepared content. It is too slow and inflexible. New materials are formally vetted over extended timelines and often pre-loaded on units/command computers prior to getting underway with no ability to update content until the next deployment. Further, a great deal of practical knowledge and understanding is continuously developed by sailors and marines through experience and, if it is shared, is shared informally through ad hoc, 1-on-1 interactions. A new peer-to-peer approach to knowledge sharing is needed to share information at the deck-plate level and within the Naval information technology environment. Efforts are currently underway to facilitate warfighters to create multimedia-based content on-demand. However, the Navy will require software tools to systematically share and curate that content within the approved IT infrastructure. Of interest are tools that facilitate all aspects of curation at both a peer-to-peer level and with authoritative doctrine and training commands. The desired tools would facilitate semi-automated content inspection for both completeness, relationship among other content, potential security/releasability issues, enabling data meta-tagging of content to facilitate brokering to interested parties and flagging potential problems with linked content.

The curation tool(s) would facilitate not just the modification and inspection of content, but enable the rapid discovery of similar existing content and reference materials that would inform the curation process and identify potentially conflicting or supporting content for adjudication. The curation would need to support consumer-level commenting and annotation across a community of users, as well as enable formal vetting from the Naval Training Enterprise (NTE) and doctrine commands when appropriate.

The desired solution(s) will:
• Be responsive to the demands of the Navy's Sailor 2025 and the Navy Ready Relevant Learning initiatives.
• Consider requirements for the application of artificial intelligence/machine learning (AI/ML) techniques for related content inspection and discovery for a range of multi-media content.
• Support operations on intermittently connected networks in which cloud-based content is managed asynchronously via offline catalogs and partial caches.
• Enable Commands to compose curation workflows and roles to different categories of curator/user roles based on the content and organization of the Command.
• Be designed to work within the existing Naval information technology environment to the greatest degree possible, and to be accessible in a range of DoD security enclaves (specifically, usable within the constraints of the DoD information systems).
• Be designed to facilitate the automated curation and distribution of quality content with minimal time requirements from content curators.
• Enable workflows for managing (i.e., detecting and deconflicting) new content with existing content, including cases where the new content originates from a different organization.
• Enable authoritative curation of previously-approved content in order to ensure that information remains fresh and relevant to consumer demands.
• Enable algorithms that facilitate efficient curation and identify issues at the enterprise level across large content data sets.
• Enable curator-driven content valuation through utility and scope metrics, and support annotation of content (to include comments and clarifications), for use in informing authoritative content managers (e.g., the Naval training community).
• Support unit-level distribution within a local Navy computer network and support the management of release authorities.
• Ensure that tools are available on-demand to sailors both ashore and on-board ship thru both Navy workstations.
• Enable a broad range of content to be curated, to include video, imagery, audio, and text, with structure provided via automated and/or semi-automated mechanisms (e.g., wizards).
• Support both enterprise-wide and command-defined checklists, which enable customized routing workflows on the basis of content creator identification of the presence of topics that require alternative or augmented curation review.

Proposals must appropriately describe anticipated processes and workflows for users working with the tools being developed under this STTR topic. Proposals will be evaluated based upon their: 1) demonstration of technical competence; 2) identification of critical science and technology capabilities and challenges; 3) adequacy of their development strategy within the scope of STTR phases and funding; 4) demonstrated understanding of the constraints of editing, adjudicating and distributing multi-media content within DoD computing environments; 5) technical innovation; and 6) adequacy of the proposed transition plan. A Phase I proposal will identify customers/resource sponsors willing to invest in the proposed project starting with Phase IIB.

PHASE I: Address the state of the art in rapid, automated content curation tools, allowing for multiple potential workflows depending on user roles and content matter. Develop at least two use cases for how the proposed system will allow for both manual content curation/vetting and take advantage of AI to make use of content meta-data in a complex military environment. Develop and describe a concept prototype tool with storyboards, mission narratives, and functional flow diagrams (or equivalent) to demonstrate how technology will support sailor content curation/vetting, how user-provided meta information connected to content will be incorporated, and how curation decisions will be implemented. The prototype description should include appropriate standards-based approaches to the maximum practical extent. Define operational and technical metrics that will permit the demonstration of the utility of the approach in Phase II. Propose notional elements on how the content could be distributed locally and more broadly (multi-ship scaling to Navy-wide). Design and prototype a basic proof-of-concept content curation capability. Define the proposed transition model and a development plan for successful development through Phase III of the STTR process. Provide a Final Phase I report that includes detailed descriptions of: the development approach; and the technical challenges to be addressed in Phase II. Develop a Phase II plan.

PHASE II: Develop, demonstrate, and refine the Phase I concept prototype. Validate utility in human performance evaluations. Demonstrate applicability to multiple use domains (e.g., professional development, TTPs) based upon planned commercialization strategy. The effectiveness of the system shall be demonstrated by satisfying the utility metrics defined in Phase I, as well as additional metrics that may be developed in Phase II. Develop a plan for transition and commercialization. Provide a Final Phase II report that includes a detailed description of the approach and results against metrics developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Refine the prototype and make its features complete in preparation for transition and commercialization. In addition to the DoD, there will be an increasing demand for curated content creation in the commercial sector, such as in human resources, plant maintenance, and remedial education instruction, and in federal and state agencies such as code enforcement and unemployment procedures. These domains could benefit significantly from the application of the solution developed in this effort.

The proposed technologies create a formal content management system that compliments content currently being created through social media such as YouTube. Knowledge Curation will create tools directly applicable to a number of corporate and government knowledge management and business process automation efforts currently underway.

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KEYWORDS: knowledge curation; knowledge management; task workflows; multi-media content management; human performance; human cognition; information management

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N21A-T017 TITLE: Compact Electric Compressors for Aerospace Applications

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Weapons

OBJECTIVE: Develop, build, and test a compact and reliable electric compressor for aerospace applications including a fast, compact controller. The compressor must be able to operate in realistic aircraft environments and must not require an external cooling system. Size, Weight, and Power (SWaP) have to be optimized with respect to given performance requirements.

DESCRIPTION: Many aerospace applications such as active flow control (AFC) require compressed air. Often, compressed air is bled and routed from engines, which requires additional hardware, thermal management systems, plumbing and margins on engine sizing. Compact electric compressors offer an alternative to this approach. Many advances in electric compressor technology have been achieved in recent years (e.g., bearing technology, size and efficiency of electric components, materials). However, the technology has not been fully utilized on aircraft. The goal of this STTR topic is to design a compact electric compressor that can withstand the harsh environment of a military aircraft such as vibration, varying ambient conditions, and air pollution.

The design of a compact electric compressor is challenged by conflicting engineering aspects. For example, minimizing the size and weight of a compressor is limited by thermal requirements, bearing design, and vibration tolerances. Many ground-operated systems require a separate cooling system for higher compression ratios. Such a system is undesirable for aircraft operation due to additional weight, volume, and power impact. Additionally, such a compressor needs to be reliable with low maintenance requirements.

Compact compressors can be an enabling technology for AFC systems. Future applications, as well as recent applications such as download alleviation on the V-22 and side force increase on a vertical tail, can directly benefit from compact compressors that are integrated near the location of AFC application. Performance losses and weight impacts can be minimized compared to using engine bleed air. Dedicated compressor systems would also be relevant for future electric or hybrid electric systems.

The compact electric compressor system (including controller) should be conceptually designed and supported by analysis to achieve a pressure ratio of at least 2 operating at sea level and high/hot conditions [Ref 6]. The compressor must not require an additional active cooling system (e.g., liquid cooling with external heat exchanger). The available mass flow rate should be of the order of 1 lbm/s. The volume and weight need to be minimized. Furthermore, the compressor needs to withstand typical military aircraft vibration levels set forth in MIL-STD-810. An overall system assessment of the proposed design should also address the required filtration system.

Demonstration of the performance objectives along with preliminary assessments of unit robustness in realistic environments will be considered the criteria for success.

PHASE I: Complete a feasibility study of a concept for a compact electric compressor system (including controller) that outlines an overall design required to meet the topic objectives and the development of a realizable plan for the manufacturing and testing of the components in Phase II.

PHASE II: Address any required design updates/revisions to achieve the performance objectives. Build the compressor system (including controller) and test for airflow performance (i.e., predicted and actual compressor curves); different ambient conditions (pressure and temperature); vibration per MILSPEC requirements; and sensitivity to dirt ingestion and containment of hub failures.

PHASE III DUAL USE APPLICATIONS: Opportunities will be sought to ground- or flight-test the complete compressor system in realistic conditions to confirm performance, reliability, lifetime, and maintenance requirements. These tests should be as close to a certification type testing as possible. Subsequent activities will then focus on the development of methods/approaches to optimize component manufacturing and reduce overall cost.

AFC technologies have been demonstrated in relevant environments within the commercial sector. Most notably, the Boeing Co. flew an Eco-Demonstrator aircraft where the vertical tail was enhanced with an array of sweeping jets. This flight test proved the performance benefits provided by AFC, with the tail and rudder achieving greater directional control than an unactuated variant. Integration of the actuator arrays, however, was not very straightforward as a result of having to route pneumatic systems from either the main engines or the aircraft auxiliary power unit. Compact electric compressors will enable pneumatic AFC systems independent of engine bleed air by providing compressed air sources. This technology will also be suitable for electric, hybrid electric, and other types of aircraft. Moreover, success of this STTR topic will provide inroads to small businesses for the supply of these enabling components.

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KEYWORDS: Compact electric compressor; active flow control; AFC; aircraft subsystems

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N21A-T018 TITLE: Airborne Radar-Based Detection and Discrimination of Small Unmanned Aerial Systems and Birds For Collision Avoidance and Force Protection

RT&L FOCUS AREA(S): Autonomy; General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Electronics

OBJECTIVE: Develop and demonstrate advanced airborne radar modes for the detection and discrimination of small Unmanned Aerial Systems (sUAS) and birds.

DESCRIPTION: When used in a nefarious manner, sUAS (DoD groups 1-3) can pose a threat to both civil and military activities [Ref 1]. However, like birds [Ref 2], sUAS, even when operated in a legal manner, can pose a collision threat for other aircraft. From a force protection perspective (e.g., providing advanced warning of sUAS operating in the vicinity of USN ships), the detection and discrimination of sUAS at ranges (on the order of one nautical mile) sufficient to employ countermeasures are needed. From an aviation safety perspective, detection and discrimination of birds and sUAS are needed at ranges sufficient to determine and execute appropriate collision avoidance maneuvers (which varies as a function of encounter speed and UAS maneuverability). While a truly robust solution will likely leverage multiple sensor modalities, radar is the first line of defense from manned and unmanned aircraft. Radar detection of sUAS and birds (either larger individual birds or flocks of smaller birds) is very challenging due to their very low backscattering radar cross sections (RCS) [Refs 3-4]. Particularly for low-altitude airborne operations overland and over water, these low-RCS returns can be buried in surface clutter returns. Techniques to separate clutter and target signatures are required. Discrimination of sUAS and birds can in part be informed by the track kinematics. Ultimately, discrimination will leverage subtle signatures contained within the radar return that are generated by wing movement of birds or movements of surfaces (e.g., propellers) on sUAS. These micro-Doppler signatures have been investigated by multiple authors [Refs 5-11]. Developing an operationally suitable airborne bird and sUAS detection and discrimination capability for Navy fixed and rotary wing aircraft radar systems requires thorough study. Candidate radar systems range from UAS collision avoidance radars like the ZPY-9, maritime surveillance radars like the ZPY-8 and APS-153, and fire control radars like the APG-79 and APG-81. These radar systems and their host platforms are all dramatically different. Constraining the surveillance volume and balancing the radar timeline for this mode with other mission requirements are required. Not all radar/platform combinations will be able to provide an operationally suitable capability.

PHASE I: Identify candidate radar mode designs for conceptual radar systems representative of the Navy radar systems listed in the Description. Explore innovative approaches to maximize capability from various radar architectures through comprehensive analysis with no requirement for Navy-specific radar design information. Provide a detailed detection and discrimination algorithm description and analysis as implemented on the range of conceptual radar systems. The analyses should be sufficiently comprehensive so as to inform operational feasibility and the Phase II focus. Develop a Phase II plan.

PHASE II: Select candidate radar system(s) as the basis for detailed detection and discrimination mode development. Perform high fidelity radar, target and environmental simulation. Produce a detailed airborne radar collection and analysis plan. Assess hardware, software and firmware impacts to accommodate the new radar mode. Provide software source code and executable files, draft system/subsystem specification updates, and draft performance specification inputs.

PHASE III DUAL USE APPLICATIONS: Integrate into existing Military sense and avoid radar systems and comparable commercial UAS systems, as well as radar systems (e.g., weather radar systems) used in manned private and commercial passenger aircraft.

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KEYWORDS: Radar; collision avoidance; force protection; bird strike; air space integration; aviation safety; small unmanned aircraft systems; sUAS

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