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

IMPORTANT

- DON provides notice that Other Transaction Agreements (OTAs) may be used for Phase II awards.
- Discretionary Technical Assistance (DTA) is renamed Discretionary Technical and Business Assistance (TABA) for the STTR 19.B BAA.
- The optional Supporting Documents Volume (Volume 5) is available for the STTR 19.B BAA cycle. The optional 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.
- A Phase I Template is provided to assist small businesses to generate a Phase I Technical Volume (Volume 2).

INTRODUCTION

Responsibility for the implementation, administration, and management of the Department of the Navy (DON) SBIR/STTR Programs is with the Office of Naval Research (ONR). The Program Manager of the DON STTR Program is Mr. Steve Sullivan. For program and administrative questions, contact the Program Managers listed in Table 1; **do not** contact them for technical questions. For technical questions about a topic, contact the Topic Authors listed for each topic during the period **02 May 2019 through 30 May 2019**. Beginning **31 May 2019,** the SBIR/STTR Interactive Technical Information System (SITIS) (https://sbir.defensebusiness.org/) listed in Section 4.15.d of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) must be used for any technical inquiry. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-800-348-0787 (Monday through Friday, 9:00 a.m. to 6:00 p.m. ET) or via email at sbirhelpdesk@u.group.

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

Topic Numbers	Point of Contact	SYSCOM	Email
N19B-T025 to N19B-T034	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	donna.attick@navy.mil
N19B-T035 to N19B-T036	Mr. Dean Putnam	Naval Sea Systems Command (NAVSEA)	dean.r.putnam@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. Firms are encouraged to address the manufacturing needs of the defense sector in their proposals. 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://sbir.defensebusiness.org/ 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 new DoD Phase I Proposal Template located on the Submission Web site (https://sbir.defensebusiness.org/) as a guide for structuring proposals. Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.

PHASE I PROPOSAL SUBMISSION REQUIREMENTS

The following MUST BE MET or the proposal will be deemed noncompliant and will be REJECTED.

- **Technical Volume (Volume 2).** Technical Volume (Volume 2) must meet the following requirements:
  - Not to exceed **20** 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 **20-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, and imbedded tables, figures, images, or graphics that include text, a font size of 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.

  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 not exceed six (6) months and the Phase I Option Period of Performance must not exceed six (6) months.

- **Supporting Documents Volume (Volume 5)**. DoD has implemented a Supporting Documents Volume (Volume 5). The optional Volume 5 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. Volume 5 should only be used for the following documents:

- Letters of Support
- Additional Cost Information – The “Explanatory Material” field in the online DoD Cost Volume (Volume 3) is to be used to provide sufficient detail for subcontractor, material, travel costs, and Discretionary Technical and Business Assistance (TABA), if proposed. If additional space is needed these items may be included within Volume 5.
- Funding Agreement Certification
- Technical Data Rights (Assertions) - If required, must be provided in the table format required by DFARS 252.227-7013(e)(3) and be included within Volume 5.
- Lifecycle Certification
- Allocation of Rights

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 of 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 has implemented the optional Fraud, Waste and Abuse Training Certification (Volume 6). DON does not require evidence of Fraud, Waste and Abuse Training at the time of proposal submission. Therefore, DON will not require proposers to use Volume 6.

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 STTR Policy Directive section 9(b) allows the DON to provide TABA (formerly referred to as DTA) to its awardees to assist in minimizing the technical risks associated with STTR projects, developing and commercializing products and processes resulting from such projects, and 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 provider in an amount not to exceed the values specified below. This amount is in addition to the award amount for the Phase I or Phase II 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 (firm name)
- TABA provider point of contact, email address, and phone number
- An explanation of why the TABA provider is uniquely qualified to provide the service
- Tasks the TABA provider will perform
- Total TABA provider 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 $5,000 per 12-month period of performance, not to exceed $10,000 per Phase II contract

NOTE: The Small Business Administration (SBA) is currently developing regulations governing TABA. All regulatory guidance produced by SBA will apply to any STTR contracts where TABA is utilized.

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.

CONTRACT DELIVERABLES

Contract deliverables for Phase I are typically progress reports and final reports. 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.

Funding Limitations. In accordance with 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, excluding TABA. 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 (less TABA) is $1,600,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $1,600,000 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
60 Days	50% of Total Base or Option
120 Days	35% of Total Base or Option
180 Days	15% of Total Base or Option

TOPIC AWARD BY OTHER THAN THE SPONSORING AGENCY

Due to specific limitations on the amount of funding and number of awards that may be awarded to a particular firm per topic using SBIR/STTR program funds (see above), Head of Agency Determinations are now required (for all awards related to topics issued in or after the SBIR 13.1/STTR 13.A solicitations) before a different agency may make an award using another agency's topic. This limitation does not apply to Phase III funding. Please contact the original sponsoring agency before submitting a Phase II proposal to an agency other than the one that sponsored the original topic. (For DON awardees, this includes other DON SYSCOMs.)

TRANSFER BETWEEN SBIR AND STTR PROGRAMS

Section 4(b)(1)(i) of the 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. A firm wishing to transfer from one program to another must contact its designated technical monitor to discuss the reasons for the request and the agency's ability to support the request. The transition may be proposed prior to award or during the performance of the Phase II effort. No transfers will be authorized prior to or during the Phase I award. Agency disapproval of a request to change programs will not be grounds for granting relief from any contractual performance requirement(s) including but not limited to the percentage of effort required to be performed by the small business and the research institution (if applicable). All approved transitions between programs must be noted in the Phase II award or an award modification signed by the Contracting Officer that indicates the removal or addition of the research institution and the revised percentage of work requirements.

ADDITIONAL NOTES

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).

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 Out brief (as applicable) will be used to evaluate the offeror'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. Thus, a Phase III award is any contract, grant, or agreement where the technology is the same as, derived from, or evolved from a Phase I or a Phase II SBIR/STTR award and given to the firm that received the Phase I/II award. 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 Technical 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 19.B Topic Index

NAVY STTR 19.B Topic Descriptions

N19B-T025 TITLE: Overall Aircraft System-of-Systems Thermal Model and Simulation Tool

TECHNOLOGY AREA(S): Air Platform, Electronics, Ground/Sea Vehicles

ACQUISITION PROGRAM: PMA265 F/A-18 Hornet/Super Hornet

OBJECTIVE: Design and develop a model and simulation (M&S) tool to establish the overall aircraft system-of-systems (SoS) thermal management to determine the least efficient sub-system so that improvements can be made to increase the overall aircraft energy efficiency.

DESCRIPTION: The aircraft is a SoS that presently is not well defined with respect to overall thermal management, with only the individual systems defined including their size and weight. The Navy seeks a tool that can accurately model the overall thermal management of the aircraft SoS, including all individual sub-systems (i.e., fuel, engine, Aircraft Mounted Accessory Drive (AMAD), electrical, avionics, sub-systems, fuel/air energy processes), to determine where improvements can be made to overall efficiency. This model would be used to assess and quantify failure modes on the aircraft when changes/improvements are made to individual sub-systems for present and future aircraft upgrades. Avionics upgrades increase generator electrical load, which increases the heat to the generator cooling oil. The cooling oil increases heat transfers to an oil/fuel heat exchanger to the fuel. Additionally, the radar upgrades would increase heat that goes through a Polyalphaolefin Liquid to the fuel heat exchanger. Any engine upgrades may also increase the engine heat that transfers through the engine oil to the fuel. The increased heat to the fuel can coke the engine. The tool should be developed using the known thermal aircraft predicted loads that are defined in the thermal load analysis. The model would use predicted heat loads (kilo-watts) and calculate the resultant temperature data. The calculated temperatures will be compared to aircraft temperature data archived by Boeing to test the model’s validity. Fighter aircraft temperature data and thermal load analysis will be provided by the Government. As upgrades occur, the software would be used to predict thermal increases. The tool should have the ability to import data from Microsoft Excel.

PHASE I: Define and develop an approach for a modeling and simulation tool able to analyze existing fighter aircraft heat loads using data to be provided by the Government. Ensure that the model approach is capable of adding future heat loads that result from an aircraft upgrade. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate prototype software modeling and simulation tool for an aircraft system. Validate the software using Government-furnished thermal and temperature data.

PHASE III DUAL USE APPLICATIONS: Develop and demonstrate a platform-specific thermal management system modeling tool using temperature data. Transition the tool to appropriate program offices. Commercial aircraft and automotive manufacturers can benefit from using the model to determine the thermal impact on cooling systems.

REFERENCES:

1. Ahlers, Mark. “Aircraft Thermal Management: Systems Architectures.” . SAE International, April 30, 2016; ISBN-10: 076808296X; ISBN-13: 978-0768082968. https://www.sae.org/publications/books/content/pt-177/

2. Sundén, Bengt and Fu, Juan. “Heat Transfer in Aerospace Applications.” Academic Press, 2017; ISBN 978-0-12-809760-1. https://www.elsevier.com/books/heat-transfer-in-aerospace-applications/sunden/978-0-12-809760-1

KEYWORDS: Thermal; Integration; Fuel; Electrical; Oil; Analysis

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T026 TITLE: Fatigue Prediction for Additive Manufactured (AM) Metallic Components

TECHNOLOGY AREA(S): Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a comprehensive toolset to predict the fatigue life of flight-critical metallic components fabricated by additive manufacturing.

DESCRIPTION: Additive manufacturing (AM) is considered a revolutionary technology to fabricate lightweight, flight- and marine-critical metallic components. The ability to produce complex and tailored structure designs opens the door for improved efficiency in existing products and can function as a key enabler to new uses like hypersonic applications. Many merits, such as high efficiency, flexibility, and cost saving, give AM the potential to become a widely utilized fabrication process for industrial applications. Despite the high potential of this manufacturing technology, it has been found that the fatigue life of as-deposited AM components is often low compared to wrought components produced by conventional technology. For critical components, like those in airframe applications, developing a better understanding of fatigue performance is essential for further adoption of this technology [Ref 1].

AM is far more complex than traditional fabrication processes. The starting material is typically a high-quality powder with specific characteristics such as size, morphology, and chemical composition. The AM process is comprised of numerous cycles of material addition and rapid heating and cooling / melting and solidifying. As a result, the fatigue performance in AM parts has been attributed to a complex combination of material and process-induced imperfections. For example, fatigue crack growth mechanisms have been correlated with microstructure, such as a/a’ phases and colonies, in AM-fabricated Ti-6Al-4V [Ref 2]. Fatigue performance has also been found to be strongly related to porosity and defects that could be formed due to localized incomplete melting, often influenced by process parameters [Ref 3]. As with traditional machine design rules, the fatigue lives of an AM part are dominated by surface roughness effects. The effect of residual stress on fatigue performance has also been demonstrated by removing a compressive residual stressed surface layer to reduce fatigue performance [Ref 4].

Due to the complexity of fatigue behavior of an AM part, a comprehensive toolset, based on an Integrated Computational Materials Engineering (ICME) framework [Ref 5], is needed to predict fatigue strength and fatigue life in AM metallic components. This toolset should address the fatigue contributing factors at the part level, such as residual stress during the AM process, the microstructure of the fabricated metallic component, porosity level and distribution in the AM part, and surface roughness. This toolset should be able to assess fatigue environments typically experienced by Navy aircraft like flight spectra [Ref 6] and shocks and vibration [Ref 7]. Similar to the integrative approach in foundry processes (castings) [Ref 8], the AM fatigue predictive methodology may integrate a combination of AM process simulations to predict AM anomalies, crack growth modeling to predict the effect of the AM anomalies on fatigue life and residual strength, and modeling of nondestructive evaluation (NDE) processes to determine the inspectability of both initial anomalies and potential cracks that may grow while the component is in service. Artificial intelligence strategies like machine learning and neural networks may be integrated into the toolset. This toolset should be compatible with existing analysis software toolsets (e.g., FE-SAFE [Ref 9], nCode [Ref 10], AFGROW [Ref 11], NASGRO [Ref 12]) and exhibit equal or better performance and accuracy.

Component size limitations are largely driven by the build volume of the AM machine being used. As the technology continues to evolve, so will the build volume. For purposes of this effort, components between 2”x2”x2” and 15”x15”x15” are acceptable, however the long-term goal is for larger capability.

PHASE I: Demonstrate the feasibility of a predictive methodology for fatigue properties of metallic AM components (relating the material and processing induced imperfections noted above.) Show the feasibility by performing limited predictions of the fatigue performance of a single material (e.g., Ti-6Al-4V or 17-4PH) for a single AM machine. Validate the predicted fatigue behavior of the deposited material and characterize at a coupon level. Identify the issues involved in integrating the fatigue predictive methodology. Include, in a Phase II plan, full-scale methodology development plans to be carried out under Phase II.

PHASE II: Further develop the predictive toolset so that it can be applicable to an array of aircraft component geometries and materials, and useable across multiple machines (e.g., one powder bed machine and one powder blown machine.). Demonstrate the predictive tool on an article that is representative of basic geometries seen on aircraft components (e.g., overhangs, holes, fillets/radii, internal channels, lugs). Perform analysis of the predictive methodology to determine its ability to predict fatigue behavior of AM parts. Fully validate the predictive fatigue lives of the AM parts.

PHASE III DUAL USE APPLICATIONS: Fully develop the predictive fatigue toolset and demonstrate it in a scenario representative of Navy implementation (i.e., using similar equipment, skillsets, and selected part(s) that would be available in a Navy application). Transition the prediction tool into a standalone and/or combined product for use in Navy and commercial additive manufacturing applications. Ensure that the software tool developed through this effort will enable designers and manufacturers to better identify and address features, characteristics, and potential anomalies that could negatively impact fatigue life prior to part production, which will help to improve the quality of additively manufactured parts as well as increase the efficiency of the AM process by reducing the number of builds that fail to meet performance requirements. As these aspects are valuable to all types of AM, this toolset will be directly applicable to a wide range of commercial applications (e.g., aerospace, marine, automotive, and oil and gas.)

REFERENCES:

1. Li, P., Warner, D., Fatemi, A., and Phan, N. "Critical assessment of the fatigue performance of additively manufactured Ti–6Al–4V and perspective for future research." International Journal of Fatigue, Volume 85, April 2016, pp. 130-143. https://doi.org/10.1016/j.ijfatigue.2015.12.003

2. Zhai, Y., Galarraga, H., and Lados, D. A. "Microstructure, static properties, and fatigue crack growth mechanisms in Ti-6Al-4V fabricated by additive manufacturing: LENS and EBM." Engineering Failure Analysis, Volume 69, 2016, pp. 3-14. https://doi.org/10.1016/j.engfailanal.2016.05.036

3. Hrabe, N., Gnäupel-Herold, T., and Quinn, T. "Fatigue properties of a titanium alloy (Ti–6Al–4V) fabricated via electron beam melting (EBM): Effects of internal defects and residual stress." International Journal of Fatigue, Volume 94, 2017, pp. 202-210. https://doi.org/10.1016/j.ijfatigue.2016.04.022

4. Golden, P.J., John, R., and Porter, W.J. "Investigation of variability in fatigue crack nucleation and propagation in alpha+beta Ti–6Al–4V." Procedia Engineering, Volume 2, 2010, pp. 1839-1847. https://doi.org/10.1016/j.proeng.2010.03.198

5. "Integrated Computational Materials Engineering: A Transformational Discipline for Improved Competitiveness and National Security." National Research Council, 2008. https://doi.org/10.17226/12199

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KEYWORDS: Metal Additive Manufacturing; Fatigue Property Prediction; Process Modeling; Crack Growth; Non-destructive Evaluation; ICME

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T027 TITLE: Large Eddy Simulation (LES) Flow Solver Suitable for Modeling Conjugate Heat Transfer

TECHNOLOGY AREA(S): Air Platform

ACQUISITION PROGRAM: PMA234 Airborne Electronic Attack Systems

OBJECTIVE: Develop computationally efficient, Computational Fluid Dynamics (CFD), flow modeling toolsets suitable for modeling 3D time-resolved conjugate heat transfer (CHT) for use in predicting thermal behavior of aircraft parts including gas turbine (GT) engines.

DESCRIPTION: The Navy currently lacks a detailed 3D heat rejection system design or analysis capability. Most aircraft platforms have a substantial need to develop a better understanding of heat rejection / heat transfer in Navy systems. The science of modeling heat transfer in the presence of high-speed turbulent flow is crucial to Navy systems. Current CFD practice is to heavily simplify the airflow modeling, which removes important physics phenomena. Wall Modeled Large Eddy Simulation (WMLES)-based CFD toolset do an outstanding job of flow modeling turbulent flow, particularly in separated and poorly behaved flow cases. With improvements to the heat transfer modeling, particularly in the boundary layer, the state of the art will be improved, allowing improved design efforts, benefitting warfighter customers.

One of the most important factors determining performance, reliability and safety in aircraft systems is the thermal state of the many subsystems. Incorrectly modeled or estimated thermal effects can lead to premature degradation of components, which increases both maintenance costs and safety risk. This topic is aimed at providing to the NAVAIR Internal Flow Modeling Team (NIF-T) a toolset that will allow them to accurately solve conjugate heat transfer (CHT) problems for the benefit of the Navy fleet and program office aircraft propulsion and power customers.

Fully detailed 3D CHT modeling has long been difficult to accomplish. Its complexities are commonly side-stepped in favor of simpler (often over-simplified), far less accurate, approaches. This is especially true in current CFD state of the art toolsets, where heat transfer is often modeled using simplified flow models, using over-simplified (uniform) temperature or uniform heat flux boundary conditions. Currently available solvers, such as ANSYS Icepak [Ref 1], used commercially for analysis of CHT problems, typically focus on modeling the cooling of consumer electronics. This has been shown to be an effective tool for convection or fan forced cooling in electronics applications. However, it lacks significantly in modeling the physics of high speed / transonic / supersonic flow such as in military GT engines. The flow field in electronics is typically modeled acceptably using either direct numerical simulation (DNS) or Reynolds-Averaged Navier-Stokes (RANS) simulations. RANS solvers are often used by industry in GT engine analyses as well due to their less computationally expensive nature. When used with care, RANS can give reasonable accuracy in well-behaved flow cases. The RANS formulation relies on turbulence models to model boundary layer stress, but do not work as well with separated, poorly-behaved turbulent flows.

Large Eddy Simulation (LES) is a well-known approach to flow modeling that has been implemented in many commercial CFD toolsets. It is very good at accurately modeling time-varying turbulent flow of features at grid scale and above, while moderating the computational cost as compared to DNS. LES, while providing increased accuracy over RANS, comes at the expense of increased (5-10X) computational resource requirements (when modeling high speed flow around solid objects where an accurate representation of the flow behavior in the boundary layer is desired) as compared to RANS methods. To mitigate the non-linear growth of computational requirements with increasing flow complexity, the state of the art in LES has recently advanced with the introduction of wall modeling of boundary layers [Ref 2]. This allows for substantial grid size reduction which greatly reduces the computational requirements for accurate LES solutions. However, the various optional boundary layer turbulence / shear assumptions of the many different Wall Modeled Large Eddy Simulation (WMLES) approaches have, in most cases, not been carefully studied in order to develop accurate heat transfer predictions through this simplified boundary layer region. Many flow analysis organizations have come to rely on the outstanding unsteady flow predictions of WMLES toolsets.

This STTR topic seeks to further develop and improve the accuracy of the CHT predictions of WMLES toolsets, both with and without transpiration. It seeks to improve wall modeling assumptions such that CHT analysis results accurately predict the physics of heat transfer in turbulent boundary layers. We are seeking to develop toolsets that accurately predict CHT in selected sample cases with known results that are (threshold) at least as accurate as RANS model CHT results, with the objective being that the use of wall modeling produces CHT results that are equally as accurate as fully resolved (not wall modeled) LES analyses.

The proposed toolset must be able to accurately model the heat transfer between the fluid and the bounding structures within the respective domains of each. These toolsets must work in a computationally efficient manner, with the objective that accurate CHT results take no more computing resources than current WMLES analyses. The Threshold would be that any changes to the Wall Modeling features would result in WMLES models with accurate CHT calculations that use less computing resources that fully resolved LES models while the CHT features are active.

Any proposed toolset would be evaluated primarily on physical accuracy for both flow properties and CHT in wall regions, and secondarily on computational efficiency. Physical accuracy would need to be demonstrated against experimental results of the physics being modeled, and other well accepted WMLES tool results. Experimental comparisons are to be chosen by the proposing organization to demonstrate accuracy of the toolset when given arbitrary problems as well as established problems, while following simple modeling guidelines. Computational efficiency of the toolset would be demonstrated with representative and real-world flow problems being simulated on the DoD high-performance computers [Ref 7] (or functional equivalent) with threshold and objective measures as described above.

Note that the task / cost of developing new wall modeling features in an LES toolset that lacks wall modeling is outside the scope of this topic. Preference will be given in the Phase II selection process for proposing entities working with an already implemented LES toolset with wall modeling for accurate boundary layer flow prediction. However, an approach that selects an LES toolset currently without wall modeling would be allowed as long as the proposal commits to delivering, at the end of Phase II, a fully functional WMLES toolset that meets the objectives stated herein. Two known open source LES toolsets are High Fidelity Large Eddy Simulation (HiFiLES) [Ref 3] and OpenFOAM [Ref 4].

PHASE I: Demonstrate an in-depth knowledge of the physics and modeling issues involved in modeling turbulent air flow and making CHT predictions, with and without transpiration using both RANS and WMLES toolsets.

Select one currently available WMLES toolset to be updated / demonstrated for this effort, and one RANS tool for use in flow and CHT results comparison for this effort.

Define and describe a plan for confirming / improving / demonstrating the CHT features of the selected WMLES toolset, to be carried out in Phase II.

Develop a detailed plan (to be carried out in Phase II) to conduct one or more proof-of-concept demonstrations of the predictive power and accuracy of the proposed resulting toolset that must include measures of its computational efficiency.

Provide a risk analysis of the proposed Phase II effort, identifying key areas of technical risk, and provide a risk mitigation plan for each identified risk. (Note: Technical Risk is defined here as: “issues arising from, or aspects related to the contractor selected approach that could result in a less than satisfactory result, based on the measures of success in this solicitation”.)

PHASE II: Carry out the contractor’s development and demonstration plan for improved CHT modeling with the selected WMLES toolset (as defined in Phase I above). Enhance and / or demonstrate accurate CHT modeling performance (as described above) of the selected WMLES toolset. Demonstrate scalability, universality and applicability of the solver, including its computational efficiency for use in real-world, GT propulsion relevant flows. Evaluate, document, and demonstrate the CHT predictive power of the toolset using a contractor-obtained test data set, selected by agreement with the NAVAIR TPOC. By the end of the Phase II effort, deliver and install a working prototype version of the resulting enhanced WMLES toolset on the DoD High Performance Computer Systems (DoD HPC). Obtain and provide to the Navy all needed licenses and enabling tools for input of model data and output of results.

PHASE III DUAL USE APPLICATIONS: Perform testing and then any further development of the toolset to address any identified deficiencies to provide a commercially viable and well accepted CHT / WMLES toolset to be utilized by the developing organization as consultants and / or sold or licensed to other organizations. Deliver and install the final working version of the enhanced WMLES toolset on the DoD High Performance Computer Systems (DoD HPC), including all needed licenses and enabling tools for input of model data, and output of results. Train and assist up to 15 members of the NAVAIR NIF-T team in the use of the final WMLES toolset.

The toolset developed here are expected to have far-reaching uses for all DoD branches and many private sector companies. GT design as well as aircraft design in general would benefit from robust 3D flow-based heat transfer analysis, especially with regard to component reliability, performance, and efficiency of propulsion and cooling systems. Gas turbine engines are currently in use for land-based electrical power generation, ship power plants, land vehicles, and most aircraft. Beyond GT engines, accurate heat transfer calculations in an accurate WMLES flow modeling tool would have benefits for use in the design of gasoline and diesel engines, heat exchangers of all types, the refrigeration industry, nuclear reactor original equipment manufacturers (OEM), and design of general purpose heating, ventilation and air conditioning (HVAC). However, the high-speed flow inherent in GT engines would perhaps most benefit from the combination of WMLES with accurate CHT. Potential uses exist for any industry where accurate CHT analysis would enhance design features, such as the refrigeration industry, automotive and surface vehicle, nuclear, HVAC etc.

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KEYWORDS: Conjugate Heat Transfer; Heat Exchangers; Transpiration Cooling; High-Temperature Turbines; Large Eddy Simulation, LES; Wall Modeled LES; Gas Turbine Engines;

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N19B-T028 TITLE: Additive Manufacturing of Inorganic Transparent Materials for Advanced Optics

TECHNOLOGY AREA(S): Materials/Processes

ACQUISITION PROGRAM: PMA275 V-22 Osprey

OBJECTIVE: Develop an Additive Manufacturing (AM) process for depositing inorganic glasses with sufficient quality and precision for free form and gradient index optics.

DESCRIPTION: Naval Air Operations have a broad array of weapon and surveillance systems that utilize high performance optics. Many of these applications require greater wavelength transmission range, hardness, and temperature stability compared to polymers. The potential for utilizing AM technology to print glass lenses will provide the Navy the ability to (1) deposit net shape or near net-shape free-form optics, (2) locally adjust the index of refraction and other optical properties such as dispersion, (3) create high precision low thermal expansion meteorological frames that can form the basis for refractive optics, and (4) repair existing optical systems.

The benefits of AM are widely realized for structural systems; however, work on printing optical systems is still in its comparative nascency. The majority of the work has been primarily focused on polymers. Processes that have been demonstrated for printing optically transparent polymers include ink-jet printing [Ref 1] with/without in-situ ultraviolet (UV) curing [Ref 2] and multiphoton stereolithography (SLA) to directly polymerize resin [Refs 3-4].

These techniques have been used for rapid prototyping of non-imaging optics using Poly(Methyl Methacrylate) (PMMA) like plastics [Ref 4]. They have also been used to create curved display surfaces, sensors, display devices, and interactive devices [Refs 1-2], and to print 3D Gradient Index (GRIN) devices by locally adjusting the index of refraction during the layer-by-layer fabrication [Ref 3]. This work has progressed to the point that it is beginning to be commercialized and while it is currently suitable for non-imaging purposes the technology is approaching viability for ophthalmic applications.

Despite the benefits of inorganic glasses, there has been limited work applying AM processes to glasses. The high viscosity of glass when molten makes powder bed processes challenging because the bubbles fail to coalesce and escape due to buoyancy [Ref 5]. This can be overcome by using nanopowders to print a green part, followed by a slow high temperature burn-out/densification process [Refs 6-7]. Alternatively, fully dense material can be smoothly melted and deposited [Refs 8-9]. Both approaches have challenges and require significant development before optical devices can be successfully created. Currently no commercial AM system can be used to fabricate imaging quality optical glass with sufficient dimensional accuracy and surface finish.

A robust AM process to fabricate optical materials with good optical properties and surface quality is needed. This AM process should be able to deposit optical materials within the desired transmission band and provide a smooth optical surface quality so that minimum post-processing is needed. This process will allow engineering of new optical systems with volumetrically varying properties such as the index of refraction (i.e., GRIN lenses). Even with homogeneous glasses, AM has the potential to rapidly realize free form optics or to repair existing systems with no or minimal post (such as least amount of time for a final polish to achieve a desired surface flatness, such as lambda / 4) processing. This will dramatically enhance the logistics and maintenance of Navy aircraft and other systems.

To demonstrate a robust AM process, proposers are asked to develop an achromatic lens with a transmission window from 0.65 micrometer to 1.3 micrometer.
- Clear aperture must be 3 inches in diameter
- Effective Focal Length (EFL) must be 10 cm
- Resolution must be 100 lp/mm
- Athermalized design must work from -54 to 90 degrees Celsius
- No adhesive should be used to combine the doublets

Diameter Tolerance +0.00/-0.10 mm
Focal Length Tolerance ±1%
Surface Quality 40-20 Scratch-Dig
Spherical Surface Power lambda /2
Spherical Surface Irregularity (Peak to Valley) lambda / 4
Centration =3 arcmin
Clear Aperture >90% of Diameter
Damage Threshold Pulse 5 J/cm2 (810 nm, 10 ns pulse, 10 Hz, 0.155 mm)
CW 1000 W/cm (1070 nm, Ø0.971 mm)

In addition, provide the following analysis and measured data:
- Analyze Ray fan plots and spot diagrams
- Demonstrate that the optical path length is equal to sigma n delta s for the two discontinuity between the doublets
- Show the flatness of the wavefronts coming from a point source at the focus
- Show what does n (lambda) curve looks like
- Determine if power density at any image location is proportional to strength of corresponding object point?
- Determine the birefringence of the material delta n
- Determine the diffraction blur diameter
- Determine the aberrations for the lens using the spot diagram to show these effects
- Analyze spherical aberration; coma; astigmatism; distortion; transverse chromatic aberration
- Determine the wavefront errors for Seidel aberration
- Determine the Modulation Transfer Function (MTF) for this lens
- Show what the optical plot of the optical transmission looks like

PHASE I: Develop and demonstrate the feasibility of an AM process capable of the required optical properties, full densification, and smooth surface finish as provided in the description. The AM process should be able to realize a prescribed aspherical geometry with minimal post processing. Demonstration should include a fabrication plan of a representative achromatic lens with the specification provided in the description. Develop prototype plans to be developed under Phase II.

PHASE II: Fully develop the AM process, demonstrated in Phase I, that can be applicable to an array of naval optical component geometries. Include, in the prototype demonstration, the effectiveness of fabricating fully densified optical components with precision control of the part geometry, and smooth surface quality. Fully characterize the resulting geometry, and mechanical and microstructural properties achieved through the process to validate the effectiveness of the AM process.

PHASE III DUAL USE APPLICATIONS: Perform many experimental trials to define this additive manufacturing process since the development of an AM process for optical components is not a mature technology. Use simulation as a guide to help steer the direction of the experimentation; and to ensure the final product will meet the requirements of this topic as outlined in the specifications. Evaluate, by conventional metrology, the innovative achromatic doublet to ensure the AM process is on par with an achromatic produced by common practice. Transfer this process to platforms that have optical components.

Perform testing and make improvements to the AM Process based upon the results. Begin producing optical components for testing and use in military systems.

Laser manufacturers, camera manufacturers, and imaging technology manufacturers will benefit from this technology because they can now specify custom size optical components with unique transmission profiles that are not currently available with conventional optical processing.

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KEYWORDS: Optical AM; Optical additive manufacturing; Aberration; Lens; Achromat; 3D Graded Index lens; GRIN

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N19B-T029 TITLE: Data Science Techniques for Various Mission Planning Processes and Performance Validation

TECHNOLOGY AREA(S): Battlespace, Information Systems, Weapons

ACQUISITION PROGRAM: PMA281 (UAS) Strike Planning & Execution Systems

OBJECTIVE: Develop an Artificial Intelligence (AI) and Machine Learning (ML) based Mission Planner and Management technology that is based on initial analysis of various mission plans to determine where and how AI techniques could significantly benefit the mission planning and management process, including how to validate and verify autonomous performance.

DESCRIPTION: The National Defense strategy states, “The Department will invest broadly in military application of autonomy, artificial intelligence, and machine learning, including rapid application of commercial breakthroughs, to gain competitive military advantages.” [Ref 4] This topic is clearly aligned with this statement as it seeks to exploit the promising advantages of AI and ML in mission planning. The current Joint Mission Planning System (JMPS) mission planning process may be best described as a hybrid planning activity (i.e., partially accomplished manually by mission planners/pilots and partially accomplished through an automated process). To gain familiarity Reference 1 describes a basic mission planning process. There are a variety of mission types (e.g., Strike, Intelligence Surveillance and Reconnaissance (ISR), manned and unmanned teaming (MUM-T), Multi-Domain Missions (MDM), Close Air Support (CAS), Naval Integrated Fire Control-Counter Air (NIFC-CA)). Each type has unique mission planning components but there are many facets of the planning process that are common to each mission type. These areas should be candidates for automation using AI and ML techniques. In the near future, mission planning will include multi domains that will include air, maritime, land, and space. Many current AI applications focus on human-centric processes. Thus, since part of mission planning is a human-centric activity, increasing the potential for errors. AI technologies would provide tremendous benefit. This effort should determine a method to leverage advantages of AI and ML (to name two of the most often cited, speed and accuracy) and apply it within the mission planning process. Besides defining how to apply AI, the project will also address how to verify and validate the performance of the mission planning with AI, (i.e., what development/technique is necessary to provide planners assurance that the results of AI-generated plans are realistic and/or improved when compared to current planning processes).

In addition, aligned with the overall planning process there are two security concerns that will have to be addressed: one being multi-level security due to the fact that some planning data/information is classified at different classification levels; and the other focusing on the highly critical need to protect software and information, thus requiring the need to embed cyber security measures [Refs 9 & 10] Both security concerns should be able to be resolved with AI techniques and should seamlessly and transparently be integrated in the overall planning process.

The final step is to simulate mission plans (perhaps not as detailed as described in Reference 4, but somewhat similar) and potentially show how to improve the planning process through ML.

Note: It is anticipated that proposers to the topic have some understanding of the mission planning process (relevant mission planning documentation will be made available in Phase I that includes descriptions of different scenarios and software) and should be highly experienced with the development and transition of AI and ML technology, relating to the current state-of-the-art AI and ongoing research as it may be applicable to this topic.

PHASE I: Determine and identify where and how within the mission planning process AI can make the most significant impact to the process and develop a concept to simulate the overall mission plan with AI and ML. Define a conceptual AI-based planning process that includes multi-level security and cyber security. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype based on the results of Phase I and demonstrate the capability to verify and validate the mission plan performance with embedded AI. Generate simulated mission plans based on actual Air Tasking Orders. Additionally, show if AI can achieve / identify further improvements in the planning process via self-learning capability. Also address feasibility of dynamic real-time mission replanning during mission execution.

PHASE III DUAL USE APPLICATIONS: Finalize the complete AI/ML based mission planning capability and conduct operational testing. Transition technology to a next generation of JMPS and other services in support of mission planning processes. The development will benefit manned / unmanned mission planning that supports commercial delivery companies, especially addressing those that deliver via Unmanned Systems such as Amazon, United Parcel Service, and other organizations and companies that employ Unmanned Air Vehicles as part of their business (e.g., land management).

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KEYWORDS: Artificial Intelligence; Machine Learning; Multi-Platform Planning; Manned-Unmanned Teaming; Joint Mission Planning System; Naval Open Mission System

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N19B-T030 TITLE: Robust, Low Permeability, Water-Filled Microcapsules

TECHNOLOGY AREA(S): Materials/Processes

ACQUISITION PROGRAM: PMA276 H-1 USMC Light/Attack Helicopters

OBJECTIVE: Identify and develop a long-lasting (i.e., mechanically robust, withstand temperatures from -40°F to 135°F without rupture, and have low to zero permeability for 20+ years) dry powder of water-filled microcapsules that can be mixed into viscous pre-polymer liquids without breaking, and remain intact after rubber curing and fuel bladder manufacturing and maintenance, but will break and release their contents when mechanically shocked (i.e., shot with a .50 caliber bullet). Enable the incorporation of the microcapsules into a self-sealing material for fuel bladders solution under development by Naval Air Systems Command (NAVAIR).

DESCRIPTION: The Navy currently needs to develop robust and long-lasting water-filled microcapsules for a self-sealing material that is activated when it comes into contact with water. For the desired fuel bladder application, no external water source will be required to activate the material after the fuel bladder has been penetrated. Current water-filled microcapsules contain water for days to weeks before the water permeates the microcapsule shell; however, fuel bladders need to be able to self-seal during 20 years of fleet usage.

Microencapsulation of liquids is a process used in many industries (e.g., coatings, pharmaceuticals, cosmetics, consumer goods, agriculture); however, microencapsulating water has been a challenge due to the small size of the water molecule that causes it to permeate through the shell of the microcapsule at room temperature. For this project, the microcapsules should contain greater than 80% water by volume as determined by microscopy or a chemical reaction of a ruptured microcapsule and the particle size (in the range of 50-200 microns in diameter) needs to be tightly controlled and nearly monodisperse,(i.e., a coefficient of variation (standard deviation of particle diameter divided by mean particle diameter) of 3% or less) and analyzed with a particle analyzer for each batch of material produced, in order to provide consistent breaking strength from batch to batch (a coefficient of variation (standard deviation of breaking strength divided by mean breaking strength) of 5% or less. The breaking strength range of the microcapsules should be characterized at room temperature (75 degrees F), -40 degrees F, and 135 degrees F by a suitable method, such as Atomic Force Microscopy (AFM) with the load-deflection curves, rupture force and deformation, and Young's Modulus as significant outputs of the analysis. A large majority of the microcapsules (>99%) must remain intact when exposed to a temperature range of -40 degrees F to 135 degrees F, which is the temperature range of the crashworthy and self-sealing fuel bladder specification MIL-DTL-27422F gunfire test. This may be evaluated by temperature exposure followed by Scanning Electron Microscopy (SEM) and statistical evaluation of the images (i.e., ratio of ruptured to intact microcapsules). The water-filled microcapsules must be resistant to rupture during mixing in viscous (in the range of 100 to 25,000 mPas) pre-polymers, so a lab scale mixing test must be developed where the ratio of ruptured microcapsules before and after mixing is evaluated, again likely through SEM. The microcapsules must be resistant to JP-5 and JP-8 fuel, so their mechanical strength should be evaluated by AFM or other suitable means after exposure to fuel. The composite of the microcapsules with the cured polymer will need to withstand lab scale handling tests including a fold over test (180-degree bend) to simulate a bladder being folded during installation into an aircraft according to MIL-DTL-27422F paragraph 4.4.5.7 Stress Aging; an Impact Resistance drop test (1 lb. blunt chisel dropped from several heights) to evaluate small mechanical shocks according to MIL-DTL-27422F Paragraph 4.5.6 Impact Resistance; and quasi-static compression (up to 300 lbs./inch) to simulate maintainers walking and crawling on fuel bladders. An accelerating aging test (see MIL-STD-810G section 520.3 Temperature, Humidity, Vibration, and Altitude and section 524 Freeze/Thaw) will need to be developed to determine the likelihood of the microcapsules surviving in the fuel bladder for 20+ years. This will likely need to consist of thermal cycling and mechanical bending and compression cycling tests, while looking for activation of the microcapsule/polymer composite (i.e., the self-sealing material). An evaporation test will need to be performed by monitoring and tracking the weight loss of several ounces of microspheres in a drying oven over the course of weeks to months to determine a water evaporation rate. The microcapsule/polymer composite will need to be incorporated into a MIL-DTL-27422F Phase I test cube to undergo gunfire testing. Since the construction of a fuel bladder test cube is not a trivial task, it is recommended that the proposer partner with a fuel bladder manufacturer in the final stages of this project.

PHASE I: Define and develop a concept for a microcapsule that will meet the Description above and determine the feasibility of producing a prototype both at lab scale and on a large scale. Develop concepts for robustness (mechanical, thermal, chemical), longevity (accelerated aging and evaporation), and shock tests. Develop a concept for incorporating the microcapsules into a polymer matrix. The Phase I effort will include prototype plans to be developed during Phase II.

PHASE II: Develop, on a lab scale, prototypes of the microcapsule and microcapsule/polymer composite based on concepts developed in Phase I. Implement the test concepts using them as quality checks on the products in the lab scale process. Refine the tests, as required. Once the lab scale process for producing the microcapsules and the microcapsule/polymer composite and all of the tests are mature, generate a concept for large scale production of the microcapsules and microcapsule/polymer composite along with a concept for integration of the microcapsule/polymer composite into a fuel bladder.

PHASE III DUAL USE APPLICATIONS: Produce fuel bladders or partner with another company that already produces fuel bladders so that the microcapsule/rubber composite self-sealing layer may be evaluated in a Phase I (not STTR Phase I) fuel bladder cube gunfire test according to MIL-DTL-27422F. After passing the gunfire test, incorporate the self-sealing technology into a fuel bladder production process to bring the technology to the fleet.

Successful development of this technology could benefit fuel bladder manufacturers by giving them the ability to meet the fuel bladder self-sealing requirements. The microcapsules could be used in the pharmaceutical and consumer products industries for encapsulating aqueous medicines, activating water curing adhesives like cyanoacrylate (superglue), and self-healing coatings. The self-sealing layer that incorporates the water filled microcapsules can be used in other self-sealing applications, including pneumatic tires and inflatable rafts and life vests.

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KEYWORDS: Microcapsule; Microsphere; Microencapsulation; Dry Water; Nanosphere; Powdered Water

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T031 TITLE: Innovations in Production of Rotorcraft Airframe Components using Advanced 3D Braiding

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA276 H-1 USMC Light/Attack Helicopters

OBJECTIVE: Design and develop methodologies to fabricate a three-dimensional (3D) braided composite part, specifically those with solid cross-sections and complex geometries.

DESCRIPTION: The attraction of 3D braided architecture is that it is inherently damage tolerant and can produce near net-shape products; however, these improvements usually come with a stiffness penalty. Additionally, there are limitations on the geometries that can be braided near-net shape. This is particularly true for solid cross-sections where the geometry and shape change along the braiding axis. Conventionally, complex shapes are produced either by over braiding on an insert or by machining an oversized braided composite. The first approach results in a weak interface between the insert and the braid. The second approach is not a near net-shape and results in increased scrap and a weaker structure, resulting from the cut fibers on the surface. Innovations are sought in braiding technology that can address these deficiencies and successfully produce complex rotorcraft components. In addition to technical maturity, scalability of the approach, and automation of the process are important. These criteria will be used during the evaluation process.

PHASE I: Define and develop a concept for an innovative braiding methodology and establish the feasibility of the methodology to fabricate a rotorcraft airframe or rotor component. Feasibility can be established by fabricating coupons that are representative of geometry and cross-section changes of a rotorcraft component. Candidate components may include, but are not limited to, fuselage frame elements, rotor hub, and rotor yoke sub-assemblies. The Phase I effort will include prototype plans to be developed under Phase II. In choosing the components, please refer to JSSG-2006 [Ref 3] and AR-56 [Ref 2] for overarching requirements for Navy rotorcraft structures.

PHASE II: Demonstrate the production methodology by producing a prototype component in a lab or live environment.

PHASE III DUAL USE APPLICATIONS: Finalize and mature the technology for transition and insertion into Future Vertical Lift (FVL) for production fuselage or rotor hub components. The technology will be highly applicable to commercial aviation for reducing production costs by replacing metallic airframe structures with composites.

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KEYWORDS: Composites Manufacturing; Near Net Shape Manufacturing; 3D Braiding; Rotorcraft Airframe Structure; Composite Hub; Composite Yoke

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T032 TITLE: Strength Loss Indicator for Webbing

TECHNOLOGY AREA(S): Human Systems, Materials/Processes

ACQUISITION PROGRAM: PMA202 Aircrew Systems

OBJECTIVE: Develop a non-destructive testing capability to detect when the strength of webbing is no longer capable of withstanding the load for which it is designed.

DESCRIPTION: A capability is needed to detect when the load-bearing strength of a webbing has decreased into an unsafe zone. The strength of webbing is degraded with each use, and the degradation depends upon the webbing material, and the exposure to environmental factors. Because degradation is typically silent and invisible, unexpected failure during an emergency is a hazard that the Navy wishes to avoid. A non-destructive way to detect degradation has long been sought by the narrow fabrics industry. The demand is there, but the technology is lacking. Incorporating multiple indicator technologies rather than relying upon a single technology is an approach that may be more achievable than expecting one technology to detect every kind of failure mode. Incorporating load indicators in the load-axis of the structure without affecting the load-bearing capability is yet another challenge. Embedding sacrificial visual wear indicators, like those used in road tires, in the webbing's binder or marker yarns could indicate excessive abrasion. A dye that fades predictably and measurably under ultraviolet (UV) exposure or ozone may be another approach. Solid state mechanochromic luminescent dyes could potentially indicate when a load threshold has been breached. The goal of this STTR effort is to incrementally develop an indicator integral to a common webbing type or develop a portable test/inspection method that can be used on a common webbing type end-item in situ (e.g., on a restraint seat harness installed in the aircraft cockpit).

Current failure detection methods are limited to visual inspection by the naked eye using somewhat vague and incomplete criteria. Reference 1 directs the parachutist to check the webbing "for damage" and the harness for signs of "completeness, cuts, broken stitching, acid and signs of chafing and wear." The Parachute Industry Association [Ref 2] states, "Any cuts, nicks or heavy abrasion to webbing should be shown to a certified rigger before the next jump." Direction to check for loss of pliability or color change or loss is missing, as is direction to check specific areas of webbing exposed to flex fatigue and hardware surfaces, such as friction adjusters in buckles. Cascading failure begins on the molecular level with a weakened chemical structure [Ref 3]. Degradation of the fiber follows. Mechanical stress can cause failures of the yarn comprising these weakened fibers and Hearle, Lomas, and Cooke in Chapter 38 [Ref 4] show scanning electron microscope images of the filament fractures of ejection seat webbing yarns attributed to shear loading, flex fatigue, and friction from hardware components. The next step is failure of the end-item itself. Accelerated aging harness testing that excluded mechanical degradation showed that aged webbing tended to break before the stitched seam more frequently with a corresponding loss in tensile strength [Ref 5]. As the sewing thread is subject to the same degradants as the webbing, stitches were observed to fail before the webbing did, but less frequently.

There is currently no standard method to conduct surveillance testing of webbing. Of the very few surveillance testing studies that have been published, the criteria for accelerated aging can vary greatly by the purpose of the end item. For example, nylon is known to be degraded by exposure to UV radiation and a combination of high heat and humidity, and therefore those conditions are usually included in accelerated aging testing of ejection seat webbing. On the other hand, even though ejection nylon webbing is vulnerable to abrasion from blowing sand/dirt, ejection seat testing typically excludes that degradant because the closed cockpit shields the webbing from exposure. Military helicopter seat harnesses and aircraft tie-downs, however, always include blowing sand and dust, and ship exhaust on carriers as degradants due to their exposed conditions.

Reference 5 identifies static tensile strength as the main variable, and interpreted strength loss by age trends to determine the probability of maintaining 1.5/1 margin of safety factor over three years. Small-scale dynamic testing and static testing of elongation by age was used by the European Aviation Safety Agency [Ref 6]. The Code of Federal Regulations provides pass/fail criteria in terms of allowed percentage loss for automotive seat belt assemblies, using abrasion, UV exposure, micro-organisms as independent variables, and elongation and breaking strength as dependent variables.

Proposals for Phase I should include a background section with explanatory figures describing the basic principles of the proposed technology concept, and publications or other references that outline the application being considered.

It is recommended, but not required, that partnering with original equipment manufacturers be considered.

PHASE I: Demonstrate feasibility with an analysis that supports the proposed technology concept. Provide experimental work that demonstrates that the indicating technology is capable of detecting a 25 percent decrease in strength and elongation. Include a 3-tiered work breakdown structure with Gantt chart of Phase I design activities, and include make/break criteria and events. Provide Technical Performance Measures for Government review and approval that will be tracked throughout Phases I-III. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Incrementally develop the strength loss indicator technology. Demonstrate the technology using PIA-W-4088 Type VII Class I webbing [Ref 8], which is commonly used in both commercial and military applications, or another webbing with similar width, thickness and strength properties. Include a 3-tiered work breakdown structure with Gantt chart of Phase II design activities, and include make/break criteria and events. Track performance against agreed-upon Technical Performance Measures quarterly. Develop quality assurance measures. Demonstrate the capability of the prototype on, or incorporated in, five sets of ten webbing test articles plus one control set conditioned per MIL-STD-810 procedures [Ref 9]: Set 1 should be exposed to UV radiation; Set 2 to combined high heat and humidity; Set 3 to impact cycling; Set 4 to fluid contaminants, salt fog, blowing sand/dust, and stack gas exposure; and Set 5 to all four (in sequence, as laboratory concomitant exposure is not yet possible). Produce a final Phase II report that includes raw data, photography and/or video recording, data recording sheets, documentation of test devices (manufacturer, model, serial, accuracy, calibration status) and test reports written in accordance with any specified standards. Develop a performance specification to document the Phase II prototype technology.

PHASE III DUAL USE APPLICATIONS: Finalize the developed strength loss indicator technology for webbing in performance specification and engineering drawings in accordance with military standards. Develop and perform required operational testing, document the quality assurance test program in accordance with industry best practices, and transition into military and commercial webbing markets. This technology may benefit the private sector in such markets as industrial fall arrest harnesses and tethers, commercial aircraft and automotive seat harnesses, and recreational airborne sports such as skydiving, hang-gliding, and parasailing.

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KEYWORDS: Textiles; Webbing; Service-Life; Life Extension; Non-Destructive-Testing-And-Inspection; NDTI; Strength Loss

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T033 TITLE: Analysis and Modeling of Erosion in Gas-Turbine Grade Ceramic Matrix Composites (CMCs)

TECHNOLOGY AREA(S): Air Platform, Materials/Processes, Weapons

ACQUISITION PROGRAM: NAE Chief Technology Office

OBJECTIVE: Develop and demonstrate a physics-based erosion model for gas-turbine grade ceramic matrix composites (CMCs).

DESCRIPTION: CMCs are currently being considered for use in hot-section hardware of advanced aero engines with goals of increased performance and efficiency. Concerns exist regarding the degradation of CMCs due to life-limiting phenomena associated with thermal, mechanical, chemical, and environmental effects. Of particular concern is erosion by small particles such as sand, dust, and other fine erosive objects ingested into hot-sections of engines. Since CMCs are brittle in nature and some sections of CMC components such as airfoils are in a thin configuration, erosion generates a varying degree of damage from localized micro-fracture to significant material removal, depending on the severity of erosion events. Consequently, erosion in CMC hardware can result in a reduction in load-carrying capacity, a premature component life, and a loss of related functions. Significant science and technology activities have modeled erosion behavior in metallic, polymeric, and coating materials systems [Refs 1-3]. However, despite its importance and demand, to date no pertinent model exists able to describe erosion phenomena of CMCs. Erosion in CMCs has shown to be very complex due to the random and violent nature of erosion events coupled with the materials’ architectural and constituent complications [Refs 4,5]. As a consequence, an emerging need exists to develop an innovative physics-based erosion model for CMCs. The model, at a minimum, is to be able to predict the rate and shape of material removal with respect to type of materials for given erosion conditions. The approach is also expected to leverage overall experimental and fabrication efforts/iterations and to contribute to the improvement of the design of CMCs that are more durable and reliable against erosion. In general consideration, but not limited, target materials are gas-turbine grade CMCs, erosive particles are silica or ceramic-based and random in shape with varying sizes of 50-200 micrometers, and particle velocities are in a range of Mach 0.2 to 2.

PHASE I: Design and develop an initial erosion model concept and demonstrate feasibility for the CMC material systems. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Fully develop and optimize the approach formulated in Phase I. Demonstrate and validate the approach using pertinent data obtained from selected materials systems under appropriate erosion conditions.

PHASE III DUAL USE APPLICATIONS: Perform validation and certification testing. Transition the approaches to CMC propulsion applications for platforms such as Variable Cycle Advanced Technology (VCAT), Versatile Affordable Advanced Turbine Engines (VAATE), and other advanced Naval engines. CMC propulsion materials have great potential to the civilian aerospace engine applications and are being transitioned in some areas. The proposed erosion technology development will benefit the private sector in their efforts to enhance the overall durability and reliability of CMC hardware. Industries such as land-based or marine gas turbine engine industries, automotive industry, and material developers/designers would benefit from successful technology development.

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KEYWORDS: Ceramic Matrix Composites; CMCs; Gas-Turbine Grade CMCs; Erosion; Erosion Modeling; Erosive Particles; Erodent

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Questions may also be submitted through DOD SBIR/STTR SITIS website.

N19B-T034 TITLE: Model for Surface Finish Prediction and Optimization of Metal Additively Manufactured Parts

TECHNOLOGY AREA(S): Materials/Processes

ACQUISITION PROGRAM: PMA275 V-22 Osprey

OBJECTIVE: Develop a modeling tool to rapidly predict the surface finish of metal additively manufactured (AM) parts as a function of AM process parameters and to determine AM processing and path planning to achieve optimal surface finish.

DESCRIPTION: Additive Manufacturing (AM) technologies, such as Laser Powder Bed Fusion (LPBF) process, have become increasingly important for the rapid production of industrial products. However, AM processes also pose challenges with associated features, such as defects and inherent surface roughness, which can degrade the fatigue performance. A significantly lower endurance limit was reported for specimens with inherent surface roughness compared to polished ones [Ref 7]. Thus, the surface finish can influence the fatigue performance due to multiple stress concentrations. High cycle fatigue properties are especially dominated by surface finish [Ref 3].

There are several factors that can affect the surface finish of an AM part, such as powder distribution, energy density, build orientation, powder morphology, energy source, scan speed, hatch width, and staircase effect [Ref 4]. Although a fine powder granulation generally leads to better densities and surface qualities than a coarser material, the distribution of particle sizes can be even more important [Ref 4]. Some more in-depth physical phenomena, such as the balling process, can be commonly found as surface defects in which large drops, with size exceeding laser spot diameter, quickly spread out in droplets [Ref 6]. Geometric defects such as elevated edges disrupt the build process and distort subsequent surfaces [Ref 2]. The presence of overhangs or upwards facing surfaces produce different surface finish characteristics [Ref 2]. Although secondary processes, such as machining, may overcome the surface finish issue, the non-line-of-sight surfaces resulting from specific part geometries may not be accessible for machining.

A multi-physics modeling tool is needed to rapidly predict, in minutes to hours for a desktop environment, the surface finish of a metal AM part and to provide a strategy in AM processing/path planning to achieve the minimum roughness surface finish. There have been some efforts to model the surface finish of AM parts, such as modeling the roughness profile for the Fused Deposition Modeling (FDM) technology. This allowed the calculation of the roughness parameters as a function of the layer thickness and the deposition angle [Ref 1]. Another effort was carried out to describe the effects of partially bonded particles on the surface of an LPBF part [Ref 5], and work was also done to predict the roughness obtainable on AlSi10Mg processed by LPBF, taking into account the staircase effect, and the defects typical of this aluminum (Al) alloy. However, these models only address a portion of the issues affecting a part's surface finish.

The Navy is seeking a more developed tool that captures the process parameters used by the machine. This modeling tool should be able to predict and optimize the surface finish, preferably through implementation of machine learning or another rapid convergence technique, based on key parameters such as, but not limited to, the part geometry, material properties (e.g., powder composition, particle size distribution, morphology), and initial AM processing parameters (e.g., powder distribution, energy density, build orientation, energy source, scan speed, hatch width, layer thickness, processing conditions). Users should be provided with an updated set of process parameters to achieve the optimal surface finish. Demonstration of the tool's predictive and optimization capabilities should be on Ti-6Al-4V printed specimens. The tool should be designed to provide process parameters compatible with EOS powder bed machines.

PHASE I: Demonstrate the feasibility of a multi-physics modeling tool to predict the surface finish based on key process parameters. Predict the surface finish of some representative geometric features (overhangs, holes, radii, etc.) for typical LPBF processing. Compare the predicted surface finish of the test cases by printing Ti-6Al-4V samples to show the effectiveness of the model's prediction capability. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a full-scale multi-physics modeling prototype to rapidly optimize the surface finish based on various process parameters, including, but not limited to, powder distribution, energy density, build orientation, material properties, powder particle size distribution and morphology, energy source, scan speed, hatch width, layer thickness, part geometry, and processing conditions. Demonstrate the solution(s) in a real-world AM processing scenario and its possible transition into both military and commercial applications. Note: No Government test facility should be needed.

PHASE III DUAL USE APPLICATIONS: Develop standalone compliance with major powder bed machines (e.g., EOS, Renishaw, Concept Laser). The benefits in surface finish from this topic will directly benefit the aerospace, automotive, and energy industries utilizing AM by reducing the amount of post-process machining necessary to meet surface finish requirements for high performance parts.

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KEYWORDS: Surface Finish; Surface Roughness; Additively Manufacturing; AM; Modeling; Powder Bed Fusion

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N19B-T035 TITLE: Universal Sensor Application Programming Interface (API) for Undersea Data

TECHNOLOGY AREA(S): Information Systems

ACQUISITION PROGRAM: PEO IWS 5, AN/UYQ-100 Undersea Warfare -Decision Support System (USW-DSS) Program Office

OBJECTIVE: Develop a universal Sensor Things Application Programming Interface (API) that enables systems to utilize data from all current and future sensors without requiring new development.

DESCRIPTION: Today’s undersea environment is experiencing a proliferation of sensors, such as high-end military towed arrays, commercial side-scan SONARs on unmanned vehicles, disposable sonobuoys, and commodity temperature sensors. This is similar to the proliferation of sensors comprising the Internet of Things. Examples are sensors in a basic smartphone Global Positioning System (GPS) and smart traffic control capabilities, which utilize data gathered from sensors displayed on a user-friendly Graphical User Interface (GUI) for the user to visualize the data. The military sensors and Internet of Things sensors all have a basic common concept –sense something measured at some point in geospatial and temporal space and display.

While sensors are proliferating, a lack of standardization requires that the Navy continually re-develop and re-implement software to handle new sensors. This technology addresses the need to streamline the incorporation of new and improved sensors into networked systems. These new sensors provide similar data, causing a recurring cost and effort to maintain the software. The focus of this effort is to determine the feasibility of newly formalized Sensor Things Application Programming Interface (API) standard by which such data can be provided for the AN/UYQ-100 Undersea Warfare Decision Support System (USW-DSS). In response to the rise of the Internet of Things, along with the growing need to provide a common API through which sensors can report measurements in time and space, the Open Geospatial Consortium (OGC) has recently published the Sensor Things API. No common standard by which different types of sensors can report their measurements existed prior to this standard. As such, inclusion of data from a new sensor into a system required additional software development; specific logic unique to that sensor; and associated cost and schedule implications. Development of the universal sensor API will allow for data from new sensors to be integrated into USW-DSS (and other systems) to address this challenge and enable the integration of new sensors without requiring new development.

The Navy seeks an innovative implementation of a Universal Sensor Things API for the AN/UYQ-100 USW-DSS focused on the undersea domain and the heterogeneous types of data. Future sensors will likely acquire and report these data sets. The Navy will also require a process for generating or obtaining test data adequate to support testing. Design efforts include describing the proposed technology stack for use on the server-side. Initial efforts would be expected to quantify expected performance of the proposed API implementation in terms of anticipated data throughput for integration as well as similar expected performance for queries. Finally, a successful effort would provide a plan to utilize real sensors or sensor mockups to verify the performance of the API implementation. Implementation of the Sensor Things API offers standardization to a common API.

This effort seeks a design for an innovative Universal Sensor Things API that utilizes best open source components and technologies to allow the implementation to scale from a laptop to a large computing cluster, demonstrating an ability to integrate data at various rates and diverse data payloads. This design should also consider how evolving security threats can be addressed by this universal API. Since the Navy requires a scalable implementation which could be integrated into multiple programs with different hardware footprints, a successful design would specifically allow for both vertical scalability (fewer servers, with more resources) and horizontal scalability (more servers, with less individual capability). A critical component of this effort is determining which existing open-source technologies to leverage (i.e., the “technology stack”) to develop a scalable, re-usable Sensor Things API. This should at minimum support the development of nominal anticipated performance characteristics of an analogous implementation, specifying parameters such as maximum number of data feeds and rate of data ingest. Refinement of the proposed analogous implementation will be provided to the awardee by the Government.

PHASE I: Develop a concept for a Universal Sensor Things API for the AN/UYQ-100 USW-DSS in accordance with the Description of this topic. Demonstrate the feasibility of the concept through modeling and simulation. Develop a Phase II plan. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a solution in Phase II.

PHASE II: Develop and deliver a prototype Universal Sensor Things API based on the results of Phase I and the Phase II Statement of Work (SOW). Ensure that this prototype utilizes a design and implementation process that meets the parameters described in the Description. Include iterative development and testing of methods. Use ongoing benchmarking and analysis of implementation performance to meet the performance goals described in the Phase II SOW.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the Universal Sensor Things API into the AN/UYQ-100 USW-DSS platform using the Program Office software transition process. Finalize the technology by demonstrating the capability needs (listed in the Description) during a testing evaluation event to determine the effectiveness of the Universal Sensor API in the Navy’s sensor interface development environment. Support the Navy for test and validation in accordance with the peer review processes and test and evaluation required to support integration into the AN/UYQ-100 USW-DSS software baseline.

This technology has significant potential for commercial application, including oil, mineral, and gas industries; fishing industries; and weather forecasting, which could all benefit substantially from additional data about measured ocean characteristics.

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KEYWORDS: Open Geospatial Consortium; Standardization of Sensors; Universal Interface; Open-source; Technology Stack; USW-DSS AN/UYQ-100

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N19B-T036 TITLE: Three-Dimensional Field of Light Display

TECHNOLOGY AREA(S): Human Systems

ACQUISITION PROGRAM: PEO IWS 1.0, AEGIS Integrated Combat System (IWS 1.0) Program Office

OBJECTIVE: Develop a Human Machine Interface (HMI) for three-dimensional (3D) Field of Light Display (FoLD) visualization systems to reduce cognitive burden and enable 3D collaborative environments.

DESCRIPTION: As the Navy continues to reduce manpower requirements associated with operating ever-increasing technologically complex systems, new methods that enable natural and intuitive interaction with 3D data are required to reduce overall operator workload and to enhance situational awareness. Operators who cannot quickly access and interpret data are prone to errors ranging from missing critical data during tactical situations, to making judgments based on incorrect information. Developing an optimized capability to engage with 3D information in a high-stress environment will allow the warfighter to increase task accuracy, reduce response time, and increase overall situational awareness.

Field of Light Display (FoLD) systems are a class of autostereoscopic displays that provide 3D aerial visualizations without head tracking or eyewear (which impedes natural human vision), allowing for natural communication and collaboration among decision makers. In addition, FoLD systems provide 3D visualization without regard to viewer position or gaze direction and present correct imagery perspective to all viewers within the display’s projection frustum. Several studies highlight the advantages of 3D light-field holograms in enabling better mission planning or medical training. [Ref 1, 2, 3]. By presenting the 3D scene in a natural manner, the cognitive load on the viewer(s) is decreased and the ability to make decisions based on complicated information grows.

Deconflicting prioritization in the various theaters of air, surface, and subsurface proves challenging due to the 3D nature of the data and its subsequent visualization on two-dimensional (2D) displays. Currently, the operator is required to divert attention from their tasks to click through multiple menus to obtain such metadata as ascending or descending attributions, latitude and longitude, trajectory, and asset state. FoLD technologies provide several novel capabilities for reducing cognitive load on operators performing identification (ID) during volume searches. However, the way in which a user interacts with this 3D information requires more investigation to determine optimal human/FoLD interface.

Much of the FoLD research to date has focused on the 3D projection aspects of producing a 3D aerial image. Of equal importance is the manner in which humans interact with the 3D image to make command level decisions. For all FoLD systems, the 3D aerial image is ethereal and lacking both tactile and kinesthetic feedback. In some FoLD systems, all or part of the 3D image may be enclosed behind a transparent enclosure or cover glass.

The Navy requires a mechanism for interacting with emerging FoLDs that will provide an optimized ability for the user to engage with 3D information in a high-stress environment. These types of environments can be replicated by laboratory testing of current operator display system tasks/scenarios (ascending or descending attributions, latitude and longitude, trajectory, and asset state) which adhere to the full spectrum of the Combat Information Center (CIC) and/or watch stander environments. The proposed solution will also need to consider the resulting physical and psychological effects on the user. Understanding how humans process information through cognitive load theory, human computer interaction (HCI), and multi-modal learning should be a part of the design process for a meaningful solution. Performance will be measured by assessing task completion times, user cognitive load analysis, and physical impacts of the proposed system.

This innovation must be a novel and practical solution to providing interactivity with 3D imagery produced by a FoLD system. The solution must allow accurate and repeatable interactivity and operation within the view volume. The ability to select, rotate, scale, translate, and otherwise manipulate 3D objects within the 3D scene is required. The research and development effort may include 3D pucks, trackballs, mice, wands, gloves, hand position sensors, video game controllers, or any other comparable technology.

The solution must execute with little to no impact on the computational performance of the combat system environment under test. The proposed Human Machine Interface (HMI) should work with a variety of FoLD implementation independent technologies and complex tasks, support ruggedization for use in harsh environments, allow for natural and intuitive operation (minimize training) and support multiple simultaneous users.

PHASE I: Provide a concept for a FoLD HMI for interacting with a 3D image. The concept must show that it can feasibly meet the requirements of the Description. Establish feasibility through modeling and demonstration of the HMI concept. Develop a Phase II plan which includes human subject testing. In preparation for the human subject testing to take place during Phase II, Institutional Review Board (IRB) approval must be acquired during the Phase I. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a FoLD HMI interactive device prototype that is capable of demonstrating the implementation and integration into the combat system environment for testing and evaluation. Demonstrate accuracy, repeatability, and functionality, adhering to the requirements outlined in the Description requirements. Perform a demonstration at a Land Based Test Site (LBTS), which represents an unclassified simulation environment, provided by the Government.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use and support further refinement and testing of the HMI's functionality following successful prototype development and demonstration. Upon capability demonstration and quantifiable test results, direct the focus toward the transition and integration of the HMI with the emerging FoLD Systems for a 2024 technical insertion as a component of the Aegis Combat System.

This HMI device will allow users to interact with data in a 3D environment naturally and intuitively and greatly enhance pre-operative planning and post-operative reviews by surgeons, medical students, and hospital staff.

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KEYWORDS: FoLD; 3D Light-field Holograms; Human Machine Interface; 3D Aerial Image; Human Computer Interaction; 3D visualization

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